

500

Semiconductor Production Test System

# SHMOO

## User's Guide

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# Introduction

This manual introduces you to the ability of the MITE software to create shmoo plots. Shmoo plots are a type of datalogging which enable you to show the operating characteristics of a DUT while varying two input parameters.

Shmoo plots can represent two types of data:

- *Pass/fail* - the shmoo plot will display a pass/fail result for each parameter pair test point. Pass/fail can also display the actual value logged at each of the parameter pair test points.
- *First failed vector* (FFV)- the shmoo plot will display a pass/fail for each parameter pair tested and also reports the first failed vector of the functional test.

Shmoo plots are displayed on an X-Y grid. A single test is performed at each point on the grid. Therefore, shmoo plots require X times Y tests to fill the grid.

After configuring the shmoo plot input parameters, the plot starts with the X and Y start values and then repeats the test at each increment along the X axis, continuing line by line for each increment along the Y axis. This results in a combination of the separate tests.

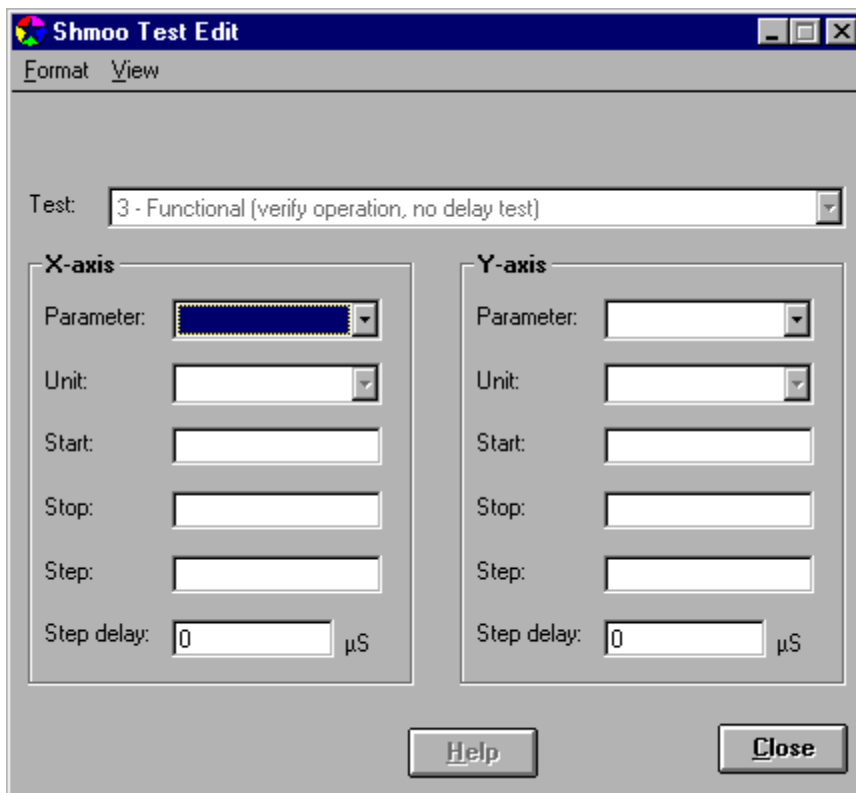
The following documentation will explain how to use the Shmoo Control to create shmoo plots on a per test basis, how to take advantage of the shmoo database files and how to create composite shmoos by combining multiple shmoo plots with identical X-Y parameters. Composites are a useful way to represent characteristics on a group of identical devices or one device being tested at multiple temperatures.

# Shmoo Control

The Shmoo Control window has two modes; test creation and interactive. Test creation mode allows you to define a shmoo for a test type to be generated each time the test is executed. Interactive mode allows you to generate shmoo plots from the Production Test window.

## Test Creation

To invoke the Shmoo Control window during test creation or modification, select a test from the Single Test Editor, click on the ‘Shmoo’ icon located on the MITE toolbar:



- The *Test* list box is not enabled when editing a single test. However, it does let you know the test for which you are setting up a shmoo.

- The **Format | Mode**, which is disabled until a test has been selected, defines when the shmoo will take place. **Shmoo** must be enabled in the Production Test window.
  - Disabled** - A shmoo will not be created at any time.
  - Always** - A shmoo will be created any time the test is performed.
  - On pass** - A shmoo will be created any time the test passes.
  - On fail** - A shmoo will be created any time the test fails.
- The **Format | Shmoo style**, which is disabled until a test has been selected, defines the style of shmoo to display once the shmoo data has been acquired:
  - Pass/Fail** - The shmoo will appear displaying pass/fail data.
  - FFV** - The shmoo will appear displaying the first failed vector for each X-Y coordinate. This option is only available for AC tests.
- In the *Parameter:* drop-down lists, select the parameters to be varied. The parameters available are dependent on test type:
  - dps1-dps4** - device power supplies
  - pmu** - parameteric measuring unit
  - vil** - input low level
  - vih** - input high level
  - vth** - output threshold
  - loads** - output load voltage
  - data edge** - edge placement of the input stimulus
  - clk/le** - clock leading edge
  - clk/te** - clock trailing edge
  - clock** - placement of clock
  - strobe** - placement of strobe
- In the *Pinlist:* field, enter the pin or pin groups to be measured. If left blank, all pins or pin groups specified for the test will be measured.
- Enter the units for each axis. The Shmoo Control window will make available only the units which are compatible with the specified parameters.
- In the *Start:*, *Stop:* and *Step:* fields, specify the search range and resolution. The step value can be specified as an absolute (by entering a value in units) or you can specify the number of steps between the start and stop values (by entering the value preceded by # - i.e. specify 20 steps by entering #20).
- Use the *Step delay:* field to specify the amount of delay or settle time to perform between each test in the axis.

## Shmoo Parameters

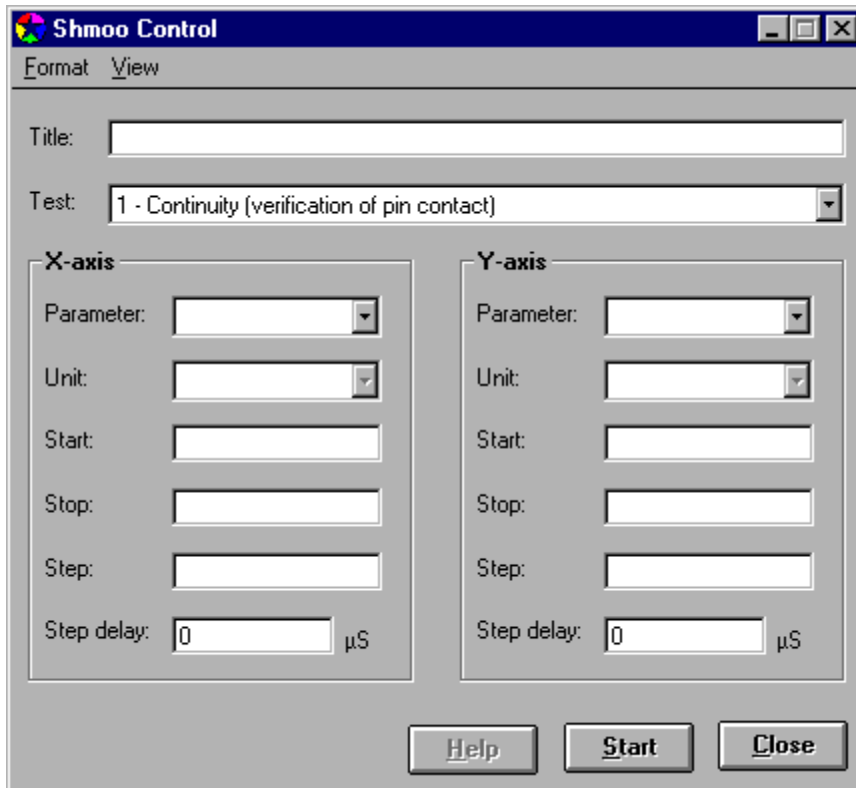
Unless otherwise indicated, a value must be specified for each of the parameters for both the X and Y axis:

- Parameter** - the DUT parameter to be varied for each point on the shmoo plot.
- Unit** - the unit for start, stop and step (V, A, mA, uA, mS, uS, nS, pS).
- Start** - the beginning of the shmoo.
- End** - the end of the shmoo.
- Step** - either the number of steps or the increment value of the shmoo.
- Step delay** - the amount of delay performed by the parameter between each test in the axis.

You have now defined a shmoo for a test.

## Interactive

The interactive Shmoo Control is very similar to the test creation Shmoo Control with the exception that you are now setting up a shmoo to be executed immediately. With that in mind, there are a few more fields displayed in the window.



1. Specify a title for the shmoo plot.
2. Select a test from the Test: drop-down list box. These are the tests currently loaded in the tester.
3. The X and Y Axis input boxes will display the shmoo values currently assigned to the test. If the boxes are blank, the test contains no shmoo data. You will need to input the data for both the X and Y axis as specified in the Test Creation section.
4. Select the shmoo style type; *pass/fail* or *FFV* (first failed vector) from the Format pull-down menu. If the specified test is not a functional or AC test, the FFV will not be available.
5. Make sure you select the desired shmoo mode from the Format | Mode pull-down menu.
6. Click Start to execute the shmoo.
7. At this point the Shmoo Plot window will be displayed. After the tester has acquired the shmoo data, it will be displayed in the Shmoo Plot window.

# Shmoo Plot

The acquired shmoo data is displayed in the Shmoo Plot window. From the **File** pull-down menu you can:

- **Open** saved shmoo plots. The most recently opened shmoo database files are also listed.
- **Save** single or composite shmoos.
- **Print** the single or composite shmoo plot.

## Open

Use this option to invoke the **Load Shmoo Database** dialog box, select a *shmoo database file* to view. A shmoo database file is where all shmoo data captured for a test program is stored. See the **Shmoo Database File** section for more details. By default, shmoo database filenames contain a *.shm* extension.

## Save as

Use this selection to save the currently displayed single shmoo plot into its own shmoo database file or save the current composite plot. Simply use the **Save Shmoo** dialog to specify the name of the file and click **Save**.

## Print

Use this selection to print the currently displayed shmoo plot using your default printer.

From the **Plot** pull-down menu you can manipulate the shmoo data in a variety of ways:

- Create **composite** shmoos.
- **Title** the single or composite shmoo plot.
- View the **properties** of a single or composite shmoo plot.
- Use the **Color Palette** to define colors used in single and/or composite shmoo plots.

## Composite

This selection will not be available unless a shmoo plot is displayed. For instance, when the Empty Shmoo Plot is displayed, this selection is not available.

The composite shmoo plot feature allows you to combine several shmoo plots to obtain a composite shmoo plot showing areas where a number of tests passed and failed. In these areas colors are used to represent percentage pass bands. Thus, a three-dimensional shmoo plot is generated, where the colors make up the third dimension.

You can use the composite shmoo plot to display the effect of a third parameter on a circuit, for example you might be sweeping propagation delay against device power supply voltage and for each overlay you change the temperature. The composite shmoo plot is also useful when making a statistical analysis on a group of identical devices.

Note that generating a composite shmoo plot is only possible for a shmoo being displayed in the pass/fail mode. When a shmoo is being displayed as a **Pin Composite** or **FFV**, you will have to revert it to the Pass/Fail mode before the composite option will be made available.

You can create or enhance a composite shmoo by:

- adding a shmoo plot to the composite plot.
- merge a saved shmoo plot or saved composite plot to the composite.

The **Composite** menu selection contains several sub-selections:

- Clear
- Add to composite
- Merge
- Undo

### Clear

Use this selection to create a composite shmoo session. The composite will be titled Composite Shmoo Plot and the currently defined pass percentage color legend will be displayed at the bottom of the window. For more information about the colors, see **Color Palette** later in this section. A pair of buttons will appear in the upper right-hand corner of the window:

- **Single/Composite** will toggle between the current composite plot and the single plot.
- **Add to comp** will add the single plot to the current composite. This button will be disabled if the single plot is being displayed as a **Pin Composite** or **FFV**. You can only add a single plot being displayed in **Pass/Fail** mode to a composite.

### Add to composite

This selection has the same effect as the Add to comp button.

## Merge

Use this selection to merge a saved composite into the currently displayed composite. The X-Y axis parameters and test type must be identical, otherwise, an error will occur.

## Undo

Will undo the last action performed on the composite, for example, this selection will remove the last plot added to the composite.

## Title

Use this selection to add a title to either the single or composite plot (depending on the which is currently being displayed). The title has a limit of 50 characters.

## Properties

This selection will invoke the **Properties** window. This window will contain data for the currently displayed single and/or composite plots such as, test data (test program name, revision, altered state), device number in the shmoo database file, serial number, test type, X and Y axis details. For more information, see the **Plot Properties** section.

## Color Palette

This selection will invoke the **Shmoo Colors** window. This window is used to define the colors used in the shmoo plots. For more information, see the **Shmoo Colors** section.

