



Metrics Tutorial

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1. Introduction

The software package, Metrics, can be used to control various semiconductor test and device characterization equipment and allows for easy viewing, analysis, and manipulation of data. In EECS 143, the program will be used to control the instruments, HP4145 and HP4284. The purpose of this tutorial is to introduce the basics of the Metrics program. Namely, we will discuss test set-up files, project files, data and plot windows, exporting and importing data to and from Metrics, as well as the linking of Metrics to the spreadsheet Excel. The reader is referred to the program manual in 218 Cory for other aspects of Metrics not covered here.

Test set-up files Test set-up files store set-up configurations for a given measurement (such as gate threshold voltage). In our case, they document connections between the instruments and the device under test (DUT) and identify which data is to be returned. Test set-ups and measured data are saved by defining a project file and cannot be copied or moved from one project file to another.

Project files A project file is a collection of test set-ups and their corresponding data window spreadsheets and plot windows. Project files are defined by specifying the contents of up to six project file attribute fields and are opened by selecting those attribute designations specified when the project file was saved. There are two modes in which project files may be stored: "wafer" mode in which six attribute fields must be specified and "package" mode in which only three attribute fields (#1,5,6) must be specified.

Data and Plot windows Each test set-up has one data window spreadsheet associated with it. The measured or calculated values contained in a data window spreadsheet can be displayed in a plot window; up to ten plot windows per data window are allowed. The spreadsheet is updated following every execution of its corresponding test set-up.

Features access While File, Window and Help pull-down menus are always present, other menus may also be present depending upon the active functional mode (Measurement, Data, or Plot). The Measurement Mode, from which test setups can be defined and executed, can always be activated by clicking on the right mouse button. The toolbar allows for easy access to the features available in the menu bar drop-down lists. The status bar, located at the base of the Metrics desktop, keeps track of the currently active Metrics feature.

2. The Set-Up Editor

The name of the current (or active) test set-up can be found in the scroll box in the top right hand corner of the Set-up Editor. To display a list of all the test set-ups defined in the active project file, click the Set-up Editor scroll arrow. To display the active test set-up, click the Set-up Editor toolbar button. New test set-ups may be created while another test set-up is active. Any editing action (such as deleting, copying, etc...) performed on a test set-up will similarly affect the corresponding data window spreadsheet and plot windows.

Timing Control The user can control the execution time of a test set-up by turning ON the mode field of the Set-up Time dialogue box. This time domain utility can be configured in Bias Delay Mode or Time Delay Mode. Bias Delay Mode allows the DUT to be stressed with a constant bias signal before performing a device measurement. The instrument remains biased during the transition between the bias delay and the device measurement. Time Measure Mode allows the DUT to be stressed with a constant bias signal while device measurements are taken at designated time intervals; the DUT also remains biased between measurement intervals.

To create a test set-up:

1. If the HP4145 or the HP4284 has not already been chosen as the current instrument, click on the toolbar INSTRUMENT button and do so.
2. Open the Set-up Editor by clicking the Set-up Editor toolbar button or selecting MEASUREMENT/EDIT SETUP from the Measurement Mode menu bar.
3. Click the NEW button. Enter a test set-up name.
4. Click the DEVICE button, and choose a device schematic that corresponds to the DUT.
5. Click the Set-up Editor SOURCES button.
Connect each device terminal to a particular source unit by clicking the source unit name and then clicking the blue button next to the desired terminal connection. When done, close the Source Unit Set-up dialogue box.

To implement the time domain utility

6. Click the Set-up Editor TIME button, and choose the desired mode.
7. Specify the desired time scale.
8. For the Bias Delay Mode:
Enter the delay time, the time in which the DUT will be biased before performing a measurement.
9. For the Time Measure Mode
Enter the contents of the Type, Wait, Start, Stop, Points, and Interval fields. Wait Time specifies how long the instrument will wait at bias before measuring the start time. Start Time specifies how much time will elapse from the end of the wait time to the initiation of the first measurement. Instrument source outputs are held at the bias value throughout the duration of the Start time.
10. Click the Set-up Time OK button.

11. Configure the device measurement conditions of the each source unit you have connected to your device. Do this by clicking once on each source unit icon to bring up their corresponding Source Unit Set-up dialogue box.
12. Click the Set-up Editor CLOSE button. An icon corresponding to the data window spreadsheet will appear at the bottom of the screen.

