

# Xilinx Power Estimator User Guide

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## Revision History

The following table shows the revision history for this document.

Date	Version	Revision
06/05/07	1.0	Initial Xilinx release.
05/04/09	2.0	Added information to describe the XPE spreadsheets for the 11.1 release of ISE.



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# About This Guide

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This User Guide describes the Xilinx Power Estimator (XPE), a power estimation tool used in the predesign and preimplementation phases of a design to be implemented in a Xilinx FPGA. XPE works with Microsoft Excel.

XPE currently supports all Spartan™-3 Generation FPGAs (Spartan-3, Spartan-3A, Spartan-3AN, and Spartan-3A DSP), Virtex™-4 FPGAs, and Virtex-5 FPGAs. Predesign power estimation support for earlier Xilinx FPGA devices is done through the Web Power Tool (WPT), which works with web browsers and is available from the Xilinx website.

For additional details about XPE, see the [Power Solutions](#) webpage on the Xilinx website.

## Guide Contents

This manual contains the following chapter:

- [“Xilinx Power Estimator User Guide”](#)

## Additional Resources

To find additional documentation, see the Xilinx website at:

<http://www.xilinx.com/literature>

To search the Answer Database of silicon, software, and IP questions and answers, or to create a technical support WebCase, see the Xilinx website at:

<http://www.xilinx.com/support>

To download the XPE spreadsheets, see the Power Solutions webpage on the Xilinx website at:

<http://www.xilinx.com/power>

The following are especially pertinent to the subject of this User Guide.

- WP353: *Seven Steps to an Accurate Worst-Case Power Analysis Using Xilinx Power Estimator (XPE)*
- *Test Boards for Area Array Surface Mount Package Thermal Measurements*
- UG331: *Spartan-3 Generation FPGA User Guide*
- UG070: *Virtex-4 FPGA User Guide*
- UG190: *Virtex-5 FPGA User Guide*
- UG112: *Device Package User Guide*
- User Guides for dedicated blocks within the FPGAs (for example, DSP and MGT blocks) are referenced in the sections describing power estimation for these blocks.

## Conventions

This document uses the following conventions. An example illustrates each convention.

### Typographical

The following typographical conventions are used in this document:

Convention	Meaning or Use	Example
Courier font	Messages, prompts, and program files that the system displays	speed grade: - 100
<b>Courier bold</b>	Literal commands that you enter in a syntactical statement	<b>ngdbuild</b> <i>design_name</i>
<b>Helvetica bold</b>	Commands that you select from a menu	<b>File</b> → <b>Open</b>
	Keyboard shortcuts	<b>Ctrl+C</b>
Italic font	Variables in a syntax statement for which you must supply values	<b>ngdbuild</b> <i>design_name</i>
	References to other manuals	See the <i>Development System Reference Guide</i> for more information.
	Emphasis in text	If a wire is drawn so that it overlaps the pin of a symbol, the two nets are <i>not</i> connected.
Square brackets [ ]	An optional entry or parameter. However, in bus specifications, such as <b>bus [7:0]</b> , they are required.	<b>ngdbuild</b> [ <i>option_name</i> ] <i>design_name</i>
Braces { }	A list of items from which you must choose one or more	<b>lowpwr</b> = { <b>on</b>   <b>off</b> }
Vertical bar	Separates items in a list of choices	<b>lowpwr</b> = { <b>on</b>   <b>off</b> }
Vertical ellipsis . . . . .	Repetitive material that has been omitted	IOB #1: Name = QOUT' IOB #2: Name = CLKIN' . . . .
Horizontal ellipsis ...	Repetitive material that has been omitted	<b>allow block</b> <i>block_name loc1 loc2 ... locn</i> ;



## Online Document

The following conventions are used in this document:

Convention	Meaning or Use	Example
Blue text	Cross-reference link to a location in the current document	See the section “ <a href="#">Additional Resources</a> ” for details. Refer to “ <a href="#">Title Formats</a> ” in <a href="#">Chapter 1</a> for details.
<a href="#">Blue, underlined text</a>	Hyperlink to a website (URL)	Go to <a href="http://www.xilinx.com">http://www.xilinx.com</a> for the latest speed files.



# *Xilinx Power Estimator User Guide*

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## Introduction

Xilinx Power Estimator (XPE) is a power estimation tool intended to be used for the predesign/preimplementation phase. XPE works with Microsoft Excel.

XPE currently supports the Spartan™-3 Generation FPGAs, Virtex™-4, and Virtex-5 devices.

XPE considers the design resource usage, toggle rates, I/O loading, and many other factors in the estimation process. The formulas used for calculations in the program are based on intended behavior of various digital circuits. The characteristic data is based on measurements, simulation, and/or extrapolation.

XPE is a preimplementation tool for use in the early stages of a design. After implementation, the XPower Analyzer (XPA) tool (available in the ISE® Design Suite software) can be used for more accurate estimates and power analysis, since XPower Analyzer utilizes the logic and routing resources of the actual design.

XPE is primarily a spreadsheet, so all MS Excel-based functionality is fully retained in the writable or unprotected sections of the spreadsheet. XPE has additional functionality oriented to ease of use. The drop-down menus and the comment-enabled cells are useful features that are helpful to the user.

## Philosophy of Power Analysis

Power analysis for programmable devices is motivated by three main aspects:

- Power supply sizing or selection
- Thermal management
- Identifying the candidate functional blocks for power reduction

Xilinx power estimation is analogous to static timing analysis. Power estimation and analysis tools can be used to report worst-case and typical power margins. The accuracy of XPE is dependent on two primary components:

- The inputs you enter into XPE to model designs
- The characterization data integrated into the tool that stems from device characterization

For realistic estimates specific to your application, enter realistic voltage and temperature conditions. Modeling a certain aspect of the design over-conservatively or without sufficient knowledge of the design can result in unrealistic estimates. Some techniques to drive the XPE to provide worst-case estimates or typical estimates are discussed in this document.

