# *Actel® Tools: SmartPower®*

*User's Guide*

R1-2003

*Windows® and UNIX® Environments*

Actel

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# Introduction

SmartPower is Actel's state of the art power analysis tool. Power analysis is a convenient and thorough method of analyzing, debugging and validating the power performance of a design. This is achieved by breaking the design down into a nets, blocks, and gates, and then calculating the power requirements of the component parts.

Not all the features described in this manual are available for all devices. Minor exceptions for device families are noted in the text.

## Document Organization

This guide provides detailed cross-platform information about SmartPower. Use it as a reference in your everyday work.

It provides step-by-step instructions for Windows and Unix platforms. Platform differences in procedures and commands are noted in the text.

This user's guide is divided into the following chapters:

**Chapter 1 - Getting Started with SmartPower** introduces the SmartPower graphical user interface and menu commands.

**Chapter 2 - Using SmartPower** contains instructions on how to use SmartPower to perform power analysis.

**Appendix A - Product Support** provides information about contacting Actel for customer and technical support.

## Document Assumptions

This document assumes you have a working knowledge of your operating system and its conventions, including standard menus and commands. It also assumes you know how to use a mouse, and how to open, save, and close files. For help with any of these techniques, see the documentation that came with your computer.

This document assumes you are familiar with the FPGA architectures and design flows, as well as the Designer software.

# Document Conventions

This document uses the following conventions:

All references to ProASIC in this manual apply to both ProASIC and ProASIC$^{PLUS}$ devices.

# Your Comments

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# Actel Manuals

Designer and Libero include printed and online manuals. The online manuals are in PDF format and available from Libero and Designer's Start Menus and on the CD-ROM. From the Start menu choose:

- Programs > Libero 2.3 > Libero 2.3 Documentation.
- Programs > Designer Series > R1-2003 Documentation

Also, the online manuals are in PDF format on the CD-ROM in the "\manuals" directory. These manuals are also installed onto your system when you install the Designer software. To view the online manuals, you must install Adobe® Acrobat Reader® from the CD-ROM.

The complete list of Designer Series manuals is available on the Actel websit at http://www.actel.com.

# Online Help

The Designer Series software comes with online help. Online help specific to each software tool is available in Libero, Designer, ACTgen, ACTmap, Silicon Expert, Silicon Explorer II, Silicon Sculptor, and APSW.

# 1

# Getting Started with SmartPower

The SmartPower tool supports ProASIC, ProASIC$^{PLUS}$, and Axcelerator devices at this time. If you are not using one of these devices, the SmartPower icon disappears from the toolbar and the User Tools, the SmartPower command does not appear in the Tools menu, and the SmartPower icon does not appear in the Designer main window.

**This chapter contains details about SmartPower's user interface and commands. For information on using SmartPower to perform power analysis (including examples) please refer to "Using SmartPower" on page 27.**

## Calculating Power with SmartPower

When you launch SmartPower for the first time, all clocks are assigned a frequency of 10 MHz by default. In addition, SmartPower sets all data frequencies to 1 MHz. In order for you to accurately measure the power consumption of a design, you must specify the target clock and data frequencies. For a more detailed explanation of the SmartPower user flow, please refer to "Power Analysis with SmartPower" on page 28.

# SmartPower Toolbar

The SmartPower toolbar (Figure 1-1) contains commands for performing common SmartPower operations on your designs. Click on a button in the toolbar to access a command.

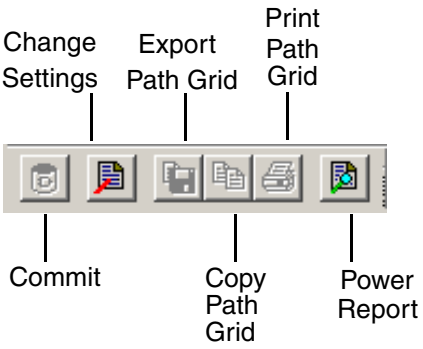



*Figure 1-1. SmartPower Toolbar*

# SmartPower Menu Commands

The PC and workstation versions of SmartPower have the same menus. However, some dialog boxes may look slightly different on the two platforms due to the different window environments. The functionality is the same on both platforms, though the locations of the fields and buttons on the dialog boxes may vary. The names of some fields may also vary between the PC and workstation versions.

## File Menu

**Commit:** Commits power information to Designer. You must commit your changes if you wish to save your settings in SmartPower. If you commit your changes, the information is stored in the .adb file, and your settings are restored the next time you open your design in SmartPower.

**Export Grid** (enabled in Dynamic tab): Exports the selected area of the Report Window to a text (.txt) file.

**Print Grid** (enabled in Dynamic tab): Prints the selected area of the Report Window.

**Preferences:** Invokes Preferences dialog box, where you can set analysis and display preferences

**Close:** Closes SmartPower

### Edit Menu

**Add Domain** (enabled in the Domains tab): Adds a clock domain or set of pins.

**Remove Domain** (enabled in the Domains tab): Removes a domain.

**Copy Grid:** Copies the selected cells of the dynamic grid onto the clipboard

### Tools Menu

**Report Power:** Generates power report

## Status Bar

SmartPower's status bar, located at the bottom of the SmartPower window, displays information on menu commands.

## Invoking SmartPower

You can only use SmartPower after you open an existing design (post-layout *.adb file), or after compiling and layout of your netlist in Designer. If you invoke SmartPower before compiling your netlist, Designer guides you through the compile and layout.

There are three ways to invoke SmartPower analysis tool:

1. Choose SmartPower from the Tools menu, or
2. Click the SmartPower icon in Designer's toolbar, or

3. Click the SmartPower button in Designer's design flow (User Tools).


SmartPower opens in a separate window, as shown in Figure 1-2 on page 11. The user interface consists of a preference window, a report window and four tabs: Summary, Activity, Dynamic and Domains (SmartPower defaults to the Summary tab). These four tab screens, the Preference window, and the report window are described in the following sections.

## Summary Tab

The Summary tab is divided into three sections: Power Consumption, Average Switching Activities, and Temperatures (Figure 1-2).