## Close

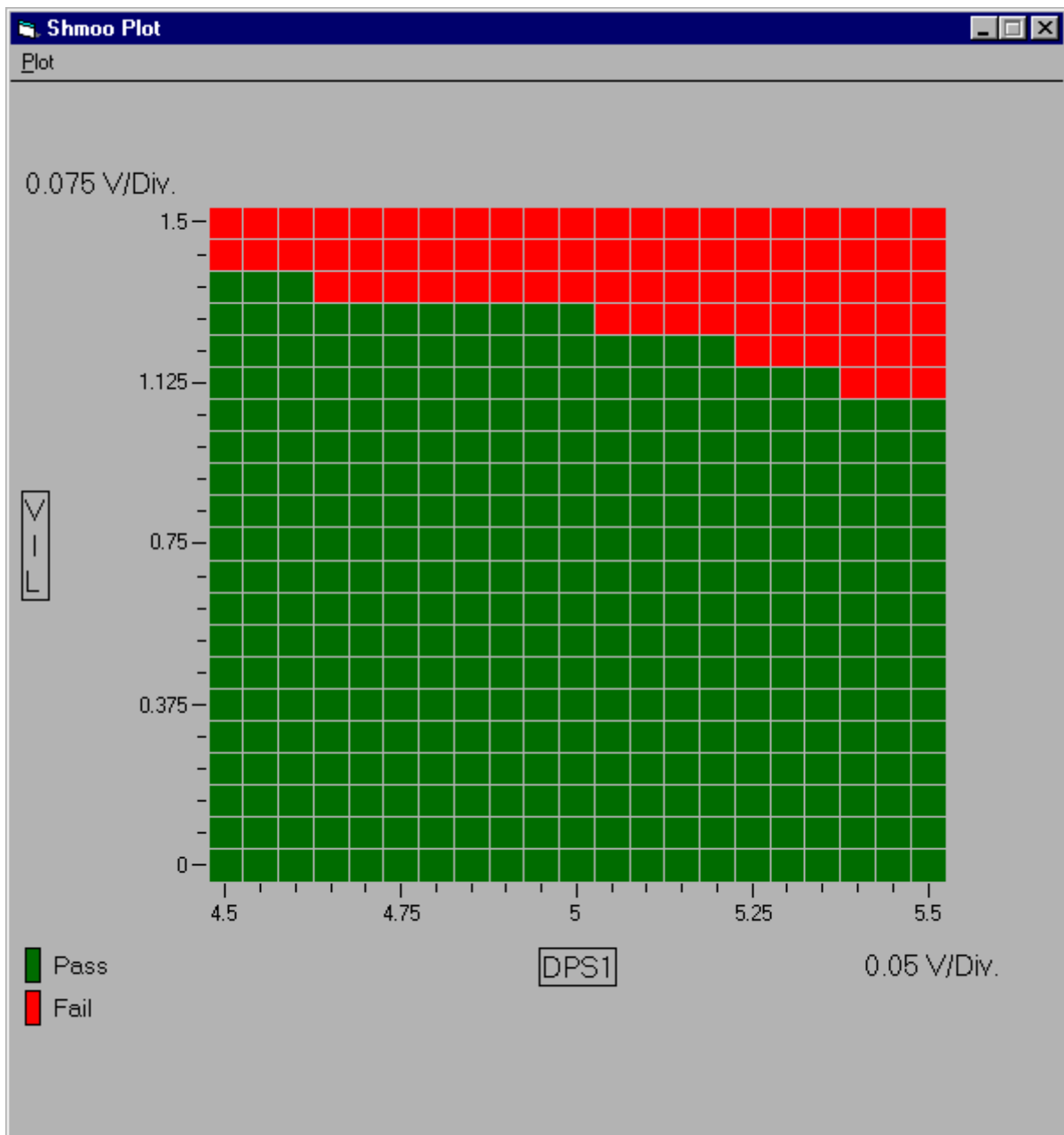
Closes the **Shmoo Plot** window. If either the single or composite plots contain unsaved data, you will be prompted to save the data.

The Shmoo Plot window can be invoked in three ways:

1. A test program is run from Production Test, the shmoo mode has been enabled and the test program contains tests which contain shmoo data.
2. A shmoo is captured using the Shmoo Control form in interactive mode.
3. An Empty shmoo plot is loaded from the Shmoo Control form. This allows you to view previously obtained shmoo plots.

## Normal Format

The Shmoo Plot window will appear when **Shmoo** has been enabled from the Production Test window. It will initially appear as an empty plot with the title, Empty Shmoo Plot, appearing on the title bar of the window. Once the test program is executed and the shmoo data is acquired for tests containing enabled shmoo data, the plot will display the data acquired for the first test in the test program. This shmoo data is considered a *single* shmoo plot.



The example above illustrates an Icc shmoo plot which was setup in the **Shmoo Control** window with the following data:

	X-Axis	Y-Axis
Parameter	DPS1	VIL
Unit	V	V
Start	4.5	0
Stop	5.5	1.5
Step	#20	#20
Step delay	100	100

The test was executed and the shmoo data acquired. Then the shmoo plot was created and displayed. This plot was not given a title, so the title above the plot is blank. The Y-Axis is labeled with the value per division in the upper left corner, the parameter is specified along the left side and the values of each cell are displayed to the immediate left of the plot. The X-Axis is labeled with the value per division in the lower right corner, the parameter is specified at the bottom and the values of each cell are displayed to the immediate bottom of the plot. The Pass/Fail legend is displayed at the bottom of the **Shmoo Plot** window.

Now that the data is displayed you can manipulate it in a variety of ways. As mentioned above the **Plot** menu allows you to create a composite, specify a title, etc. In addition, the mouse becomes a very useful tool when used inside the plot grid. With the left mouse button you can:

- Display the X-Y values for a particular cell.
- Display the datalogged value for any cell in the shmoo plot. This can be an averaged value for a multi-pin shmoo plot or the value for one pin.
- Obtain cell position and calculate the X-Y slope and X-Y delta for a pair of cells.

When the right mouse button is clicked, a pop-up menu will appear with the following selections:

- **Select pin** (multi-pin shmoo only) allows you to select a single pin to display in the plot.
- **Previous pin** (multi-pin shmoo only) allows you to display the previous pin in the pin list. This selection will be disabled if all pins or the first pin is currently being viewed.
- **Next pin** (multi-pin shmoo only) allows you to display the next pin in the pin list. This selection will be disabled if all pins or the last pin is currently being viewed.
- **All pins** (multi-pin shmoo only) allows you to display all the pins (default). This selection will be disabled all pins are currently displayed.