The following document provides additional information useful for accurate power analysis with XPE:

*[WP353: Seven Steps to an Accurate Worst-Case Power Analysis Using Xilinx Power Estimator \(XPE\)](#)*

The accuracy of the characterization data existing in the tool is reflected by accuracy designations in the **Release** tab of XPE. For most FPGAs, the accuracy designation is also displayed in the **Data** field of the **Power Summary** section of the **Summary** tab. The accuracy designations are Advanced, Preliminary, and Production.

## Advanced

The data integrated into XPE with this designation is based primarily on measurements and characterization data made on early production devices. A set of widely used device resources are included in the characterization. Characterization data is limited to these few blocks. This data is typically available within a year of product launch. Although the data with this designation is considered relatively stable and conservative, some under-reporting or over-reporting might occur. Advanced data accuracy is considerably lower than the Preliminary and Production data.

## Preliminary

The data integrated into XPE with this designation is based on complete early production silicon. Almost all the blocks in the device fabric are characterized. Data for most of the dedicated blocks like TEMAC and PCIe block are also characterized and integrated into the XPE. The probability of accurate power reporting is improved as compared to Advanced data.

## Production

The data integrated into XPE with this designation is released after enough production silicon of a particular device family member has been characterized to provide full power correlation over numerous production lots. Characterization data for all blocks in the device fabric is included.

## Scope of This Document

The purpose of this document is to describe how to use XPE to arrive at realistic estimates for real-life designs. Simple example circuits are included to illustrate the use of the tool. Examples include 16-bit counters, common block RAM configurations, and clock trees. This document also shows:

- Tool features that make design data entry, capture, and storage convenient, and
- A detailed description of the various spreadsheet tabs that are a part of the tool, their purpose, and usage.

This document focuses on how to use XPE to calculate estimated power consumption for supported devices.

White Paper *[WP353: Seven Steps to an Accurate Worst-Case Power Analysis Using Xilinx Power Estimator \(XPE\)](#)* also provides supplementary information useful for power analysis with XPE.

# XPE Requirements, Capabilities, and Features

## Requirements

XPE requires a licensed version of Microsoft Excel 2003 or later to be installed. XPE can be accessed on the Xilinx website at <http://www.xilinx.com/power>. There are separate downloadable XPE spreadsheets for each of these devices:

- Virtex-4
- Virtex-5
- Spartan-3
- Spartan-3E
- Spartan-3A (also supports Spartan-3AN)
- Spartan-3A DSP

XPE uses several macros built into the XPE spreadsheet. By default, the Microsoft Excel 2003 macro security level is set to High, which automatically disables macros. To change the macro security level, follow these steps in Microsoft Excel 2003:

1. On the Tools menu, point to **Macro** and click **Security**.
2. In the Security dialog box, click the **Security Level** tab.
3. Select **Medium**, then click **OK**.
4. Open or, if already open, reopen the XPE spreadsheet.
5. When prompted whether to enable or disable macros, click **Enable Macros**.

## Capabilities and Features

Power estimation for programmable devices like FPGAs is a complex process. To produce accurate estimates, the power estimation process requires accurate input values, such as resource utilization, clock rates, and toggle rates. To use this tool to its minimum capability with reasonable accuracy, you need the following:

- A target device-package combination
- A good estimate of resources you expect to use in the design (for example, flip-flops, look-up tables, I/Os, block RAMS, DCMs, etc.)
- The clock frequency or frequencies for the design
- An estimate of the data toggle rates for the design

This minimum data is necessary but not sufficient to provide accurate estimates that aid an optimal choice of power supplies, regulators, and optional thermal solutions.

A description of the spreadsheet's color-coding scheme is provided in [Table 1](#).

Table 1: XPE Cell Color-Coding Scheme

Cell Color	Cell Use	Comment
White	Allows user to enter data	Writable/Editable. Rounded to 1 decimal place.
Grey	Displays a calculated value	Read / Write Protected. Cannot be edited or written into.
Cyan	Displays a summary value	Read-only
Yellow	Flags a warning. Indicates that a resource is not available.	Writable / Editable
Red	Flags an error. Examples of errors are: <ul style="list-style-type: none"> <li>• A resource limit in the device has been exceeded.</li> <li>• The limits of a device specification (for example, junction temperature) have been exceeded.</li> </ul>	Error can be corrected by editing other cells in XPE.

To make data entry into the tool easier, XPE supports importing data from:

- A pre-existing XPE spreadsheet with valid data entries, as shown in [Figure 1](#).

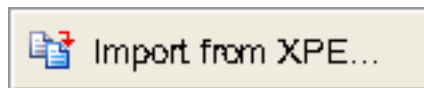


Figure 1: XPE Import Button

- A MAP report (.mrp) showing actual resource utilization for a given design, as shown in [Figure 2](#).

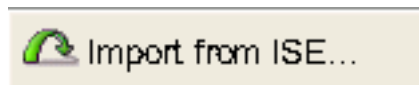


Figure 2: ISE Import Button

The MAP report import function (**Import from ISE**) fills in the XPE spreadsheet with device information and resource counts information reported by the MAP implementation stage. After import you must set clock frequencies, configuration, rates, and other usage information on each XPE tab. The clock, logic, DSP48, and GT Tab will have fanout and counts on a single line. The I/O and BRAM tabs are populated based on unique configuration. You may need to add additional rows and adjust the counts to group by clock domain, module, or other functional grouping after import. White Paper [WP353: Seven Steps to an Accurate Worst-Case Power Analysis Using Xilinx Power Estimator \(XPE\)](#) can help in all these steps to effectively enhance the power estimation after the MAP report import is done. Route-thru LUTs are not counted as their power is accounted for in the XPE interconnect model.

XPE is intended to be intuitive to the novice spreadsheet-user. For information about a cell of the spreadsheet, move the mouse over the comment indicators (red triangle at the top-right corner of the title cells) to read the relevant notes for the intended use.