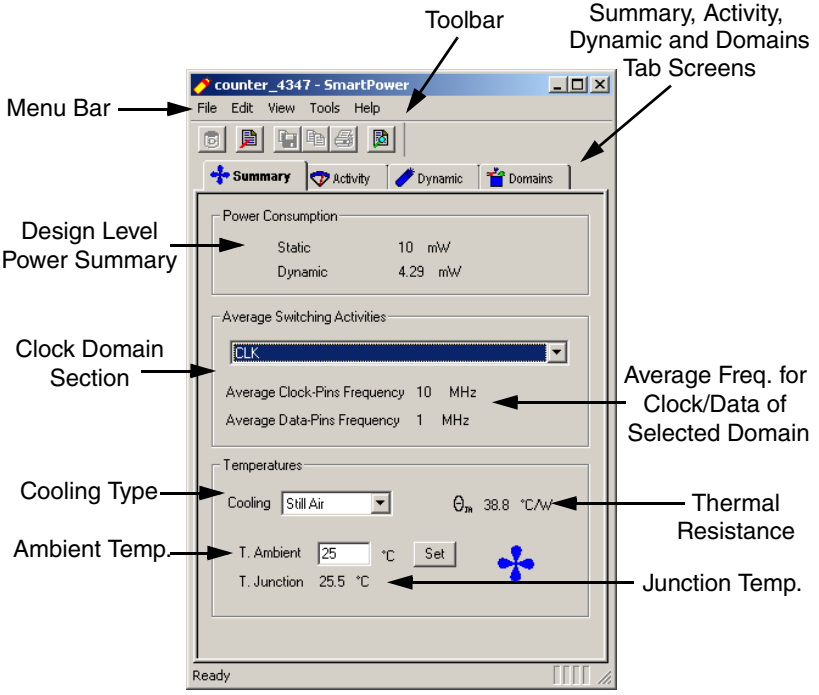



*Figure 1-2. SmartPower Summary Tab Screen*

- **Power Consumption** - Displays the total static and dynamic power of the design.
- **Average Switching Activities** - (includes the average frequency of the clock-pins and data-pins of the selected clock domain). For designs with multiple clocks, SmartPower selects the first clock domain in alphabetical order by default. You may choose another clock domain using the drop-down menu. It is also possible to select a set of pins rather than a clock domain. If you select a set of pins instead of a clock domain, SmartPower reports only one average frequency (the average frequency of all the pins of the selected set).

  Average Switching Activities are useful when you import a VCD (value

change-dump) file (PC only) or a SAIF file. Since a VCD file lets you specify the frequency of each pin individually, it is often useful to know the average clock- and data-pin frequency for a particular clock. Please refer to page 20 for more information on how to import a VCD or SAIF file.

You can import a VCD or SAIF file to specify switching activity for a design to create an accurate power usage model in SmartPower.

- **Temperatures** - Displays the impact of the power consumption on the junction temperature for a given cooling scenario and ambient temperature. You can specify a cooling scenario using the drop-down menu (available scenarios are: still air, 300 feet/min., and case cooling; default is still air). SmartPower also reports the thermal resistance, $\theta_{JA}$.

## Activity Tab

The Activity tab is used to attach switching activity information on interconnects of the design (Figure 1-3).

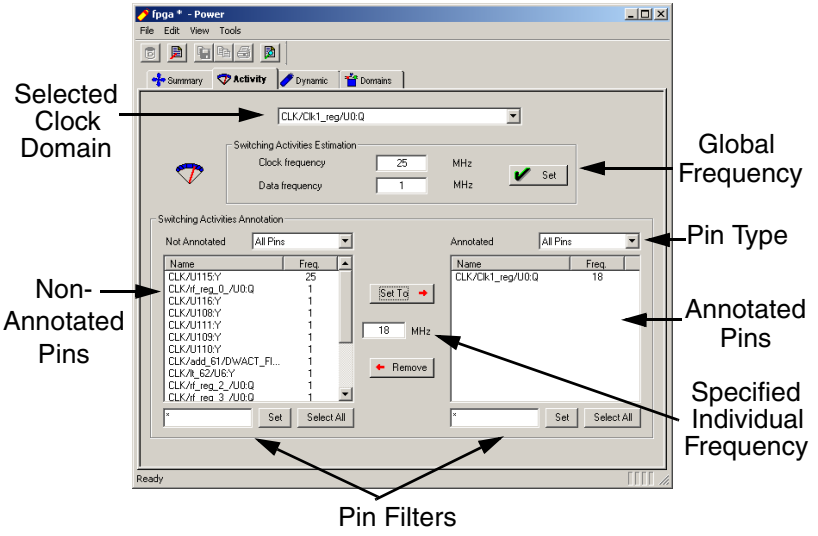



*Figure 1-3. Activity Tab*

The Activity tab is divided into three sections:

- Clock Domain - Displays the selected clock domain (or set of pins). Use the drop-down menu to select a different clock domain.

- Switching Activities Estimation - Enables you to specify the global clock frequency and data frequency for the given clock domain (or set of pins). Use this screen to modify the clock-frequency and data-frequency for the selected clock-domain. For designs with multiple clocks, SmartPower defaults to the first clock in alphabetical order (you can specify different clock-domain using the drop-down menu). It is also possible to select a set-of-pins rather than a clock-domain. In that case, only 1 frequency can be modified (this frequency is used for all the pins of the selected set).
- Switching Activities Annotation - Enables you to specify the switching activities for individual pins in the Clock Domain. SmartPower displays the pins that have not been annotated in the Not Annotated list box.

  Select a pin and specify a different frequency for this pin using the text-box and the Set To button. When you select a pin and specify a frequency, SmartPower removes the pin from the Not-Annotated list-box and adds it to the Annotated list-box. Hold down the CTRL key and click with the mouse to select multiple pins.

  Use the Select All button to select all the pins in a list-box. Filter boxes are provided below the list boxes to limit the size of each list of pins. Enter text in these boxes and click Set to apply this text as a filter (the * character is a wildcard). It is also possible to limit the type of each list of pins using a drop-down menu that enables you select All-Pins, Data-Pins or Clock-Pins.

## Dynamic Tab

The Dynamic tab enables you to inspect detailed hierarchical reports of the dynamic power consumption. The Dynamic tab consists of two windows: the hierarchy of instances window, and the report window.

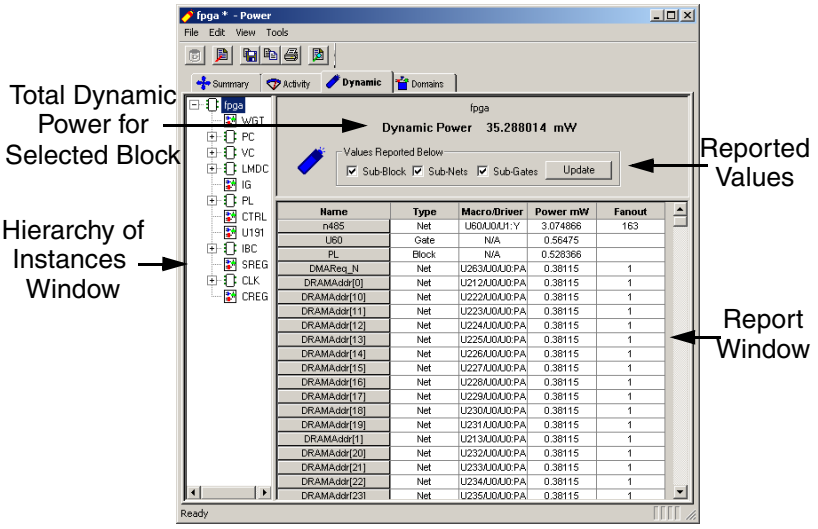



*Figure 1-4. Dynamic Tab*

SmartPower displays the hierarchy of instances in a list in the hierarchy window. Sub-blocks of a block are shown in the tree when you click the plus sign (+) next to the block. Only hierarchical blocks are displayed in this list (no gates or nets).