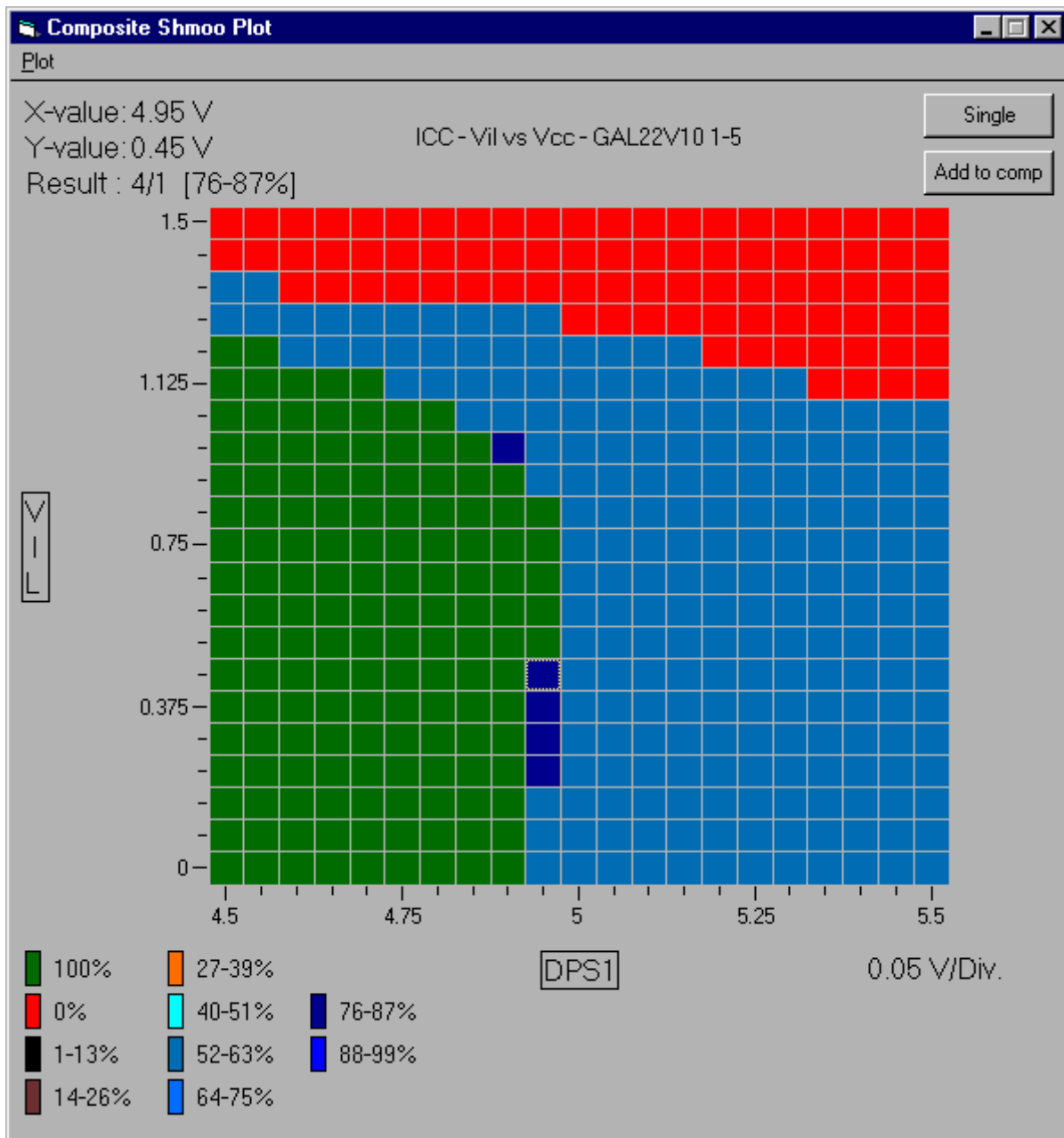
- **Current DB index** will invoke the **Database Index** window. This window will give you access to all the devices and tests with shmoo plot data acquired since the **Shmoo** was enabled. For more information, see the **Database Index** section.
- **Properties** is the same as selecting **Properties** from the **Plot** menu. For more information, see the **Plot Properties** section.

Now, I'll give you an example for each of the possible **Plot Formats**. We have already discussed the **Normal** format, but there are a few more:

- **Composite** is the plot comprised of multiple **Normal** plots of identical input data, but different devices.
- **Pin Composite** is a **Normal** plot acquired for a test with multiple pins specified in the pin list.
- **FFV** (first failed vector) is a **Normal** plot acquired for an AC test, but displaying the first failed vector for each cell or test point in the plot.

## Composite Format

The following example shows a composite plot of five devices created using the same Icc shmoo described earlier. This was accomplished by executing the Icc test with shmoo capability against five different devices, adding the result plot data to the composite shmoo after each test by clicking the **Add to comp** button.



You will notice a few differences from the **Normal Format** plot:

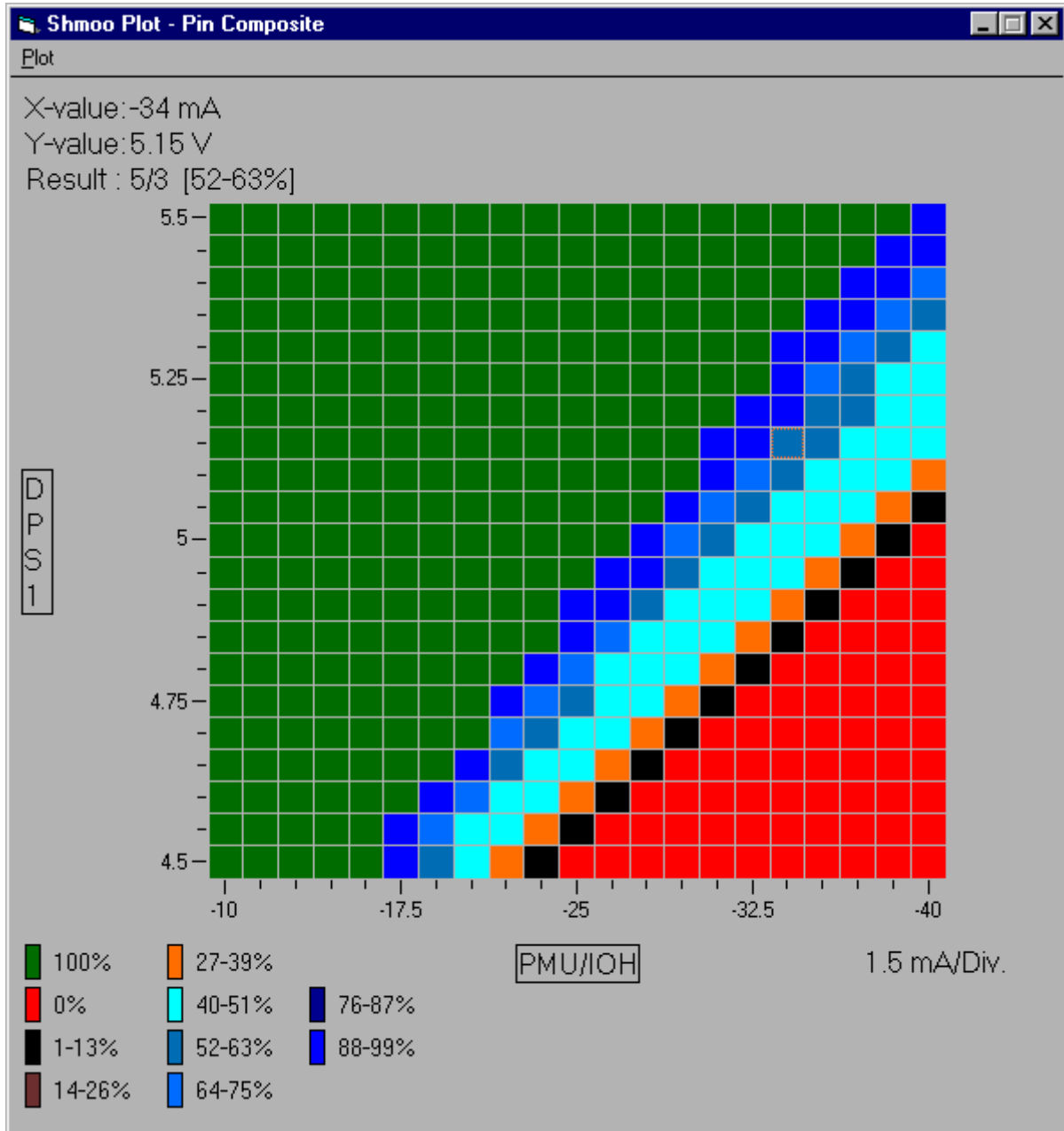
- The title is now Composite Shmoo Plot.