## Power Components Reported

As with any CMOS-based SRAM device, the power consumption reported by the tool for FPGAs has two appreciable components:

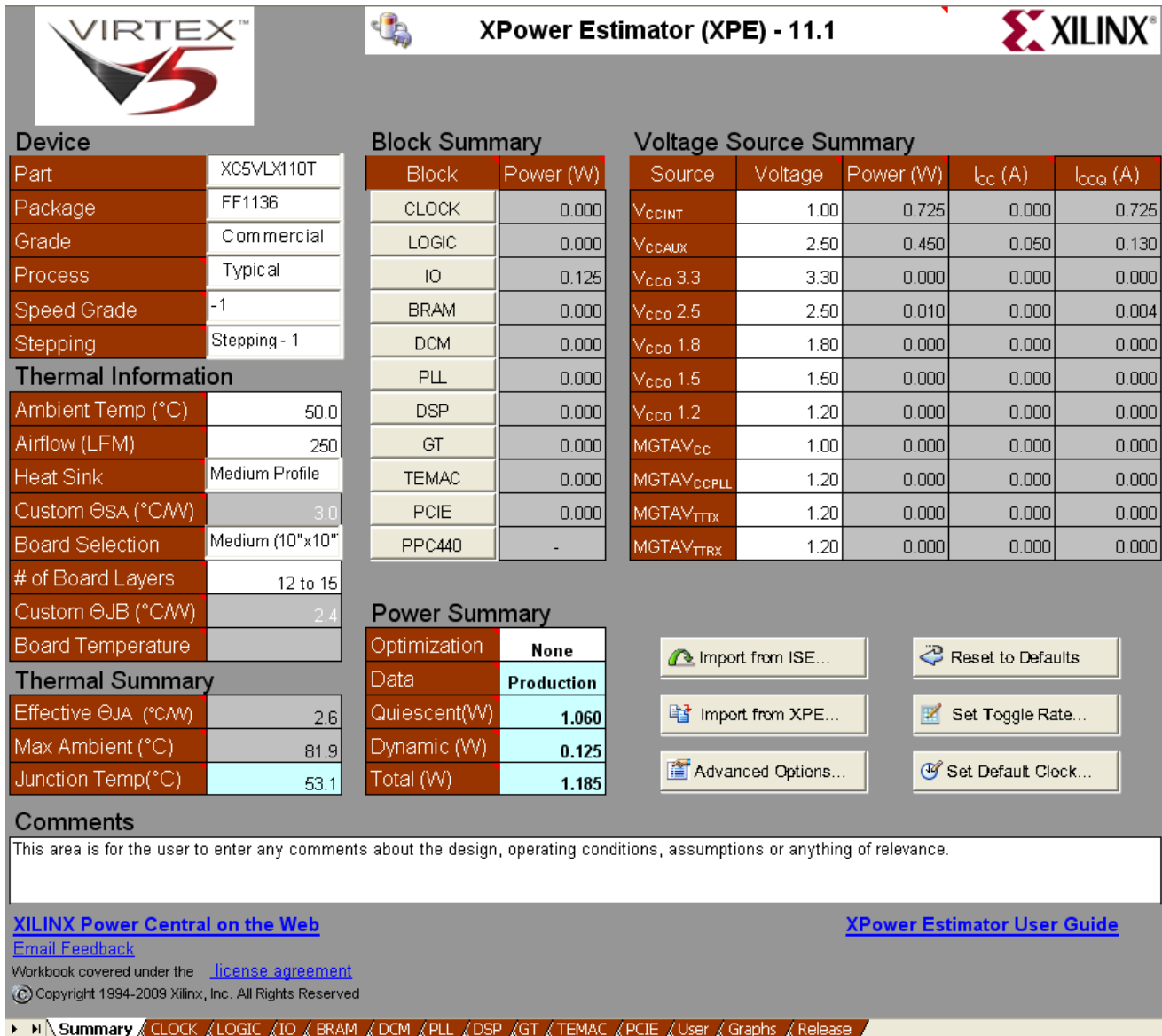
- Static power (referred to as quiescent power in XPE)
- Dynamic power

The device quiescent power is automatically determined depending on the device selected. No input into XPE is required. The estimates represent power drawn by the device when there is no switching activity. By choosing the **Maximum** or **Typical** values for **Process**, worst-case or nominal power can be estimated.

Both the reported static and dynamic power estimates are modeled to account for temperature and voltage sensitivity. Ambient temperature and regulated voltage on the system can be keyed into the appropriate cells provided for the purpose.

## Summary Tab

XPE has several spreadsheet tabs. The default tab on launch is the Summary tab, shown in [Figure 3](#). The XPE Summary tab has simple pull-down menus to select the device, package, and temperature grade of the target device. The tool supports estimating power for a device from a typical or worst-case process. It also shows a power-rail-wise and block-wise split-up of power consumption.



**VIRTEX 5** **XPower Estimator (XPE) - 11.1** **XILINX**

**Device**

Part	XC5VLX110T
Package	FF1136
Grade	Commercial
Process	Typical
Speed Grade	-1
Stepping	Stepping - 1

**Thermal Information**

Ambient Temp (°C)	50.0
Airflow (LFM)	250
Heat Sink	Medium Profile
Custom $\theta_{SA}$ (°C/W)	3.0
Board Selection	Medium (10"x10")
# of Board Layers	12 to 15
Custom $\theta_{JB}$ (°C/W)	2.4
Board Temperature	

**Thermal Summary**

Effective $\theta_{JA}$ (°C/W)	2.6
Max Ambient (°C)	81.9
Junction Temp (°C)	53.1

**Block Summary**

Block	Power (W)
CLOCK	0.000
LOGIC	0.000
IO	0.125
BRAM	0.000
DCM	0.000
PLL	0.000
DSP	0.000
GT	0.000
TEMAC	0.000
PCIE	0.000
PPC440	-