When you select a block of the hierarchical tree, SmartPower displays its name and its dynamic power consumption in the report window.

SmartPower displays the list of sub-elements of the selected block in the Report window. By default, this list includes all sub-elements. The dynamic power consumption of each sub-element is displayed with useful information like the fanout and the driver-name for a net, or the macro model-name for a gate. You may limit the list of sub-elements to a list of sub-blocks, or gates, or nets, or any combination of these 3 classes of sub-elements. You may also sort the list according to different criteria (double-click a column label to sort the list based on this column, or change the sort-order).

You can export (to a text file) and print the grid that details your design's power consumption. To do so, select the elements of the grid that you wish to export or print, and then from the File menu select Export Grid or Print Grid, respectively.

## Domains Tab

The Domains tab consists of two windows: the Domain Management window and the Pin Management window. You can use these windows to add or remove domains. In addition, you can change the clock and/or data frequency of a selected domain.

The Domain Management window displays a list of existing domains with their corresponding frequencies. You may also select a set-of-pins rather than a clock-domain (Figure 1-5).

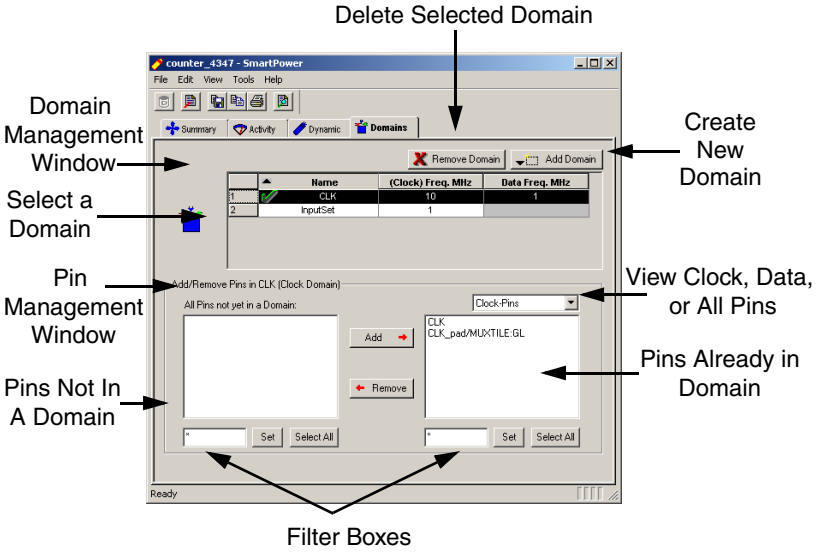



*Figure 1-5. Domains Tab*

Any pins that do not belong to a Clock domain are listed in the "All Pins not in a Domain" list box in the Pin Management window. You can select a pin from the "All Pins not yet in a Domain" list box and add it to the current domain. You may also select a pin from the current domain and remove it from the domain (this pin will appear in the "All Pins not yet in a Domain" list box). Use

the CTRL key while selecting with the mouse to select multiple pins. Use the Select All button to select all pins displayed in a list.

You may filter the list of pins using the filter boxes below the list boxes. Enter a text in the filter boxes and click Set to apply this text as a filter (the * character is a wildcard).

You may also filter the type of pins listed in the domain using the drop-down menu. Choose from All-Pins, Data-Pins or Clock-Pins in the drop-down menu to refine your choice. Create a new clock domain and set of pins as needed.

### To create a new clock domain:

1. **Click Add Domain from the Domain Management window.**
2. **Select the clock domain.** This opens the Create Clock Domain dialog box.

Or, from the Edit menu, select Add Domain, and Add Clock Domain. The Create Clock Domain dialog box appears, as shown in Figure 1-6.

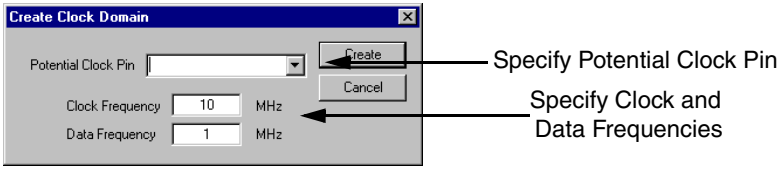



*Figure 1-6. Create Clock Domain Dialog Box*

In the Create-Clock-Domain dialog box, choose a clock in a list of potential clocks. Based on this selection, SmartPower constructs a new clock-domain. The lists of clock-pins and data-pins of this new Clock-Domain are automatically computed (their computation is based on the netlist topology). You may also set a clock-frequency and a data-frequency for this new clock. It is possible to create a new clock-domain without selecting a potential-clock. If you do so, you must enter a name for this new clock-domain, and the list of clock-pins and data-pins is not computed automatically (you must do it manually).

*To create a new Set of pins:*

1. **Click Add Domain in the Domain Management window.**
2. **Select a set of pins.** This displays the Create Set of Pins dialog box (Figure 1-7).

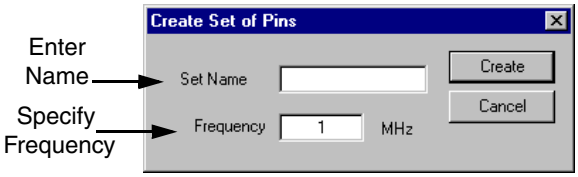



*Figure 1-7. Create Set of Pins Dialog Box*

3. **Input the name and frequency for the new set of pins.**

Alternatively, from the Edit menu, select Add Domain and Set of Pins to open the Create Set of Pins dialog box.

You can use the Create Set of Pins dialog box to enter a name for this new domain, but the domain created is empty (no pins added to this newly created set). You can also set a frequency for this new Set of Pins.

# SmartPower Preferences Dialog Box

The Preferences dialog-box enables you to set options that affect the graphical and textual reports (Figure 1-8). To open the Power - Preferences dialog box, from the File menu choose Preferences. Alternatively, you can click Options in

the Power - Report (select Report Power from the Tools menu) dialog box (see "SmartPower Reports" on page 19).