- The **Result:** now displays the pass percentage for a cell in the composite. In this case, the cell is located at 4.95 V along the X axis and 0.45 V along the Y axis and the result is 4 devices passed and 1 device failed. This pass percentage falls in the 76-87 % range.
- The legend at the bottom of the window now displays the defined pass percentage colors and values. The more colors defined on the Color Palette, the smaller the range for each color.

As noted previously, this composite plot contains the results of an Icc test performed on five different devices. The red (0%) shows that all five devices failed, the green (100%) shows that all five devices passed. The light blue (52-63%) shows that three of the five devices passed and the dark blue (76-87%) shows that four of the five devices passed. This is just one scenario where a composite plot can be used. Another might be one device having a test performed at three different temperatures, then creating a composite from the three test results.

## Pin Composite Format

The following example shows a pin composite plot of a Voh test performed on one device. This was accomplished by executing the Voh test with shmoo capability against one device. After acquiring the Normal plot (pass/fail), right click on the plot, select Properties, click on the Options tab, select Pin Composite in the Format frame.

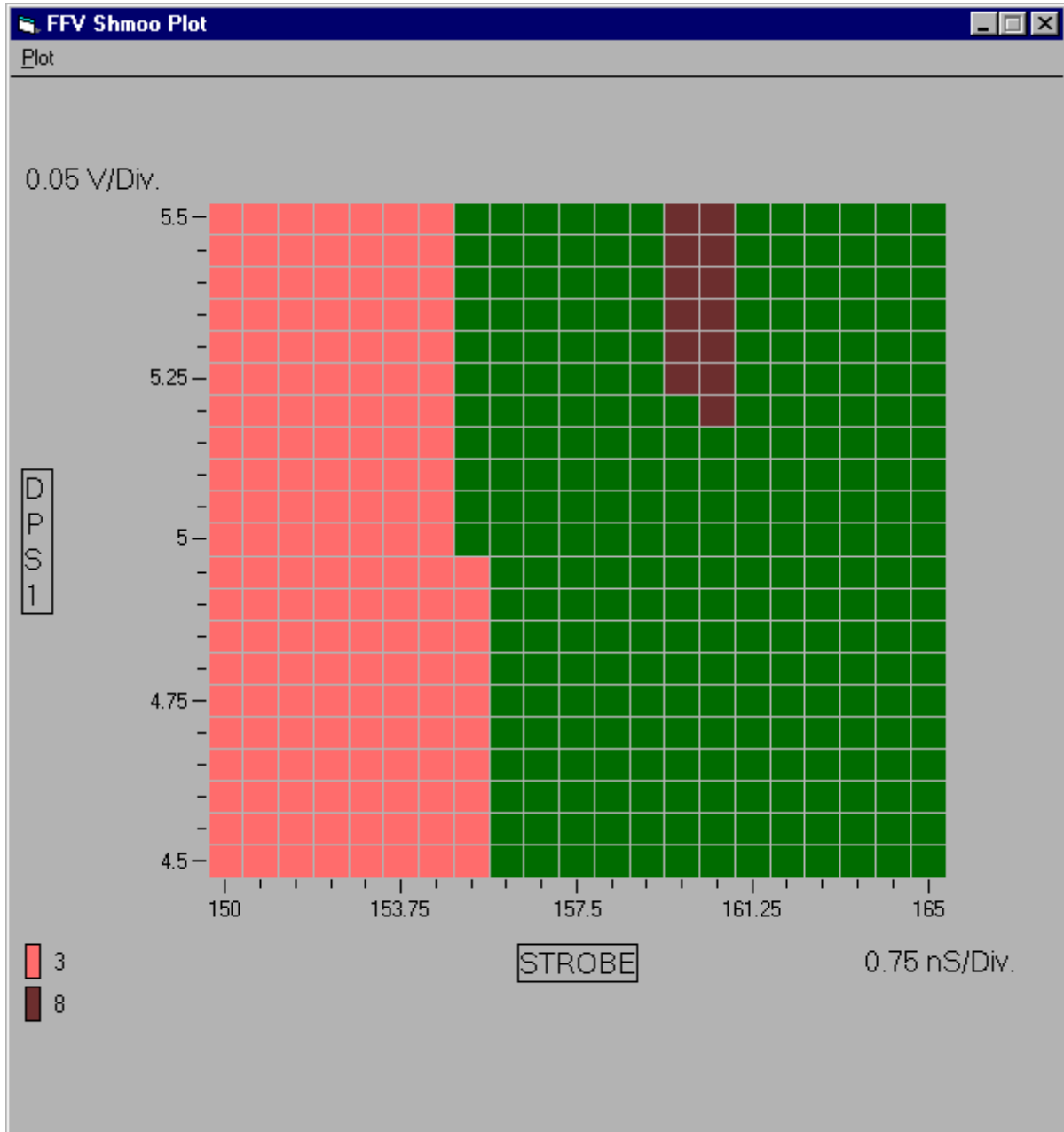


The **Pin Composite** is very similar to the **Composite** plot with the exceptions:

- The **Pin Composite** is made up of tests on multiple pins on the same device. Whereas the **Composite** plot was made up of tests on multiple devices.
- The title is now Shmoo Plot - Pin Composite.
- The functionality of the Pin Composite is identical to that of the Composite. Displaying the pass percentage color legend at the bottom of the window. The X-Y result and passing percentage represent the number of passing pins versus failing pins.

## FFV Format

The following example shows a FFV plot of a Functional test performed on one device. This was accomplished by executing the Functional test with shmoo capability against one device. Selecting **FFV** from the **Format | Style** menu in the Shmoo Control window, the default is **Pass/Fail**.



You will notice a few differences from the **Normal Format** plot:

- The title is now FFV Shmoo Plot.