**Voltage Source Summary**

Source	Voltage	Power (W)	I <sub>CC</sub> (A)	I <sub>CCQ</sub> (A)
V <sub>CCINT</sub>	1.00	0.725	0.000	0.725
V <sub>CCAUX</sub>	2.50	0.450	0.050	0.130
V <sub>CC0 3.3</sub>	3.30	0.000	0.000	0.000
V <sub>CC0 2.5</sub>	2.50	0.010	0.000	0.004
V <sub>CC0 1.8</sub>	1.80	0.000	0.000	0.000
V <sub>CC0 1.5</sub>	1.50	0.000	0.000	0.000
V <sub>CC0 1.2</sub>	1.20	0.000	0.000	0.000
MGTAV <sub>CC</sub>	1.00	0.000	0.000	0.000
MGTAV <sub>CCPLL</sub>	1.20	0.000	0.000	0.000
MGTAV <sub>TTTX</sub>	1.20	0.000	0.000	0.000
MGTAV <sub>TRX</sub>	1.20	0.000	0.000	0.000

**Power Summary**

Optimization	None
Data	Production
Quiescent(W)	1.060
Dynamic (W)	0.125
Total (W)	1.185

Buttons: Import from ISE..., Reset to Defaults, Import from XPE..., Set Toggle Rate..., Advanced Options..., Set Default Clock...

**Comments**

This area is for the user to enter any comments about the design, operating conditions, assumptions or anything of relevance.

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Summary / CLOCK / LOGIC / IO / BRAM / DCM / PLL / DSP / GT / TEMAC / PCIE / User / Graphs / Release

Figure 3: Summary Tab Displaying XPE Defaults on Launch

XPE also allows for setting a default clock rate and a default toggle rate at which the tool assumes the entire design to run. To set the default clock rate, click on the **Set Default Clock...** button as shown in [Figure 4](#). To set the default toggle rate, click the **Set Toggle Rate...** button. When these settings are keyed in, the clock rate and toggle rate cells in all the spreadsheet tabs are automatically populated with them. To learn more about toggle rates, refer to the section, [“Understanding Toggle Rates”](#). To reset all settings to their default values, click on the **Reset to Defaults** button.



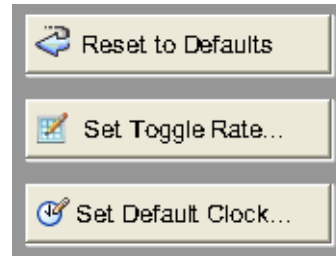


Figure 4: Reset, Toggle Rate, and Default Clock Buttons

## Voltage Source Summary

The Summary tab is organized by the voltage rails. As more than one power supply is required to power an FPGA design, the  $V_{CCINT}$ ,  $V_{CCO}$ , and  $V_{CCAUX}$  supplies power the various resources in the FPGA. Table 2 summarizes resources in Xilinx FPGAs and the power source that typically powers them. This table is provided only as a guideline because these details may vary across Xilinx device families.

**Note:** FPGAs containing MGTs (Multi Gigabit Transceivers) have MGT-specific power supplies. For information on these MGT-specific power supplies, see the applicable MGT User Guide.

Table 2: FPGA Resources and the Power Supply that Typically Powers Them

Power Supply	Resources Powered
$V_{CCINT}$	<ul style="list-style-type: none"> <li>All CLB resources</li> <li>Most configuration SRAM cells</li> <li>All routing resources</li> <li>Entire clock tree, including all clock buffers</li> <li>Block RAM</li> <li>DSP blocks (DSP48, DSP48A, DSP48E<sup>(1)</sup>)</li> <li>All input buffers</li> <li>Logic elements in the IOB (ILOGIC/OLOGIC<sup>(1)</sup>)</li> <li>ISERDES/OSERDES<sup>(1)</sup></li> <li>PowerPC™ processor<sup>(1)</sup></li> <li>Tri-Mode Ethernet MAC<sup>(1)</sup></li> <li>DCM (minor)</li> </ul>
$V_{CCAUX}$	<ul style="list-style-type: none"> <li>IODELAY<sup>(1)</sup></li> <li>Differential Input buffers</li> <li><math>V_{REF}</math>-based, single-ended I/O standards, e.g., HSTL18_I</li> <li>Clock Managers (DCM, PLL, PMCD)<sup>(1)</sup></li> <li>IDELAYCTRL</li> <li>Some Configuration memory</li> </ul>
$V_{CCO}$	<ul style="list-style-type: none"> <li>All output buffers</li> <li>Some input buffers</li> <li>Digitally controlled impedance<sup>(2)</sup></li> </ul>

**Notes:**

1. These resources are available only in certain device families. Refer to the appropriate data sheets and user guides for more information.
2.  $V_{CCO}$  in bank 0 ( $V_{CCO_0}$  or  $V_{CCO\_CONFIG}$ ) powers all I/Os in bank 0 as well as the configuration circuitry. See the applicable [Configuration User Guide](#).

## Thermal Information

Since junction temperature should not exceed the maximum ratings (85°C for Commercial and 100°C for Industrial), it is important to know the junction temperature at which the design should perform. In predicting the junction temperature, the **Thermal Information** section of the **Summary** tab accepts ambient temperature, air flow in linear feet per minute (LFM), or even a custom sink-to-ambient thermal resistance value through a specified range. These ranges can be viewed by using the comment indicators. Alternatively, if a heatsink is needed and the heatsink details are known, a custom sink-to-ambient thermal resistance should be used. To account for the thermal resistance of the board, a **Board Selection** can be made from a list of five board sizes (**Small (4"x4")**, **Medium (10"x10")**, **Large (20"x20")**, **Custom**, and **JEDEC (2S2P)**). By default, **Airflow** is set to 250 LFM. The number of layers on the board can also be modeled. The **# of Board Layers** can have an appreciable effect on the die-to-board heat transfer coefficient (or thermal resistance parameter called  $\Theta_{JB}$ ). For accurate junction temperature estimates, all of this data is important. The JEDEC board is a test board as specified in EIA/JESD51-9 (see reference in the Preface). Depending on the board selected, XPE reports precalculated junction temperatures for various settings. See [Figure 5](#).