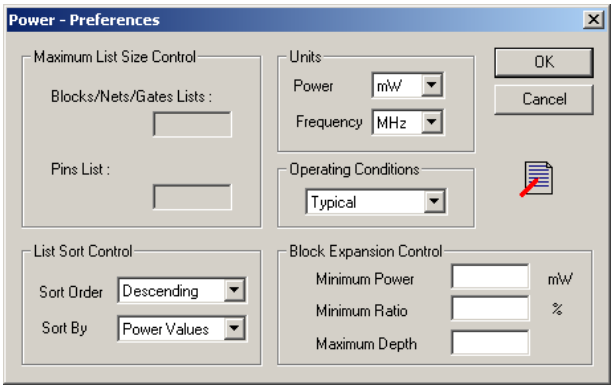



*Figure 1-8. SmartPower Preferences Window*

The Preferences dialog box is divided into five sections:

- **Maximum List Size Control** - Enables you to limit the size of all lists displayed in the SmartPower tab screens; options are grayed out and unavailable at this time
- **List Sort Control** - Modifies the default sort for all the lists in SmartPower (available sort keys are Alphabetical or Power values, in either ascending or descending order)
- **Units** - Sets units preferences for power and frequency
- **Operating Conditions** - Displays operating conditions; Typical is the only option available at this time
- **Block Expansion Control** - Filters reported power values returned in the report. This box does not control which values are included, rather it specifies which blocks are detailed/expanded.

  You may specify which blocks are expanded using a minimum power value, a minimum power ratio (with regards to the total power of the design) and a maximum hierarchical depth; a filtered value is not included in displayed lists, but still counted for upper hierarchical levels.

# SmartPower Reports

SmartPower gives a report of all the activities of the design. There are two ways to generate a report:

- Click the Power Report button in the toolbar.
- From the Tools menu, select Report Power (Figure 1-9)

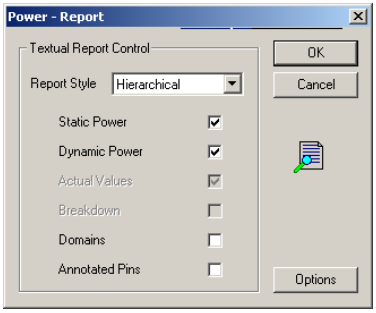



*Figure 1-9. Report Dialog Box*

You have several options in the Report Dialog Box. You can filter the following types of information in your report:

- Report Style - Only Hierarchical is available at this time
- Static Power values
- Dynamic Power values
- Clock Domain information
- Annotated Pin information

Click the checkbox next to the item to include it in your report results. An example of the beginning of a textual power report is shown in Figure 1-10.

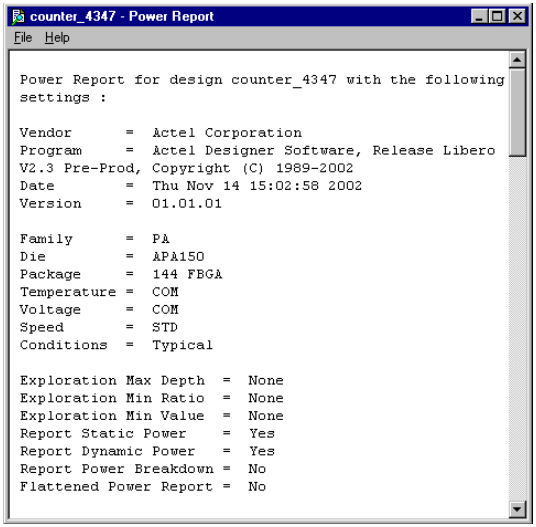



*Figure 1-10. Sample Textual Report from SmartPower (partial)*

The SmartPower report returns a complete list of all the blocks, gates, and nets and the related power consumption in the device. It returns the same information displayed in the Dynamic tab. The report fully expands all the info included in the Dynamic tab by default; use the Block Expansion Control in the Preferences dialog box to expand only the blocks you are interested in.

# Importing a VCD File

The VCD (value change-dump) file is a file format specified in the IEEE 1364 standard. It is an ASCII file that contains header information, definition of variables, and the values of variables.

You can generate a pre- or post-layout VCD file using ModelSim or any other simulation tool that supports VCD file generation. Please refer to the user manual of your simulation tool for more information on how to generate a VCD file.

Use the following instructions to import a VCD (value change dump) file into your design.

### To import a VCD file:

1. **From the File menu in the main Designer window, select Import Auxiliary Files.** Click Add to browse to your VCD file and select it. When you have selected a VCD file, click OK to continue.

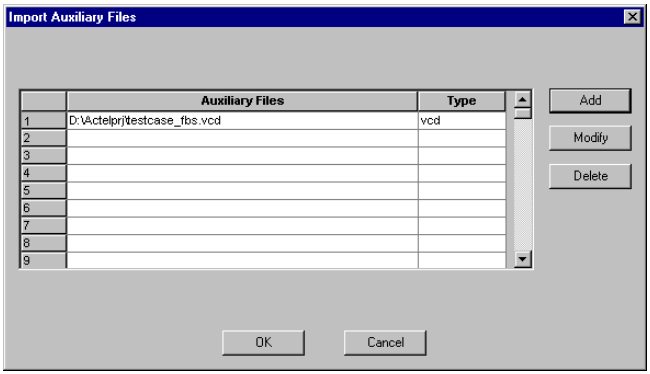



*Figure 1-11. Import Auxiliary Files Dialog Box*

   If you have not yet laid-out the design, the design software guides you through place-and-route so that you can import the VCD file. In order to successfully annotate your VCD values to the design, Designer must complete place-and-route even if you generated your VCD file using functional simulation (pre-layout) or timing simulation (post-layout).

   You may import multiple VCD files. If these files conflict (attempt to set a different frequency for the same net of your design, for example), the latest imported value takes precedence.

2. **Specify your VCD import options.** Use the VCD Import Options window to specify the instance name of your design in the simulation

testbench (Figure 1-12). The instance name is the instance name of your design instantiated in the simulation testbench. Click OK to continue.


*Figure 1-12. VCD Import Options Dialog Box*

For example, the instance name of the design "top_comp" in the following verilog test-bench is "inst".

```
module test;
  reg [3:0] DataA, DataB;
  wire AGEB;
  top_comp inst(DataA, DataB, AGEB);
  initial
  begin
  ……
  end;
endmodule;
```

It also possible to identify the instance name of your design in the VCD file. You have to look for a line starting with the keyword $scope. For example, the instance name of the design "top_comp" in the following VCD file is "inst".

```
$date
  Oct 18, 2001  16:02:16
$end
$version
  VERILOG-XL 3.30.p001
$end
$timescale
  100ps
$end

$scope module inst $end
……
```

3. **Check the Log window for notification that you successfully imported the VCD file ("The Import command succeeded...").**

Even if the Import command succeeds, Actel recommends that you verify which of the pins have been affected after you import the file.