To designate or undesignate instrument (HP4145, HP4284) / DUT connections:

1. Click the Set-up Editor SOURCES button.
2. Select the source unit or supply you wish to connect or disconnect from the device schematic.
3. Click the blue pad next to the schematic pin that you want to connect or disconnect. If more than one source unit is connected to the selected schematic pin, click the source unit icon to display a list of attached source units.
4. If undesignating a connection, click YES to confirm.
5. Close the Source Units dialogue box.

To make a particular test set-up the active test-up:

1. Click the Set-up Editor scroll arrow to display a list of defined test set-ups.
2. Click once on the name corresponding to the test set-up you would like to be active.

To execute a single test set-up:

1. Designate a particular test set-up to be the active test set-up.
2. Make sure that the Set-up Editor is closed.
3. Click the toolbar or menu MEASURE button.

To delete a test set-up:

1. From the Set-up Editor window, select the test set-up to be deleted.
2. Click the DELETE button.
3. Click the YES button to confirm.

To copy a test set-up:

1. From the Set-up Editor window, select the test set-up to be copied.
2. Click the COPY button.
3. Enter a unique set-up name.
4. Click the OK button.

To rename a test set-up.

1. From the Set-up Editor window, select the test set-up to be renamed.
2. Click the RENAME button.
3. Enter a unique set-up name.
4. Click the OK button.

3. The Project File Manager

The File Manager was designed so that the attribute hierarchy could be used to designate increasingly specific details about the project file. Therefore, the attribute fields must be specified in sequential order starting with attribute #1. Any project file saved in one of the two modes, "wafer" or "package", is not accessible when the File Manager is in the other mode. Project files created in one database are not available when functioning in another database. Only one project file can be opened at a time, and you may only delete project files from the current database.

To display the File Manager Set-up Dialogue Box, either select FILE/FILE MANAGER SETUP from the menu bar or choose OPTIONS/WORKSPACE and then click on the File Manager Set-up button.

To create a new project file:

1. Select the toolbar SAVE button.
2. Specify the contents of each attribute field with an alpha numeric string. The TAB key will advance you from one attribute field to the next. The Comments field is not an attribute field.
3. The contents of at least one attribute field must be unique or an existing project file will be overwritten. The user will be notified of this error before the original file is overwritten.
4. Click the OK button. The keyboard RETURN key should not be used at any time while in the File Manager as this results in closure of the File Manager and voiding of any specifications or changes just made.

To save a project file:

All information specific to the active project file is automatically written to a temporary file and updated following any changes or measurements. Selecting FILE/SAVE AS results in the copying of the temporary file to the designated project file. Selecting FILE/SAVE however, results in the active project file being updated.

To open a project file:

1. Select FILE/OPEN from the Measurement Mode menu bar.
2. Specify the relevant attribute designations.
3. Click the OK button to open the specified project file.

To delete a single project file:

1. Select FILE/DELETE from the Measurement Mode menu bar.
2. Specify the relevant attribute designations. Click the desired selection.
3. Click the OK button to delete the specified project file .

To delete a family of project files:

1. Select FILE/DELETE A PROJECT from any menu bar.
2. Specify attribute #1.
3. Click the DELETE button. All project files defined with specified attribute #1 will be deleted.

To copy a project file from one storage mode to another:

1. In the File Manager Set-up dialogue box, designate the storage mode of the project file you would like to copy.
2. Open the project file you wish to copy.
3. In the File Manager Set-up dialogue box, designate the alternative storage mode.
4. Select FILE/SAVE AS.
5. Specify the relevant attributes. Click the File Manager OK button.
6. The original version of the project file will remain unchanged.

To make multiple measurements on a single device:

1. Create a different test set-up for each measurement.
2. Take the measurement with the first test set-up.
3. Click SAVE AS and specify the attributes.
4. Take the measurement with the second test set-up. Click SAVE AS and specify a new set of attributes.
5. Continue in this fashion until done with the different measurements.

To make a single measurement on multiple devices:

1. Set the project file storage mode to "wafer".
2. Either select or create the desired test set-up.
3. Take the measurement for the first device. Click SAVE AS and specify the attributes.
4. Change devices and take the measurement again. The data spreadsheet and plot windows will reflect the most recently taken measurement without overwriting those of the just newly saved project file. Again click SAVE AS and specify the attributes.
5. Continue in this fashion until all devices have been tested.

To copy a project file from one database to another:

1. Make the project file to be copied the active project file.
2. Open the File Manager Set-up dialogue box.
3. Choose the root directory of the target database. Since Metrics will now operate from the target database, any changes made will not be written to the original project file.
4. From the toolbar or menu bar, select FILE/SAVE AS. Specify the desired attributes.