Thermal Information	
Ambient Temp (°C)	50.0
Airflow (LFM)	250
Heat Sink	Medium Profile
Custom $\Theta_{SA}$ (°C/W)	3.0
Board Selection	Medium (10"x10")
# of Board Layers	8 to 11
Custom $\Theta_{JB}$ (°C/W)	2.4
Board Temperature	
Thermal Summary	
Effective $\Theta_{JA}$ (°C/W)	3.0
Max Ambient (°C)	81.5
Junction Temp(°C)	53.5

Figure 5: Summary Tab - Thermal Information and Thermal Summary

For more details about the thermal parameters of the Xilinx Power Estimator, please refer to Chapter 3: Thermal Management & Thermal Characterization Methods & Conditions of the [Device Package User Guide](#) (UG112).

## Power Summary

Figure 6 shows the **Power Summary** section of the **Summary** tab.

Power Summary	
Optimization	None
Data	Production
Quiescent(W)	1.612
Dynamic (W)	4.023
Total (W)	5.635

Figure 6: Summary Tab - Power Summary

The information in the Power Summary section is:

- **Optimization**

The **Optimization** selection should be considered when you have used optimization options in Synthesis and Implementation tools within ISE. The levels are:

- ◆ **None** - Design implemented without any power optimization settings.
- ◆ **Typical** - Design implemented with power optimization and average improvement results expected.
- ◆ **Worst Case** - Design implemented with power optimization and least improvement results expected.

- **Data**

Data designations will reflect the characterization data level as follows:

- ◆ **Advance** - The data integrated into XPE with this designation is based primarily on measurements and characterization data made on early production devices. A set of widely used device resources are included in the characterization. Characterization data is limited to these few blocks. This data is typically available within a year of product launch. Although the data with this designation is considered relatively stable and conservative, some under-reporting or over-reporting might occur. Advanced data accuracy is considerably lower than the Preliminary and Production data.
- ◆ **Preliminary** - The data integrated into XPE with this designation is based on complete early production silicon. Almost all the blocks in the device fabric are characterized. Data for most of the dedicated blocks like TEMAC and PCIe block are also characterized and integrated into the XPE. The probability of accurate power reporting is improved as compared to Advanced data.
- ◆ **Production** - The data integrated into XPE with this designation is released after enough production silicon of a particular device family member has been characterized to provide full power correlation over numerous production lots. Characterization data for all blocks in the device fabric is included.

- **Quiescent (W), Dynamic (W), and Total (W)**

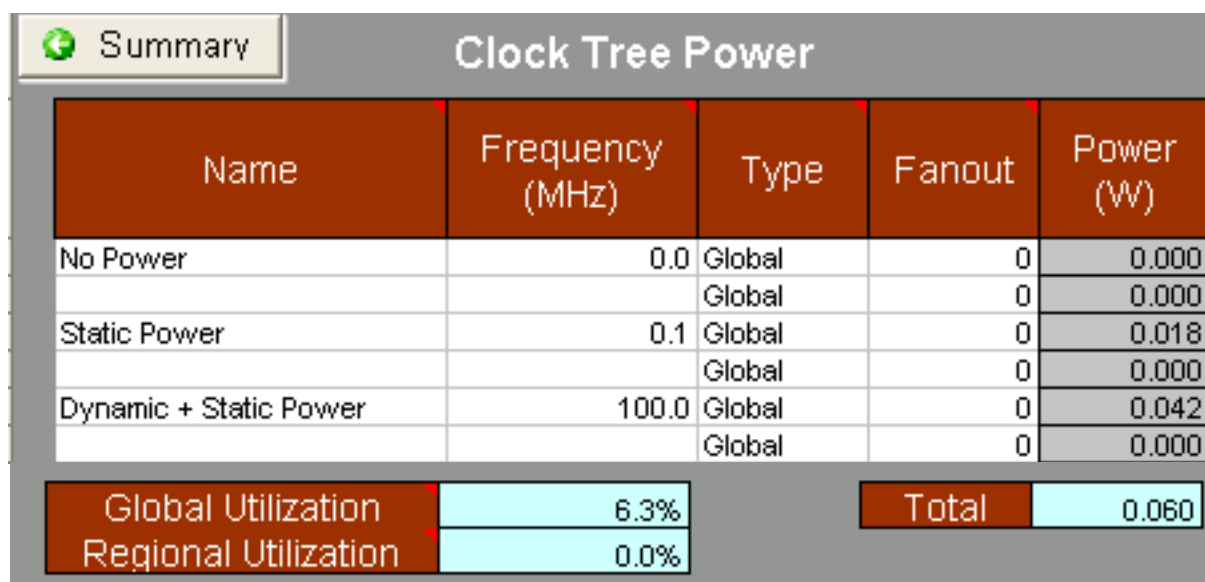
The quiescent and dynamic power are reported for the entire device and both are added up in the **Total** power box.

## Clock Tab

An important factor in dynamic power calculation is the load capacitance that needs to be switched. With clocks typically having higher fan-outs, the capacitance and therefore the power associated with clock nets can be significant and is thus reported separately. The clock types can be selected using the drop-down menu in the **Type** column for each clock:

- **Global** - These clocks are assumed to be driven by a BUFG.
- **Regional** - These clocks are driven by a BUFR. The **Regional** selection only applies to Virtex-4 and Virtex-5 families.
- **Other** - These are intended to be used for logic-generated clocks, clocks from non-clock I/O or any clock other than a global or regional clock not using the dedicated clock resources.

Figure 7 shows the **Global** type as an example.



Name	Frequency (MHz)	Type	Fanout	Power (W)
No Power	0.0	Global	0	0.000
		Global	0	0.000
Static Power	0.1	Global	0	0.018
		Global	0	0.000
Dynamic + Static Power	100.0	Global	0	0.042
		Global	0	0.000

Global Utilization	6.3%	Total	0.060
Regional Utilization	0.0%		

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Figure 7: Clock Tree Power

Because of its buffered interconnect structure, the clock tree has two components, a dynamic component and a static component. If the clock's frequency is zero, the dynamic power is also zero. Every clock net has a minimum, frequency-independent, fan-out-insensitive static power component. This static power from enabling the clock tree can be seen by entering a small clock frequency value signifying that global buffers have been instantiated but have no loads (Fanout = 0). This is actually equal to the number of slice flip-flops, block RAM, I/O flip-flops, distributed RAM, and shift registers.