To verify results of an imported VCD file, launch SmartPower and navigate to the Activity tab screen to view pins with annotated switching activities (Figure 1-13). If your file was imported successfully, you will see a long list of pins with annotated switching activity and specific individual frequencies.

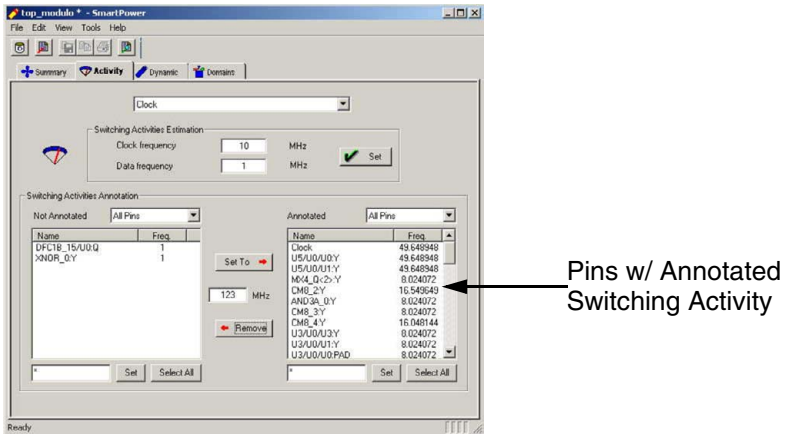



*Figure 1-13. Successful VCD Import - Annotated Switching Activity Results*

Check the annotated values to gauge the effect of your VCD file. For example, the “Clock” pin in Figure 1-13 is an input of the design directly controlled by the stimuli generator. So it is easy to check the computed frequency and ensure that it is correct (close to 50 MHz for this example).

It may be that some pins of your design are not annotated by a VCD import command (like DFC1B_15/U0:Q in the example above). This happens if you simulate a pre-synthesis netlist; it is normal because not all logic elements are in the pre-synthesis netlist. Thus, for accurate power estimation it is better to run post-layout simulation with a back-annotated netlist.

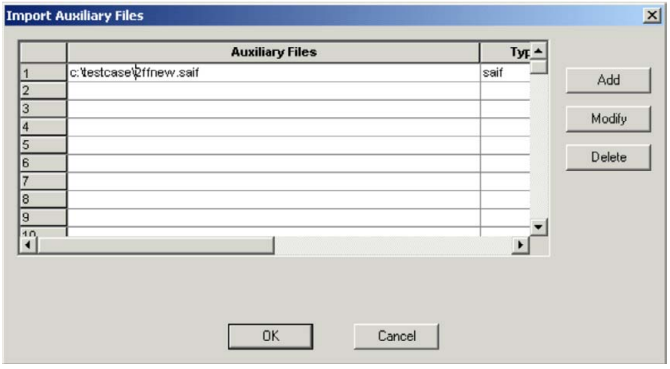
# Importing a SAIF File

The SAIF (Switching Activity Interchange Format) is the EDA industry's most widely used power format that provides switching activity information to power optimization and analysis tools.

Use the following instructions to import a SAIF file into your design.

### To import a SAIF file:

1. **From the File menu in the main Designer window, select Import Auxiliary Files.** Click Add to browse to your SAIF file and select it. When you have selected a SAIF file, click OK to continue.




   If you have not yet laid-out the design, the design software guides you through place-and-route so that you can import the SAIF file. In order to successfully annotate your SAIF values to the design, Designer must complete place-and-route even if you generated your SAIF file using functional simulation (pre-layout) or timing simulation (post-layout).

   It is also possible to import multiple SAIF files. If these files conflict (attempt to set a different frequency for the same net of your design, for example), the latest imported value takes precedence.

2. **Specify your SAIF import options.** Use the SAIF Import Options window to specify the instance name of your design in the simulation

testbench (Figure 1-14). The instance name is the instance name of your design instantiated in the simulation testbench. Click OK to continue.


*Figure 1-14. SAIF Import Options Dialog Box*

You must include the hierarchy in the instance name, as in "TEST_BENCH/UUT" in the example above.

The following example shows how to identify the instance name of your design in the SAIF file. For example, the instance name of the design in the following SAIF file is "TEST_BENCH/UUT".

```
(SAIFILE
(SAIFVERSION "1.1")
(DESIGN 2ff)
(DATE "Fri May 10 14:48:46 2002")
.....
(TIMESCALE 1ns)
(DURATION 50000)

(INSTANCE TEST_BENCH/UUT (PORT (OUT_PORT (TC 26) (IG 0) (T1
25994)
(T0 22000) (TX 2006))))
(INSTANCE TEST_BENCH/UUT/\outpad/U0/U1\ (PORT (Y (TC 26) (IG 0)
(T1 25995) (T0 22000) (TX 2005))))
(INSTANCE TEST_BENCH/UUT/\ff1/U0\ (PORT (Q (TC 27) (IG 0) (T1
26000)
(T0 22997) (TX 1003))))
(INSTANCE TEST_BENCH/UUT/\clkpad/U0/U0\ (PORT (Y (TC 99) (IG 0)
(T1 25000) (T0 24999) (TX 1))))
.....
```

### 3. Check the Log window for notification that you successfully imported the SAIF file ("The Import command succeeded...").

To verify results of an imported SAIF file, launch SmartPower and navigate to the Activity tab screen to view pins with annotated switching activities (Figure

1-15). If your file was imported successfully, you will see a list of pins with annotated switching activities, like the “U9/U0/U1:Y” pin in Figure 1-15.

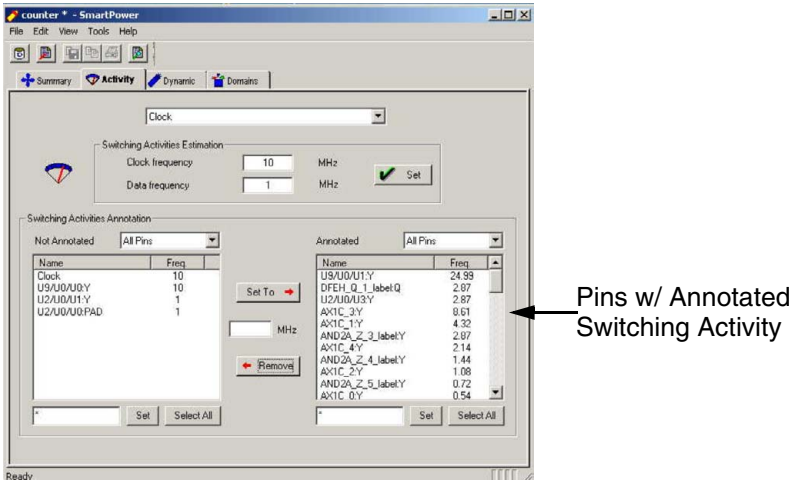



*Figure 1-15. Successful SAIF Import - Annotated Switching Activity Results*

It may be that some pins of your design are not annotated by a SAIF import command (like “U2/U0/U0:PAD” in Figure 1-15). This sometimes happens if you simulate a pre-synthesis netlist. It is normal; not all logic elements are in the pre-synthesis netlist. Thus it is better to do a post-layout simulation with a back-annotated netlist for the most accurate power estimation.