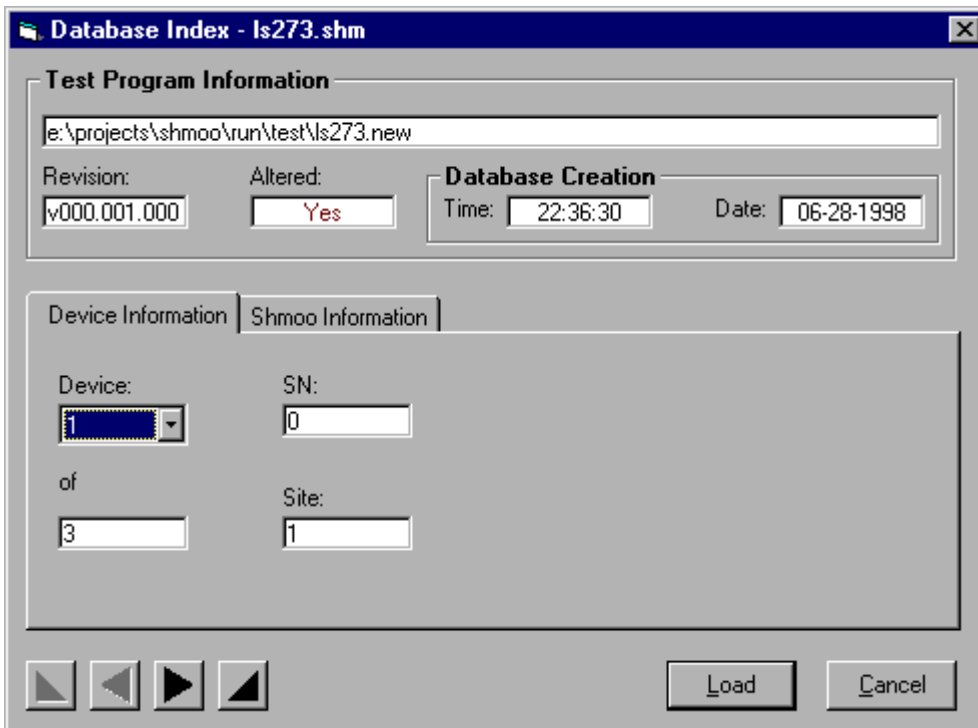
- The X-Y result will now display the first failing vector number or Pass.
- The color legend at the bottom of the window now corresponds to failing vector numbers instead of pass percentage.

# Shmoo Database File

All shmoo data acquired is stored in files called **Shmoo Database Files**. The file is initially created when **Shmoo** is enabled from the **Production Test** window or when a shmoo is setup and started from the **Shmoo Control** window. The file contains data such as:

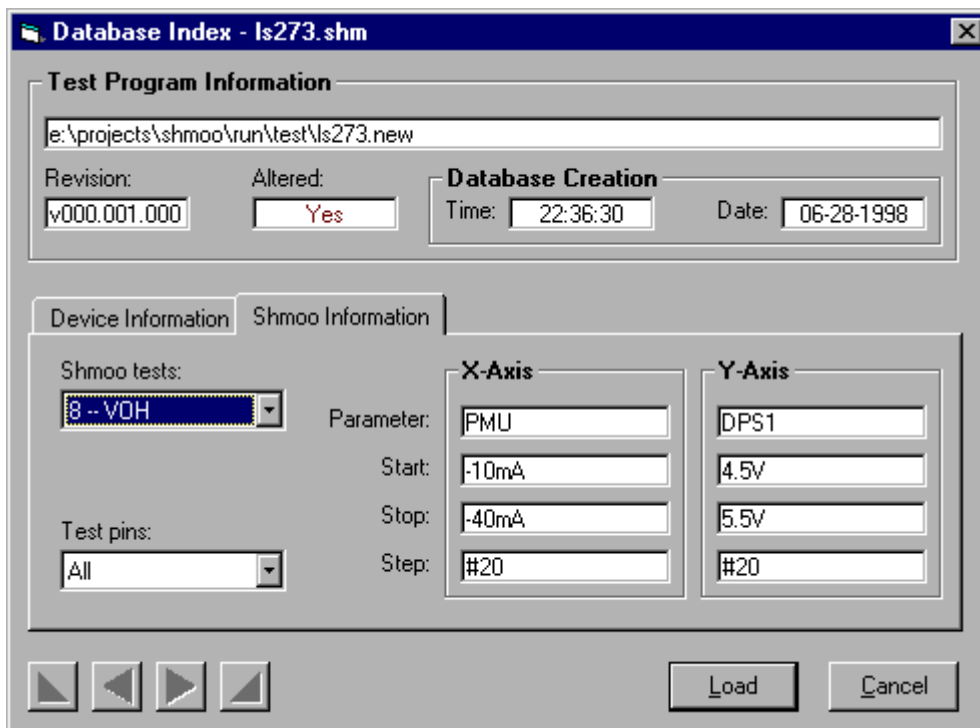
- Test program name
- Revision level of test program
- Operator name and information
- Creation time and date
- Number of devices contained in the database file
- Individual test shmoo data acquired for each device

As previously discussed, selecting Load from the Plot menu results in the **Load Shmoo Database** dialog box being displayed. Select a shmoo database file (default extension is .shm) and the **Database Index** will be displayed:



The **Database Index** title contains the name of the shmoo database file currently being viewed. The dialog also breaks down the information into two sections; **Device Information** and **Shmoo Information**. The rest of the fields and functions:

- Test program name, revision, altered state
- Time and date of shmoo database file creation
- **Device Information** tab contains list of devices contained in the database, the total number of devices, the serial number assigned to the selected device and the site at which the test was performed.
- The arrows at the bottom-left of window will step through the list of devices



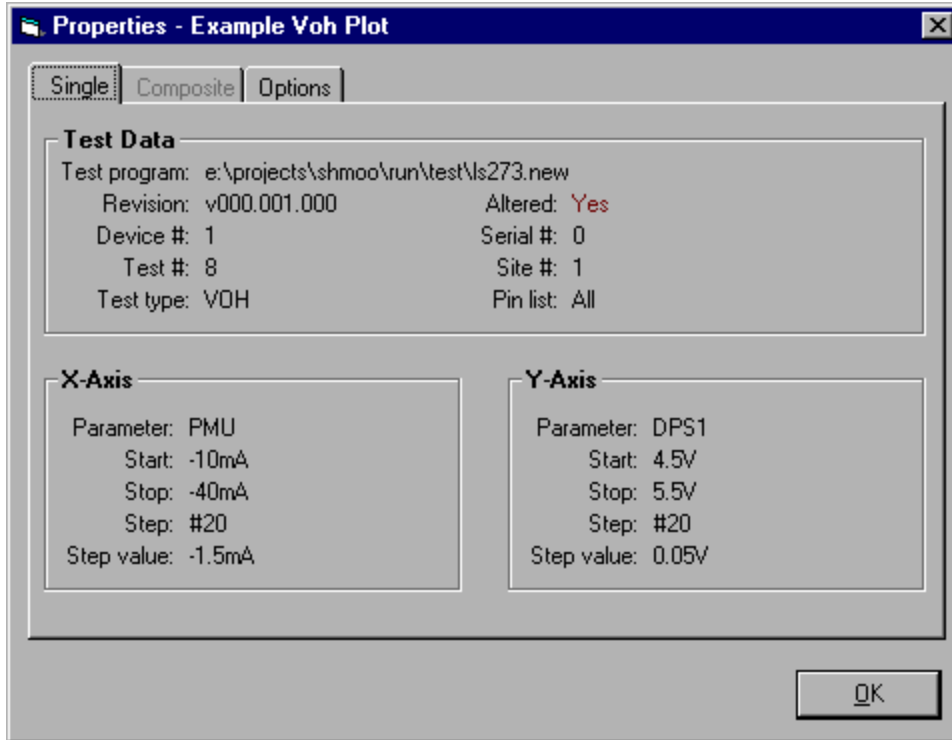
The Shmoo Information tab contains the following fields and functions:

- A list of tests which shmoo data was acquired for this device
- A list of pins which shmoo data was acquired for the test
- The X-Y axis shmoo input values
- The arrows at the bottom-left of window will step through the list of tests (in this case there was only one test, so the buttons are disabled).