**Note:** The PAR Report in ISE contains the slice fanout for the clock tree. XPE needs the FF level fanout to calculate power.



## Understanding Toggle Rates

A less intuitive detail is modeling the toggle rates for the various sections of the design or estimating an average toggle rate for the entire design. Toggle rate reflects how often an output changes relative to a given clock input and can be modeled as a percentage between 0–100%. The max data toggle rate of 100% means that if the clock frequency is 100 MHz, a data toggle rate of 100% equates to a data frequency of 50 MHz. This convention stems from an assumption that a net with a 100% toggle rate toggles every rising (or falling) edge of a clock whose frequency is specified. So, this means that the LSB of a 16-bit counter toggles every clock cycle and the MSB toggles every 32,768<sup>th</sup> clock cycle. The default toggle rate picked by XPE is 12.5%, which accounts for the average toggle rate of a 16-bit counter.

For nonperiodic or event-driven state machine designs, toggle rates cannot be easily predicted. An effective method of estimating average toggle rates for a given design is to segregate the different sections of the design based on their functionality and estimate the toggle rates for each of the sub-blocks. An average toggle rate can then be arrived at by calculating the average for the entire design. Most logic-intensive designs work at around 12.5% average toggle rate, which is the default toggle rate setting in XPE. For a worst-case estimate, a toggle rate of 20% can be used. Average toggle rates greater than 20% are not very common. Arithmetic-intensive modules of a design seem to take toggle rates of up to 50%, which is representative of the absolute worst case. An example of this would be a Multiply-Accumulate operation. It is also common to model toggle rate for random input data at 50%. Data toggle rate should be scaled by the Clock Enable rates. If data toggle rate is modeled at 50% but the slice logic is clock-enabled 50 percent of the time, the resulting toggle rate should be 25%. To appreciate what 100% toggle rate means, think of a constantly enabled toggle flip-flop (TFF) whose data input is tied High. The T-output of this flip-flop toggles every clock edge. Very few designs could possibly have an average toggle rate that high (100%).

## I/O Tab

With higher switching speeds and capacitive loads, switching I/O power can be a substantial part of the total power consumption of an FPGA. Because of this, it is important to accurately define all parameters related to I/Os in the I/O tab of XPE.

An I/O pin should be modeled as an output when its Output Enable signal is active and as an input when the Output Enable signal is disabled. Accordingly, XPE considers the I/O as an input when the **Output Enable** rate is set to 0%. If no outputs are set (the **Output Pins** column says "0"), the **Output Enable** setting does not affect the power consumption. In the bidirectional I/O case, XPE allows the **Output Enable** rate to be set between 0-100% (limits-inclusive). However, a bidirectional I/O that is used only as an output consumes more power than one configured as output only. This is because the input receiver and/or on-chip termination is used and draws static current. When no 3-state enables are used on outputs, leave the **Output Enable** rate set to 100%, which is the default option.

[Figure 9](#) shows the **I/O Power** tab illustrating the effect of output enable rate on power estimates for inputs, outputs, and bidirectional I/Os.

Name	I/O Standard	Clock (MHz)	Input Pins	Output Pins	Bidir Pins	Bank	Toggle Rate	Output Enable	Output Load (pF)	Data Rate	V <sub>CCINT</sub> Power (W)	V <sub>CCAUX</sub> Power (W)	V <sub>CCO</sub> On-chip Thermal Power (W)	V <sub>CCO</sub> Supply Current(A)
Input Only 100% OE	SSTL2 Class II	200.0	50	0	0		12.5%	100.0%	30	SDR	0.069	0.340	0.000	1.250
Input Only 50% OE	SSTL2 Class II	200.0	50	0	0		12.5%	50.0%	30	SDR	0.069	0.340	0.000	1.250
Output Only 100% OE	SSTL2 Class II	200.0	0	50	0		12.5%	100.0%	30	SDR	0.003	0.007	0.429	0.542
Output Only 50% OE	SSTL2 Class II	200.0	0	50	0		12.5%	50.0%	30	SDR	0.003	0.004	0.215	0.271
Bidirectional 100% OE	SSTL2 Class II	200.0	0	0	50		12.5%	100.0%	30	SDR	0.003	0.007	0.429	0.542
Bidirectional 50% OE	SSTL2 Class II	200.0	0	0	50		12.5%	50.0%	30	SDR	0.036	0.174	0.215	0.896
Output with 0% OE	SSTL2 Class II	200.0	0	50	0		12.5%	0.0%	30	SDR	0.003	0.000	0.000	0.000

Name	I/O Standard	Clock (MHz)	Input Pins	Output Pins	Bidir Pins	Bank
Input Only 100% OE	SSTL2 Class II	200.0	50	0	0	
Input Only 50% OE	SSTL2 Class II	200.0	50	0	0	
Output Only 100% OE	SSTL2 Class II	200.0	0	50	0	
Output Only 50% OE	SSTL2 Class II	200.0	0	50	0	
Bidirectional 100% OE	SSTL2 Class II	200.0	0	0	50	
Bidirectional 50% OE	SSTL2 Class II	200.0	0	0	50	
Output with 0% OE	SSTL2 Class II	200.0	0	50	0	

Toggle Rate	Output Enable	Output Load (pF)	Data Rate	V <sub>CCINT</sub> Power (W)	V <sub>CCAUX</sub> Power (W)	V <sub>CCO</sub> On-chip Thermal Power (W)	V <sub>CCO</sub> Supply Current(A)
12.5%	100.0%	30	SDR	0.069	0.340	0.000	1.250
12.5%	50.0%	30	SDR	0.069	0.340	0.000	1.250
12.5%	100.0%	30	SDR	0.003	0.007	0.429	0.542
12.5%	50.0%	30	SDR	0.003	0.004	0.215	0.271
12.5%	100.0%	30	SDR	0.003	0.007	0.429	0.542
12.5%	50.0%	30	SDR	0.036	0.174	0.215	0.896
12.5%	0.0%	30	SDR	0.003	0.000	0.000	0.000