# 2

# Using SmartPower

This chapter contains information on how to use SmartPower to analyze your power consumption. For more information on the SmartPower interface, please refer to "Getting Started with SmartPower" on page 7.

## SmartPower Calculation

SmartPower calculates two power values for your design:

1. Static Power - This value is family and die-size dependent and is estimated at the design level (at this time all die sizes for each family have the same static power).
2. Dynamic Power: This value is a summation of the dynamic power consumed by each element of the design (nets, modules, IOs, RAM, FIFO, PLL, etc.).

   Note: The examples below are for general evaluation purposes only. They are not a precise representation of the actual calculations, since each calculation takes into account family-specific information.

   - For a net,

     $$P = C \cdot V^2 \cdot F$$

     where C is the total capacitive loading of the net (extracted from the routing topology), V is the net's voltage swing, and F is the average switching frequency.

   - For a module, the power is computed using a characterized library (by family and die-size) describing a specific power model for each type of module. For example, the power model of a flip-flop is given by

     $$P = P_{CK} \cdot F_{CK} + P_{DOUT} \cdot F_{DOUT} + P_{Din} \cdot F_{Din}$$

     where $F_{CK}$ is the average clock-input frequency for this flip-flop, $F_{DOUT}$ is its average data-output frequency, and $P_{CK}$, $P_{DOUT}$, and $P_{Din}$ are three constants estimated by electrical simulation and silicon characterization for this flip-flop module.

   - For an IO, the formula used for computing the power consumption

depends on the IO technology and the family. For example, for a TTL output, the dynamic power is given by

$$P = P_{INT} \cdot F + C \cdot V^2 \cdot F$$

where C is the output load of the port (35 pf for TTL), V is the output's voltage swing (3.3 V for TTL), $P_{INT}$ represents an internal power contribution dissipated in the pad, and F is the average switching frequency of the IO.

- For a complex block, like a RAM, a FIFO, or a PLL, SmartPower uses a high-level power model that integrates design parameters.

SmartPower automatically computes all the constant parameters of these equations. However, the frequencies depend on the target frequencies of your design. Since it is impractical to enter each frequency manually, SmartPower has several flows that help you to estimate the frequencies and calculate the power consumption.

## Power Analysis with SmartPower

The procedure for power analysis with SmartPower may be roughly divided into four steps:

1. Define clock domains (Domains tab) - Define clock domains, and specify a clock frequency and a data frequency for each clock domain.
2. Specify individual pin frequencies (Activity tab) - This step is optional, but gives you pin-by-pin control of the frequency.
3. View global power consumption (Summary tab) - View global power at the design level and its impact on junction temperature.
4. Analyze power consumption (Dynamic tab) - View detailed hierarchical analysis of your power consumption (this step is also optional). If your power consumption exceeds your budget, this step helps you identify where there is room for improvement.

Each of these steps is described in detail below.

## Define Clock Domains

When you run SmartPower, it researches your existing clock domains and partitions your design automatically. You may wish to review the list of clock domains in the Domains tab to ensure that all the clocks of your design are included in the list. Add or remove clocks as necessary.

### To add a new clock domain:

1. **Open the Create Clock Domain dialog box.** Click the Domains tab, and click the Add Domain button. Select Clock Domain from the drop down menu.
2. **Create a new clock Domain.** Select a potential clock pin, specify a clock and data frequency, and click Create. The new clock domain appears in the Domains window. If you select an existing clock-pin from the drop-down menu, the lists of clock-pins and data-pins of this new clock domain are computed automatically based on the netlist topology.

   You may wish to create an empty clock domain and fill the lists of clock-pins and data-pins manually. If so, do not select a clock-pin, just type a new name for your clock domain.

For more information on the Clock Domain dialog box, please refer to "Domains Tab" on page 15.

Beyond the verification of the list of clock domains, you may also wish to verify that the lists of clock-pins and data-pins computed for each clock domain are correct.

### To verify the lists of clock-pins and data-pins of a clock domain:

1. **Select a Clock Domain.** Click the Domains tab, and select a specific Domain in the list.
2. **Display the list of clock-pins or data-pins of this Domain.** A drop-down menu in the Domain tab enables you to select clock-pins or data-pins. SmartPower displays the list of pins corresponding to your selection below the drop-down menu. You can add or remove clock-pins and data-pins as necessary.
3. **Remove a pin from a clock domain.** Highlight the selected pin and click the Remove button. The pin is removed from the clock domain, and is made available in the list of pins that you can add in another clock domain.

4. **Add a pin in a clock domain.** Highlight the selected pin in the list of pins that are not yet in a domain and click the Add button. This pin is added to the clock domain. It is a clock-pin or a data-pin, depending on the specification of the drop-down menu when you click the Add button.

   Note: You cannot add a pin that exists in another domain until you free it from the existing domain. The pin is unavailable until you remove it from the existing domain.

After you have verified that all the clocks of your designs are correctly identified and constructed, you must specify the correct clock and data frequency for each clock domain.

To specify a clock and data frequency, highlight the Clock/Data frequency cell and type in a new value. SmartPower defaults to 10 MHz for each clock frequency, and 1MHz for the data frequency. Input your target for each clock and data frequency (5% of your clock frequency is a typical guideline for your data frequency - this corresponds to a toggle-rate of 10%.)

Not all the pins/gates/nets of your design are associated with a specific Clock. For example, the frequency of a design input port is not always correlated to a clock frequency. By extension, all pins that are upstream of the first level of sequential elements are not associated with any clock. SmartPower creates an InputSet by default that it uses to group all the pins that are controlled by design inputs (instead of sequential elements).

### To verify the InputSet:

1. **Select the InputSet.** Click the Domains tab, and select the domain named InputSet in the list.
2. **Verify the list of pins of this Domain.** All the input ports of your design (except the clocks) belong in the InputSet. Also, all the pins that are between these input ports and the first level of sequential elements belong in the InputSet. You can add or remove pins as necessary.
3. **Specify an average input frequency.** SmartPower uses the same frequency for all pins of the InputSet. The default InputSet frequency is 1 MHz. Type in a new value to change it.

You may wish to split the InputSet into several sets in order to specify different frequencies. A classic example is to create a ResetSet, a reset-tree with a very low frequency.