Test Set-up Sequences

Metrics can store and execute any combination of test set-ups as long they all belong to the same project file; however, each project file may only have one test set-up sequence defined. When the Sequence Enabled switch in the Measure Sequence dialogue box is OFF, Metrics can only execute the single active test set-up.

To define a test set-up sequence:

1. Click the toolbar SEQUENCE button to open the Measure Sequence dialogue box or select MEASURE/SELECT SEQUENCE from the Measurement Mode menu bar.
2. Define a test set-up sequence by selecting the desired combination of test set-ups.
3. The test set-ups will be executed in the same order as they appear in the test set-up scroll list and not in the order in which the set-ups were selected. To rearrange the sequence order, you will need to CUT and PASTE the test set-ups so that they appear in the desired order in the test set-up scroll list.
4. Select the Sequence Enabled switch. To later execute only a single test set-up, unselect the Sequence Enabled switch.
5. Click the OK button.

To execute a test set-up sequence:

1. Define the test set-up sequence.
2. Click the toolbar MEASURE button.

4. Data Windows

A new data window spreadsheet is created each time a new test set-up is created. Its contents are automatically updated after each execution of its corresponding test set-up. Only active spreadsheet cells can be manually edited. To make a particular cell or group of cells active, click and drag the mouse from one range boundary to the other. To select an entire column or row, click on the column or row label. The Edit command can then be used to delete, cut, copy, or paste data. Spreadsheet precision can be altered by selecting OPTIONS/WORKSPACE from the Measurement Mode menu bar and designating a new value.

Transform Editor

The Transform Editor allows the user to define transforms which are algebraic equations of the form "VECTOR = EQUATION". EQUATION is an algebraic function whose result, VECTOR, depends upon the measured data. Transforms defined in one data window spreadsheet may not access measured data from another spreadsheet. Data vectors, the measured data, can be inserted into the active transform expression by double clicking on the data vector name in the Data Vectors list box; the same procedure holds for constants and the Constants list box.

To create a new transform or edit an existing one:

1. Click the toolbar TRANSFORM button.
2. Specify the test set-up in which the transform is defined or in which you want it defined.
3. If this is a new transform, enter the "VECTOR = EQUATION" expression in the Transform Edit field. Otherwise, click the Transform scroll arrow, click once on the desired transform expression, and edit the now active transform expression.
4. Select the SAVE TO DEFINED button.
5. Select the DONE button.

To make changes to the Constants list:

1. Open the Transform Editor.
2. Click the EDIT CONSTANTS button.
3. If adding a constant, enter the constant's name. If editing or deleting an existing constant, click on the appropriate name in the Constant Name scroll.
4. Use the keyboard TAB key to advance to the Value and Units field and make any necessary additions or corrections. The Units field specifies the units of the constant.
5. If adding or editing the constant, click the STORE and then DONE buttons. If deleting the constant, click the DELETE and then DONE buttons.

5. Plot Windows

A plot window is a graphic presentation of the data found in its corresponding data window spreadsheet. By clicking the REDRAW button at the top of the spreadsheet, the associated plot windows can be updated. Closed plot windows are permanently destroyed and deleted from the project file. The buttons on the left hand side of the plot window correspond to the tool ribbon.

To print a data window spreadsheet or plot window

1. Make the data window spreadsheet or plot window to be printed the active desktop window.
2. Click the toolbar Print button.

To create a plot window:

1. Make the corresponding test set-up active.
2. Click the PLOT toolbar button or select WINDOW/NEW PLOT from the Plot Mode menu bar.
3. Identify the x-axis variable and up to ten y-axis variables by double clicking on the desired data vectors. The Y1-axis corresponds to the left hand side of the plot where as the Y2-axis corresponds to the right hand side of the plot.
4. Click the APPLY button. Because no other functions can be selected while the Plot dialogue box is open, click the CLOSE button. You will be asked if you want to destroy the plot; click NO. The Plot dialogue box will disappear leaving only the plot.

To edit a plot window:

1. Make the active window the plot in question.
2. Select SETUP/DATA from the Plot Mode menu bar.
3. To add more data vectors to the plot, double click on the appropriate Data Vector Labels. To change which data vectors are included in the plot, click the CLEAR button to remove the existing vectors and redesignate the x and y variables.

Cursors

Up to five cursors, identified by the five cursor shapes displayed in the Cursors toolset, can be assigned to each plot window. Cursors may be used to reveal the (x,y) coordinates of particular points on the plot or designate the points for which a particular curve fit will apply. The tracking option assigns each newly positioned cursor to the nearest data point.