Figure 9: I/O Tab - Effect of Output Enable Rate on Power Estimates for Inputs, Outputs, and Bidirectional I/Os

Different I/O standards have different termination requirements. A significant proportion of I/O power can be accounted for through I<sup>2</sup>R loss in these terminations. I/O standards such as HSTL and SSTL require terminations to V<sub>TT</sub> which can be an independent or derived power supply from V<sub>CCO</sub>. The V<sub>CCO</sub> supply current reported by XPE assumes that these terminations are as required by the I/O standard and that V<sub>TT</sub> is derived from V<sub>CCO</sub>. Refer to the applicable *FPGA User Guide* (listed in “Additional Resources”) for specific terminations recommended and used by XPE for calculations.

Some I/O standards (especially those that involve open drain drivers) can contribute no appreciable power draw from the V<sub>CCO</sub> supply that powers the driver while drawing power from the receiver’s V<sub>CCO</sub>. These drivers can potentially contribute only to the I<sup>2</sup>R power loss rather than drawing any current from the driver’s V<sub>CCO</sub> rail. As these I/Os contribute purely to the junction temperature estimate, XPE additionally reports V<sub>CCO</sub> on-chip thermal power which is only used in predicting junction temperature for the design.

XPE calculates the portion of  $V_{CC0}$  dissipated on-chip for thermal considerations. It also calculates the required supply current including current drawn into off-chip termination resistors.

Toggle rates for I/Os are typically in the range of 10–15%. The default setting is 12.5%. The most conservative or worst-case I/O power estimates can be reasonably modeled using toggle rates of 30–35%. For differential I/O standards such as LVDS, DIFF\_HSTL, etc., enter the number of pairs of differential pins. For example, to model 8 LVDS input pairs (16 pins), enter 8 into the corresponding cell in **Input Pins** column. [Figure 10](#) shows a portion of an I/O Tab showing a differential pair count entry.

		I/O Power												
Name	I/O Standard	Clock (MHz)	Input Pins	Output Pins	Bidir Pins	Bank	Toggle Rate	Output Enable	Output Load (pF)	Data Rate	$V_{CCINT}$ Power (W)	$V_{CCAUX}$ Power (W)	$V_{CC0}$ On-chip Thermal Power (W)	$V_{CC0}$ Supply Current (A)
8 LVDS Input Pairs	LVDS (pair)	200.0	8	0	0		12.5%	100.0%	0	SDR	0.000	0.052	0.000	0.000
	LVC MOS 2.5V 12mA (Slow)	0.0	0	0	0		12.5%	100.0%	0	SDR	0.000	0.000	0.000	0.000
16 LVDS Output Pairs	LVDS (pair)	200.0	0	16	0		12.5%	100.0%	0	SDR	0.001	0.000	0.351	0.148
	LVC MOS 2.5V 12mA (Slow)	0.0	0	0	0		12.5%	100.0%	0	SDR	0.000	0.000	0.000	0.000
			<b>Count</b>	16	32	0				<b>Subtotal</b>	0.001	0.052	0.351	

Name	I/O Standard	Clock (MHz)	Input Pins	Output Pins	Bidir Pins
8 LVDS Input Pairs	LVDS (pair)	200.0	8	0	0
	LVC MOS 2.5V 12mA (Slow)	0.0	0	0	0
16 LVDS Output Pairs	LVDS (pair)	200.0	0	16	0
	LVC MOS 2.5V 12mA (Slow)	0.0	0	0	0
		<b>Count</b>	16	32	0

Figure 10: I/O Power Tab - Differential Pair Count Entry



## BRAM (Block RAM) Tab

All Spartan-3 generation, Virtex-4, and Virtex-5 devices offer True dual-port block RAM configurations. In True dual-port mode, the block RAM can be written independently to either or both ports (A and B) and can be read from either or both ports, provided both ports do not address the same memory location at the same time. Each port can also use an independent clock. Distributed RAM (LUTRAM and SRL16) usage should be specified on the [“Logic Tab”](#). If implementation details of the block RAM are known, follow the guidelines under the [“For Better Accuracy”](#) section. If implementation details of the block RAM are not known, refer to [“Preliminary BRAM Estimates”](#).

For more details about the block RAM configurations, refer to the applicable *FPGA User Guide* (listed below). Each *FPGA User Guide* has a dedicated chapter about BRAM that is important to be familiar with in order to accurately set all BRAM parameters in the **Block RAM** tab of XPE.

- [Spartan-3 Generation FPGA User Guide](#)
- [Virtex-4 FPGA User Guide](#)
- [Virtex-5 FPGA User Guide](#)

### Preliminary BRAM Estimates

If the exact block RAM types and modes to be used in the design are unknown, the best approach is to determine how many kilobytes of memory are needed in the design and use the appropriate number of basic 18k True dual-port RAMs. Use the Virtex-4 RAMB16 and Virtex-5 RAMB18 modes for such estimates. If the data width of memory access is known, select this from the drop-down menu for each port. Depth and width are the two most important characteristics of a memory.

The toggle rate, enable rate, clock frequency, and number of blocks also should be specified in the **BRAM** tab of the XPE spreadsheet. The enable rate specifies the percentage of time during which the block RAM ports are enabled for reading and/or writing. To save power, the RAM enable can be driven Low on clock cycles when the block RAM is not used in the design. BRAM Enable Rate, together with Clock Rate, are important parameters that must be considered for power optimization. The enable rate specifies the percentage of time during which the block RAM ports are enabled for reading and/or writing. To save power, the RAM enable can be driven Low on clock cycles when the block RAM is not used in the design.

The write rate represents the percentage of time that each block RAM port performs write operations. The read rate is understood to be 100% – write rate.

[Figure 11](#) illustrates the effect of block RAM configuration modes and bit widths on power estimates.