### To split the InputSet into several sets:

1. **Create a new Set of Pins.** In the Domains tab, click the New button, and select Set-of-Pins from the drop down menu. In the Create Set Of Pins dialog-box type a name and a frequency for the new set and click Create. The new set of pins appears in the Domains window. You can only create an empty set of pins, but it is possible to add pins in this Domain latter.
2. **Remove a group of pins from the InputSet.** Click the Domains tab, and select the domain named InputSet in the list. Highlight the pins that you want to remove and click the Remove button.
3. **Add this group of pins in the new Set of Pins.** Click the Domains tab, and select the newly created set of pins in the list. Highlight the pins in the list of pins that are not yet in a domain, and click the Add button. Repeat these 3 steps as necessary to create multiple inputs sets.

## Specify Individual Pin Frequencies

The Clock Domains tab enables you to specify an average clock and data frequency for each clock domain, and also an average frequency for each set of pins. This gives you an initial estimate of the power consumption of your design. However, if this estimate is not accurate enough, you may wish to refine it with a pin-by-pin annotation of the frequency.

### To specify a frequency annotation for an individual pin:

1. **Locate the pin in the Activity tab.** You may need to select different clock domains from the drop-down menu on the Activity tab, then search in the Not-Annotated Pins list to find the specific pin. It is possible to use filters to facilitate this research.
2. **Specify a new frequency for this pin.** Highlight the pin in the list of Not Annotated pins, enter a new frequency value, and click the Set To button. The pin with this new frequency appears in the list of annotated pins. Repeat these 2 steps as necessary to annotate the frequency of several pins.

This annotation procedure enables you to set the frequency of an individual pin, but this does not mean that the pin is removed from its clock-domain. A frequency annotation just overrides the domain-level frequency.

You may need to change or remove a frequency annotation of an individual pin. This may be useful when you import a VCD (value change-dump) file or a SAIF (Switching Activity Interchange Format) file.

### To change the frequency annotation of an individual pin:

1. **Locate the pin in the Activity tab.** You may need to select different clock domains from the drop-down menu on the Activity tab, and then search in the Annotated Pins list to find the specific pin. You can use filters to facilitate the search.
2. **Specify a new frequency for this pin.** Highlight the pin in the list of Annotated pins, enter a new frequency value, and click the Set To button. The pin appears in the list of annotated pins with this new frequency. Repeat these 2 steps as necessary to change the frequency annotation of several pins.

### To remove the frequency annotation of an individual pin:

1. **Locate the pin in the Activity tab.** You may need to select different clock domains from the drop-down menu on the Activity tab, and then search in the Annotated Pins list to find the specific pin. You can use filters to facilitate the search.
2. **Specify a new frequency for this pin.** Highlight the pin in the list of Annotated pins and click the Remove button. The pin appears in the list of Not Annotated pins. Repeat these 2 steps as necessary to remove the frequency annotation of several pins.

   Note: You can also import a VCD file. See “Importing a VCD File” on page 20 for more information.

## View Global Power Consumption at the Design Level

Click the Summary tab to view global power consumption at the design level. The Summary tab shows your designs' estimated Power Consumption, Average Switching Activities, and Temperatures. For more information on the Summary tab, please refer to "Summary Tab" on page 11.

The power estimation reported in the Summary tab is the total static and dynamic power consumption of your design. For a more detailed view of this power consumption, click the Dynamic tab.

Average Switching Activities are useful when you import a VCD file or SAIF file. Since these files enable you to specify the frequency of each pin individually, it is often useful to know the average clock-pins frequency and data-pins frequency for a particular clock domain.

### To view the Average Switching Activities of a clock domain:

1. **Select a clock domain.** Click the Summary tab, and select a specific domain in the list.
2. **Verify the average clock frequency.** If you did not specify a frequency annotation for any clock-pin in this clock domain, the average value is equal to the default clock-frequency of the clock domain. If you annotated one or several clock-pins, SmartPower takes these specific annotations into account to compute an average value.
3. **Verify the average data frequency.** If you did not specify a frequency annotation for any data-pin in this clock domain, the average value is equal to the default data-frequency of the clock domain. If you annotated one or several data-pins, SmartPower takes these specific annotations into account to compute an average value.

#### Junction Temperature

The junction temperature estimation T is dependent on the thermal resistance ($\theta_{JA}$) (which is itself package and cooling-style dependent), and also on the ambient temperature $T_A$ and the total dynamic power consumption of your design P. The formula is: $T_J = T_A + P \cdot \theta_{JA}$ where

$\theta_{JA} = f(\text{Pkg \& Cooling Style})$

### To estimate the junction temperature:

1. **Verify your package.** You cannot change your package directly in SmartPower, because it may obsolete your place and route information (and

thus it may severely impact the total power consumption). If you wish to choose another package, you have to do it in Designer - Tools - Device Selection.

2. **Select a cooling-style.** Click the Summary tab, and select a cooling-style in the list. Thermal resistance changes automatically when you update the cooling-style.

3. **Specify an ambient temperature.** Enter an ambient temperature (default value is 25°C), and click the Set button.

   Note: The junction temperature value changes according to the package, cooling style, and ambient temperature values you choose.

## Analyze Power Consumption at the Block, Net, or Gate Level

The Dynamic tab displays the estimated power consumption of individual blocks, gates, and nets and enables you to make a hierarchical analysis of your power consumption. The dynamic tab may also help you to improve your power consumption by identifying the blocks, gates and nets consuming a significant amount of power.

You can export (to a text file) and print the grid that lists your design's power consumption. To do so, select the elements of the grid that you wish to export or print, and then from the File menu select Export Grid or Print Grid, respectively.

### *To identify the blocks, gates, or nets that are consuming the most power:*

1. **Expand the design hierarchy.** The Dynamic tab enables you to expand your design hierarchy and view a complete list of the blocks in your

design. Click the '+' next to your design to view the hierarchy. Click the '+' next to a sub-block to view its sub-elements (Figure 2-1).

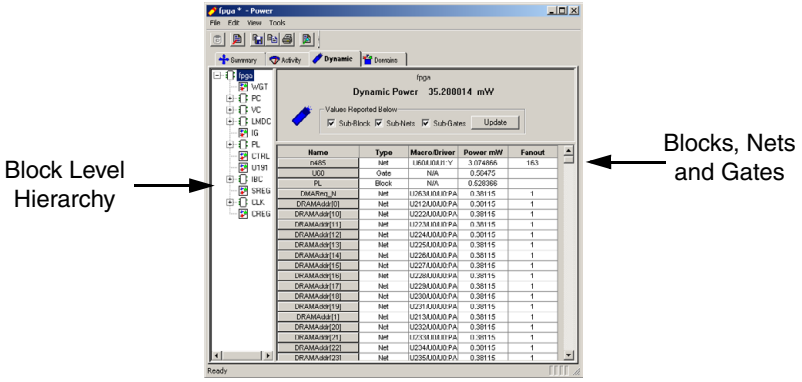



*Figure 2-1. Possible Clock Pin with High Fanout*

2. **Select a block.** By default SmartPower selects the design-level block, but you can always select another block in the hierarchical-tree. The report window displays the list of sub-elements of the selected block. By default, this list includes all sub-elements. SmartPower displays the dynamic power consumption of each sub-element with useful information like the fanout and the driver-name for a net, or the macro model-name for a gate.