The Load button will load the selected test shmoo data into the Shmoo Plot window. Cancel will cancel the action.

# Plot Properties

Selecting **Properties** from the Plot menu or the pop-up menu (displayed when a right mouse click occurs on the plot grid) results in the Properties dialog box being displayed.



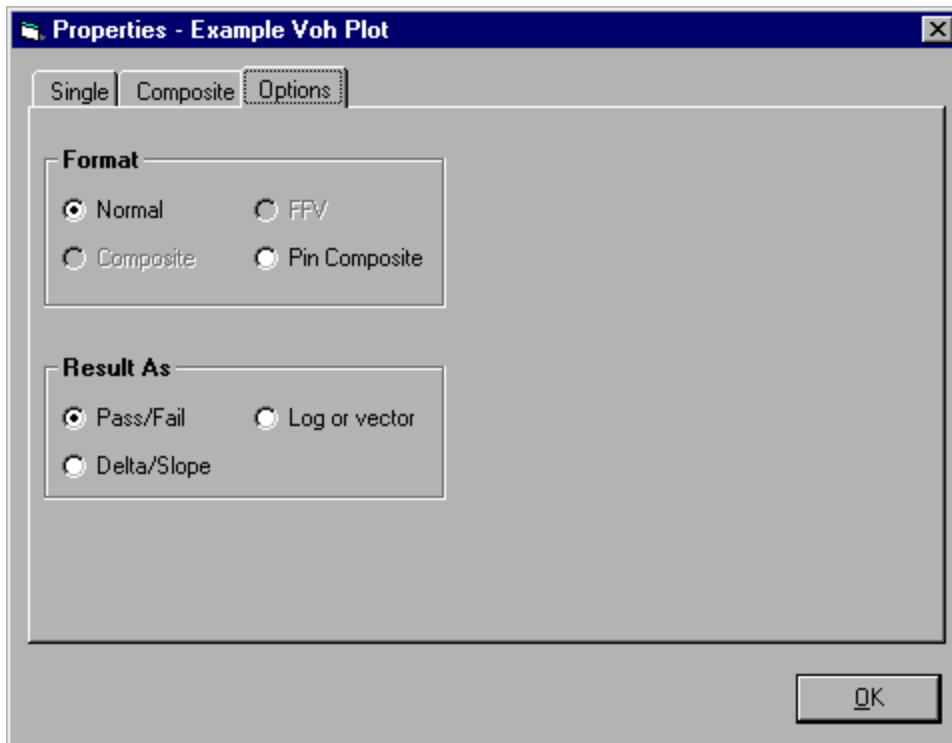
The data available in the Properties dialog is broken into three categories; **Single**, **Composite** and **Options**. The Single tab displays the data which comprises the shmoo plot:

- Test program name, revision, altered state
- Number of the device in the shmoo database file, serial number, test number, site number, type of test and the pin list
- X-Y axis data

The Composite tab displays the data which comprises the current composite plot (if this tab is disabled, a composite plot has not been created):

- Test program name, revision, altered state
- Number of the device in the shmoo database file, serial number, test number, site number and type of test
- The buttons which appear at the lower-left corner of the test data will index through each of the shmoo plots which comprise the composite.
- X-Y axis data

The Options tab allows you to change the format of the current plot and change the type of result displayed in the upper-left corner of the Shmoo Plot window:

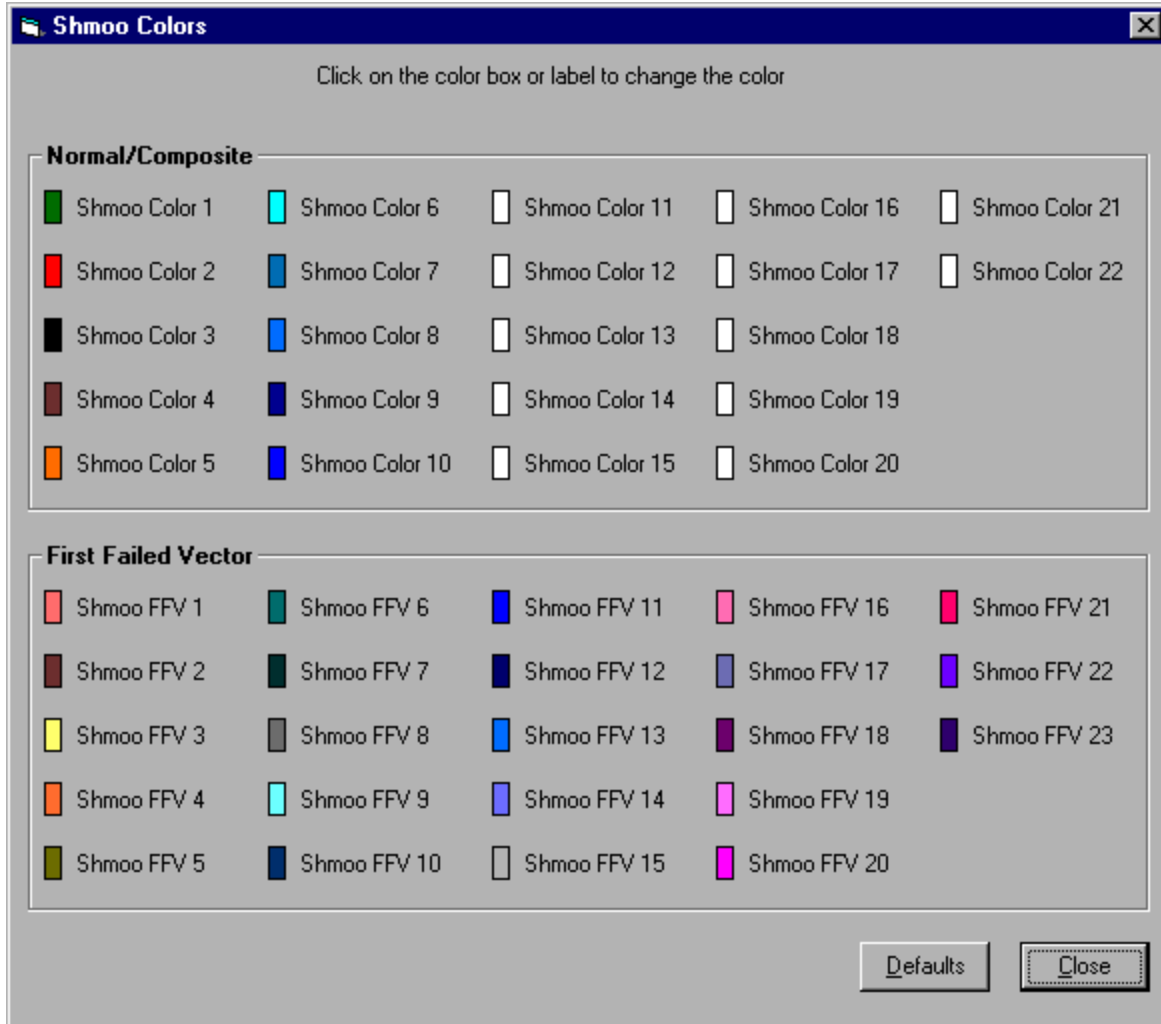


Selecting a format option will change the format of the plot being displayed. Some of the formats may not be available:

- **Normal** is always available.
- **Composite** is only available if Properties is invoked from a Composite plot.
- **FFV** is only available for plots acquired for AC test types.
- **Pin Composite** is only available if the plot contains multiple pins.