To assign or delete cursors:

1. Click the CURSORS button on the plot window tool ribbon.
2. To assign a cursor to the Y1 axis, click the assignment button once. To assign a cursor to the Y2 axis, click the assignment button twice. Clicking the assignment button three times, turns OFF or deletes the cursor.
3. To move the cursor to a specific plot window position, move the mouse pointer to the center of the cursor and then click and drag it to the desired position.
4. Click the tool ribbon CURSORS button again.

Curve Fitting

Up to two of the following curve fit routines: the gradient fit, the linear fit, the exponential fit and the tangential fit, can be applied to a plot window. For the exponential curve fit, the corresponding cursors must not be positioned on the X-axis and should not be positioned at the same X-value. The tangential fit is only functional when the Tracking option is active.

To apply a curve fit routine to a plot window:

1. Click the FITS button on the left hand side of the plot window.
2. Click on either the Fit #1 or Fit #2 buttons.
3. Specify the cursors through which the curve fit will be applied by depressing the appropriate cursor buttons in the Cursor Selection strip.
4. Designate the curve fit type.
5. To hide the Curve Fit toolset from view, click the tool ribbon Curve Fit button.
6. To add a second curve fit to the plot window, select the alternative Curve Fit button from the Curve Fit toolset and repeat steps 3,4.
7. To remove a curve fit from the plot window, click the tool ribbon Curve Fit button and select the appropriate Curve Fit number. To turn off the fit line, click the curve fit selection button corresponding to the fit type.

Options toolset

The Options toolset allows the user to add information or edit the appearance of the plot window. The user can display a legend or the test conditions which resulted in the plot, label the plot axes or title, or make each plot window object (data curves, axis numbers, plot title, cursors, axes, axis labels and comment line, window background) a different color.

To edit the default plot colors:

1. Select OPTIONS/WORKSPACE from the Measurement Mode menu bar.
2. Designate the default color of each plot window object.

3. Click the OK button. The new color designations will apply to any plot windows created from this point on; the color composition of existing plot windows will not be updated.

To edit the range of a plot window axis:

1. Select SETUP/AXES from the Plot Mode menu bar.
2. The axis range is controlled by specifying the desired limits in the MIN/MAX fields.
3. 3. Click the APPLY button to update the plot window with the current changes.

6. Exporting and Importing Data

Project File Binary Export function

Project files exported in binary format include all the original project file information, may be copied from one machine to another, and can not be read with an ASCII text editor.

ASCII Export function

Project file data exported by the ASCII Export function is compatible with other data analysis applications and does not include the higher-level test set-up and HP4145 connection information. In addition, the user can export data from any number of the project file's test set-ups.

ASCII Auto-Export

Files generated by the ASCII Auto-Export function are similar to those generated with the ASCII Export function, with the one exception that so long as the Auto-Export Mode is ON, selected test set-up data is automatically appended to the ASCII Auto-Export file after every test set-up execution. The Auto-Export controls are located in the Global Control dialogue box.

To export project file data:

1. Open the project file to be exported.
2. If exporting in ASCII format, create a test set-up sequence consisting of those test set-ups for which you want data to be exported.
3. Select FILE/EXPORT.
4. Designate the destination path in the Directory window.
5. In the SAVE AS filename field, designate a DOS filename for the file you are exporting.
6. Select the desired exporting format by choosing the Binary or the ASCII switch.
7. Click the OK button.

To import a project file:

1. Either select FILE/IMPORT or click the filename once and then click the OK button.
2. In the Directory window, designate the directory from which the project file is to be imported.
3. In the Files window, specify the name of the project file to be imported. Only project files that have been exported in binary format can be imported to the desktop.

7. Linking Metrics and Excel

Any Metrics data window spreadsheet can be linked to an Excel spreadsheet. Changes made to the data window spreadsheet in Metrics can be transferred to the Excel spreadsheet by selecting the Excel LINKS/UPDATE command.

To create a link between Metrics and Excel:

1. In Metrics, make sure the active test set-up corresponds to the data window spreadsheet you want linked to Excel.
2. Determine the data window spreadsheet array size.
3. In Excel, select the appropriate number of columns and rows to correspond to the data window spreadsheet array size.
4. At the Excel command line, enter: =ics\data!TestSetupName
5. After entering the Excel syntax, hit the Shift, Ctrl, and Enter keys simultaneously.
6. Once the data has been transferred to Excel, you may need to standardize its presentation format by selecting FORMAT/NUMBER from the Excel worksheet menu.

Vivien Lee, Spring 1994

Alex Chediak, Spring 2000