3. **Sort and filter the sub-elements to find the block, gate, or net that is using the most power.** By default SmartPower sorts the sub-elements according to their power consumption. The top of the list of sub-elements gives you the main sources of dynamic power consumption at the hierarchical level. Double-click a column heading to sort by that column (or to change the sort order). Click a checkbox to limit the list of sub-elements to a list of gates, nets or blocks.

# SmartPower Results

Use the information below to manage the way SmartPower returns your results.

## Generating a Power Report

The power report enables you to quickly determine if any power consumption problems exist in your design. The power report lists the following information:

- Global device information, and SmartPower Preferences selection information (see "SmartPower Preferences Dialog Box" on page 17 for more information on the Preferences)
- Design level static power summary
- Dynamic power summary
- Hierarchical detailed power report (including gates, blocks, and nets), with a block by block, gate by gate, and net by net power summary

### To generate a power report:

1. **In the Tools menu, click *Report Power*.** The Power Report dialog box appears (Figure 2-2). You have the following options:

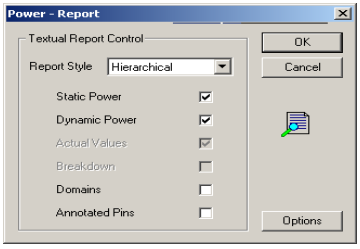



*Figure 2-2. Power Report Dialog Box*

- **Static Power** - Returns static power information
- **Dynamic Power** - Returns dynamic power information
- **Report Style** - Specifies report style (only hierarchical available at this time)

2. **For additional Power Report Options, click the *Options* button.** This displays the Preferences dialog box, as shown in Figure 2-3.

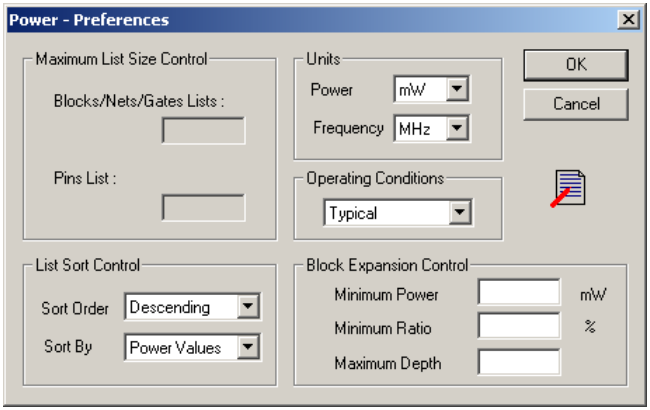



*Figure 2-3. Preferences Dialog Box*

3. **Select analysis preferences.** The default settings are shown in Figure 2-3. You have the following options for your Power Report:

   - **Units** - Sets units preferences for power and frequency
   - **Operating Conditions** - sets preferences for operating conditions (Typical is the only option available at this time)
   - **Block Expansion Control** - Filters reported power values returned in the report. This box does not control which values are included, rather it specifies which blocks are detailed/expanded.

     You may specify which blocks are expanded using a minimum power value, a minimum power ratio (with regards to the total power of the design) and a maximum hierarchical depth; a filtered value is not included in displayed lists, but still counted for upper hierarchical levels.

4. **Once you are satisfied with your selections, click *OK* in the Preferences dialog box and then click *OK* in the Power Report dialog box.** SmartPower displays the report in a separate window.

# B

# Product Support

Actel backs its products with various support services including Customer Service, a Customer Technical Support Center, a web site, an FTP site, electronic mail, and worldwide sales offices. This appendix contains information about contacting Actel and using these support services.

## Actel U.S. Toll-Free Line

Use the Actel toll-free line to contact Actel for sales information, technical support, requests for literature, Customer Service, investor information, and using the Action Facts service.

The Actel toll-free line is (888) 99-ACTEL.

## Customer Service

Contact Customer Service for non-technical product support, such as product pricing, product upgrades, update information, order status, and authorization.

From Northeast and North Central U.S.A., call (408) 522-4480.
From Southeast and Southwest U.S.A., call (408) 522-4480.
From South Central U.S.A., call (408) 522-4434.
From Northwest U.S.A., call (408) 522-4434.
From Canada, call (408) 522-4480.
From Europe, call (408) 522-4252 or +44 (0) 1276 401500.
From Japan, call (408) 522-4743.
From the rest of the world, call (408) 522-4743.
Fax, from anywhere in the world (408) 522-8044.

## Actel Customer Technical Support Center

Actel staffs its Customer Technical Support Center with highly skilled engineers who can help answer your hardware, software, and design questions. The Customer Technical Support Center spends a great deal of time creating application notes and answers to FAQs. So, before you contact us, please visit our online resources. It is very likely we have already answered your questions.

# Guru Automated Technical Support

Guru is a web-based automated technical support system accessible through the Actel home page (http://www.actel.com/guru/). Guru provides answers to technical questions about Actel products. Many answers include diagrams, illustrations, and links to other resources on the Actel web site.

# Web Site

Actel has a World Wide Web home page where you can browse a variety of technical and non-technical information. The URL is http://www.actel.com.

# Contacting the Customer Technical Support Center

Highly skilled engineers staff the Technical Support Center from 7:00 A.M. to 6:00 P.M., Pacific Time, Monday through Friday. Several ways of contacting the Center follow:

## Electronic Mail

You can communicate your technical questions to our e-mail address and receive answers back by e-mail, fax, or phone. Also, if you have design problems, you can e-mail your design files to receive assistance. We constantly monitor the e-mail account throughout the day. When sending your request to us, please be sure to include your full name, company name, and your contact information for efficient processing of your request.

The technical support e-mail address is **tech@actel.com**.

## Telephone

Our Technical Support Center answers all calls. The center retrieves information, such as your name, company name, phone number and your question, and then issues a case number. The Center then forwards the information to a queue where the first available application engineer receives the data and returns your call. The phone hours are from 7:00 A.M. to 6:00 P.M., Pacific Time, Monday through Friday. The Technical Support numbers are:

***(408) 522-4460***
***(800) 262-1060***

Customers needing assistance outside the US time zones can either contact technical support via email (tech@actel.com) or contact a local sales office. Please see our list of Worldwide Sales Offices.

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## V



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