# Shmoo Colors

The Shmoo Colors window allows you to define all displayed shmoo colors. The colors are broken into two sections; **Normal/Composite** and **FFV**.



## Normal/Composite

The colors are labeled Shmoo Color 1 - Shmoo Color 22:

- Shmoo Color 1 always represents a Pass (default color is green).
- Shmoo Color 2 always represents a Fail (default color is red).
- Shmoo Color 3 - Shmoo Color 22 are used in Composite and Pin Composite formats to depict pass percentages. Initially only Shmoo Color 3 is defined, but this results in a representation of 1-99% in the composite plots. All other colors are white, which is the undefined color. To break down the pass percentage

## First Failed Vector

The colors are labeled Shmoo FFV 1 - Shmoo FFV 23. When a FFV plot is displayed, this table of colors will be referenced. The first color (Shmoo FFV 1) is assigned to the first FFV number, the second color (Shmoo FFV 2) is assigned to the second FFV number, and so on. If the number of FFV's is greater than the number of defined FFV colors, these will be represented by the color assigned to Shmoo Color 2 (red).

To change a color, click on the label or the color box. A color definition dialog box will appear. Use this dialog box to select a color, then choose OK. The color will change to the color you just selected.

After defining the color or colors you can choose Close, the colors will then be applied to the current plot being displayed.

# Appendix A. Shmoo Plot Warning/Error Messages

This section will discuss the warning and error messages that may appear while interrogating the results of a shmoo plot.

*Cannot add to composite, the shmoo plot is not compatible with the composite!*

You have attempted to add a Single plot to a Composite plot which contains:

- Different test types

*Cannot add to composite, X and Y dimensions differ from the composite!*

You have attempted to add a Single plot to a Composite plot which contains:

- Mismatched X-Y axis definitions, start, stop or step.

*Shmoo is already present in composite!*

You have attempted to add a Single plot which already exists in the Composite plot.

*This composite file contains parameters which do not match the currently displayed composite! Clear the current composite and attempt the merge again.*

You have attempted to merge a saved Composite to the current Composite plot with mismatched X-Y axis definitions.

*This composite file contains a shmoo which is already represented in the currently displayed composite! Clear the current composite and attempt the merge again.*

You have attempted to merge a saved Composite which contains a device plot which is already represented in the Composite.

*Composite contains unsaved data! Would you like to save it?*

This warning occurs any time you are about to overwrite unsaved composite data. Choose **Yes** to save the composite data, **No** to discard the composite data or **Cancel** to cancel the action.

*You have selected a test type which cannot be shmooed at this time!*

At this time, not all tests can perform shmoo. You have selected one of these test types.

*You cannot select the same parameter as the Y axis!*

*You cannot select the same parameter as the X axis!*

You have attempted to assign the same parameter to both the X and Y axis. The X and Y axis must have different parameters assigned.

*Please select a parameter prior to selecting a unit for the X axis!*

*Please select a parameter prior to selecting a unit for the Y axis!*

You have attempted to select a unit prior to defining the X or Y axis parameter. You must select a parameter first, then select the unit.

*Shmoo is currently disabled for this test!*

You have attempted to execute an acquisition of shmoo data from the Shmoo Control window and the Shmoo Mode is currently disabled for the test. Select a mode other than Disabled from the Format | Mode menu.

*A parameter for the X-Axis must be specified!*

*A parameter for the Y-Axis must be specified!*

*A unit for the X-Axis must be specified!*

*A unit for the Y-Axis must be specified!*

You have attempted to execute an acquisition of shmoo data from the Shmoo Control window without a complete definition of the X and/or Y axis.

*The value specified for 'X-Axis Start' is illegal!*

*The value specified for 'Y-Axis Start' is illegal!*

*The value specified for 'X-Axis Stop' is illegal!*

*The value specified for 'Y-Axis Stop' is illegal!*

*The value specified for 'X-Axis Step' is invalid!*

*The value specified for 'Y-Axis Step' is invalid!*

You have specified a non-numeric value for either the start, stop or step value for the X or Y axis. A numeric value must be specified.

*You have specified an illegal voltage!*

*Parameter: parameter in question*

*Value: invalid value*

*The value must fall in the following range:*

*Min: legal minimum value*

*Max: legal maximum value*

You have specified a voltage which is illegal for the specified parameter. Change the value so it falls within the min/max range.

*You have specified an illegal time!*

*Parameter: parameter in question*

*Value: invalid value*

*The value must fall in the following range:*

*Min: legal minimum value*

*Max: legal maximum value*

You have specified a time which is illegal for the specified time-based parameter. Change the value so it falls within the min/max range.

*You have specified an illegal current!*

*Parameter: parameter in question*

*IRange: parameter current range*

*Value: invalid value*

*The value must fall in the following range:*

*Min: legal minimum value for current range*

*Max: legal maximum value for current range*

You have specified a current which is illegal for the specified current-based parameter. Change the value so it falls within the min/max range.

*You have specified a step value which is out of range!*

*Parameter: voltage or time-based parameter in question*

*Value: invalid step value*

*The value must be equal to or greater than the following:*

*Resolution: legal minimum value*

You have specified a step count or value which falls out of range for the specified parameter. Change the step count or value.

*You have specified a step value which is out of range!*

*Parameter: current-based parameter in question*

*IRange: parameter current range*

*Value: invalid value*

*The value must be equal to or greater than the following:*

*Resolution: legal minimum value*

You have specified a step count or value which falls out of range for the specified current-based parameter. Change the step count or value or the current range for the specified parameter.

*The number of steps for either axis cannot be 0 or less and cannot exceed 100!*

The step count or value is less than or equal to 0 or is greater than 100. Change the step count or value to fall within the range 1 - 100.

*The step value cannot be greater than the start/stop range!*

You have specified a step count or value that is greater than the entire start/stop range. Change the value to a lesser value.

*The value cannot be greater than 1 Second!*

You have attempted to specify a value greater than 1 second in the **Step delay** field. Change the value to less than 1 second.

*The value must contain a numeric value only!*

You have specified a non-numeric value in one of the Step delay fields.

*The legend color assignment file: shlegend.cfg*

*could not be opened for write!*

This is a serious error, please contact LMO's customer support.

*The shmoo database file is empty!*

You have attempted to load a shmoo database file which does not contain any data.

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