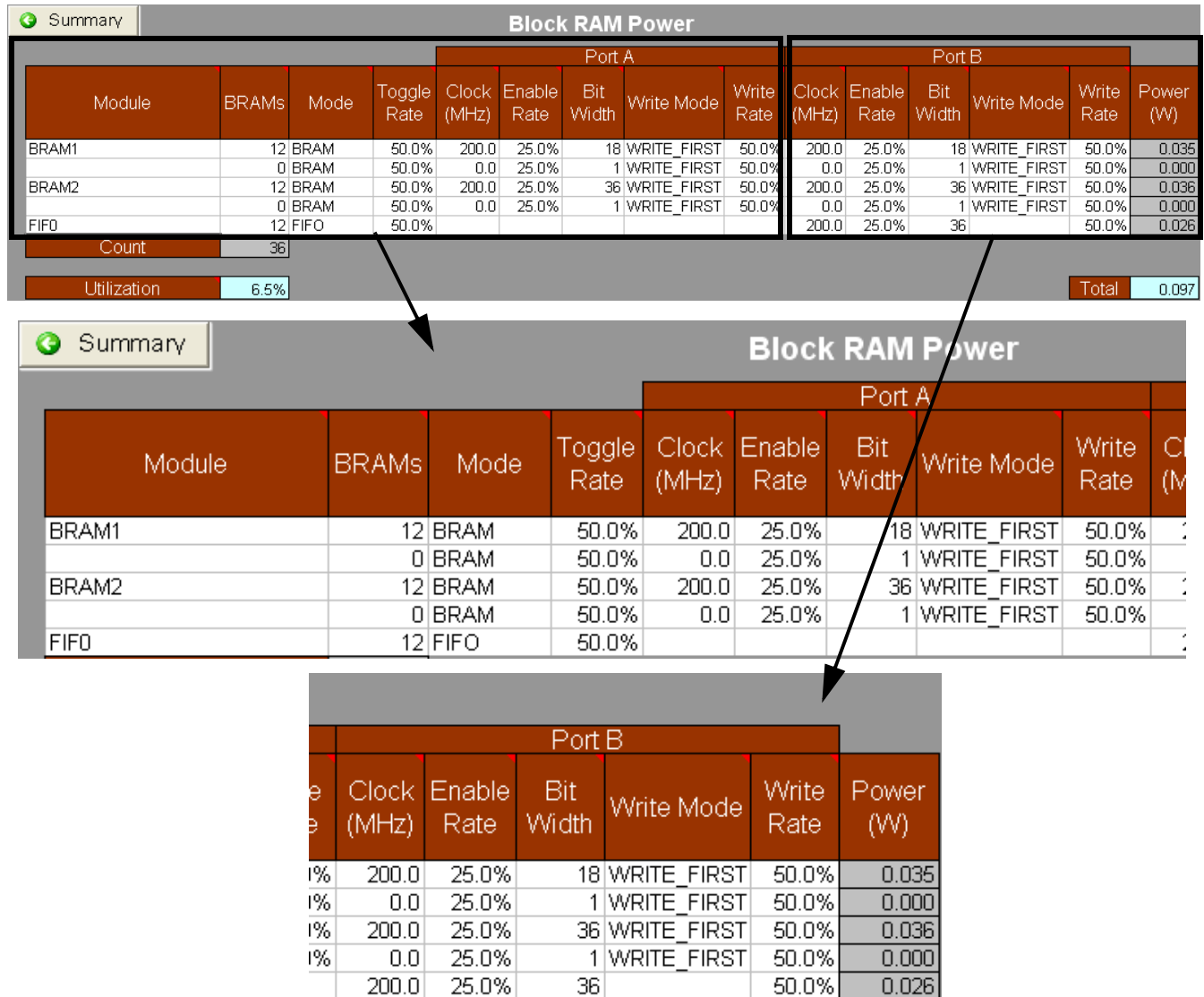


Figure 11: Block RAM Tab - Effect of Block RAM Configuration Modes and Bit Widths on Power Estimates

### For Better Accuracy

If the breakdown of the memory usage of your design is known, the Virtex-4 and Virtex-5 XPE spreadsheets allow you to specify which block RAM modes are being used. The Mode column has selectable values from a drop down menu that lists the different SW primitives and modes of the block RAM. These include:

- **BRAM** - Simple dual-port or True dual-port Block RAM,
- **FIFO** - Dedicated built in FIFO,
- **CASC (pair)** - Cascaded block RAM blocks (built from two RAM blocks), and
- **ECC** - when the block RAM is configured in ECC mode. (See the Virtex-4 or Virtex-5 User Guide, referenced in the Preface.)

In True dual-port mode the following data write mode options are available:

1. **WRITE\_FIRST** – The port will first write to the location and then read out the newly written data.
2. **READ\_FIRST** – The old data is first read out and then the new data is written in. This mode effectively allows 4 operations per clock cycle (saving power or resource utilization) – as the old data can be read out and replaced with new data on the same clock cycle of each port.
3. **NO\_CHANGE** – When a Write happens the block RAM outputs remain unchanged.

In Virtex-5, there are separate Simple dual-port primitives, which are defined as having one read-only port and one write-only port. This allows the Virtex-5 Simple dual-port primitives to support double the max Virtex-5 True dual-port port width. RAMB18 Simple dual-port has max port width 36 and RAMB36 Simple dual-port has max port width 72, whereas the True dual-port RAMB18 has max port width 18 and True dual-port RAMB36 has max port width 36.

True dual-port can be used as a Simple dual-port for smaller port widths by choosing to use one True dual-port as a read-only port and one True dual-port as a write-only port. For True dual-port SW primitives used as a Simple dual-port in your design, use the following settings in XPE:

- Write Rate = 100% would be “always-write” on one port
- Write Rate = 0% would be “always-read” on the other port

Similarly, a True dual-port primitive can be configured as a two-port ROM by changing the write rate to 0% on the two ports intended to be read-only.

[Figure 12](#) shows the **BRAM** tab and illustrates the effect of write modes on power estimates.

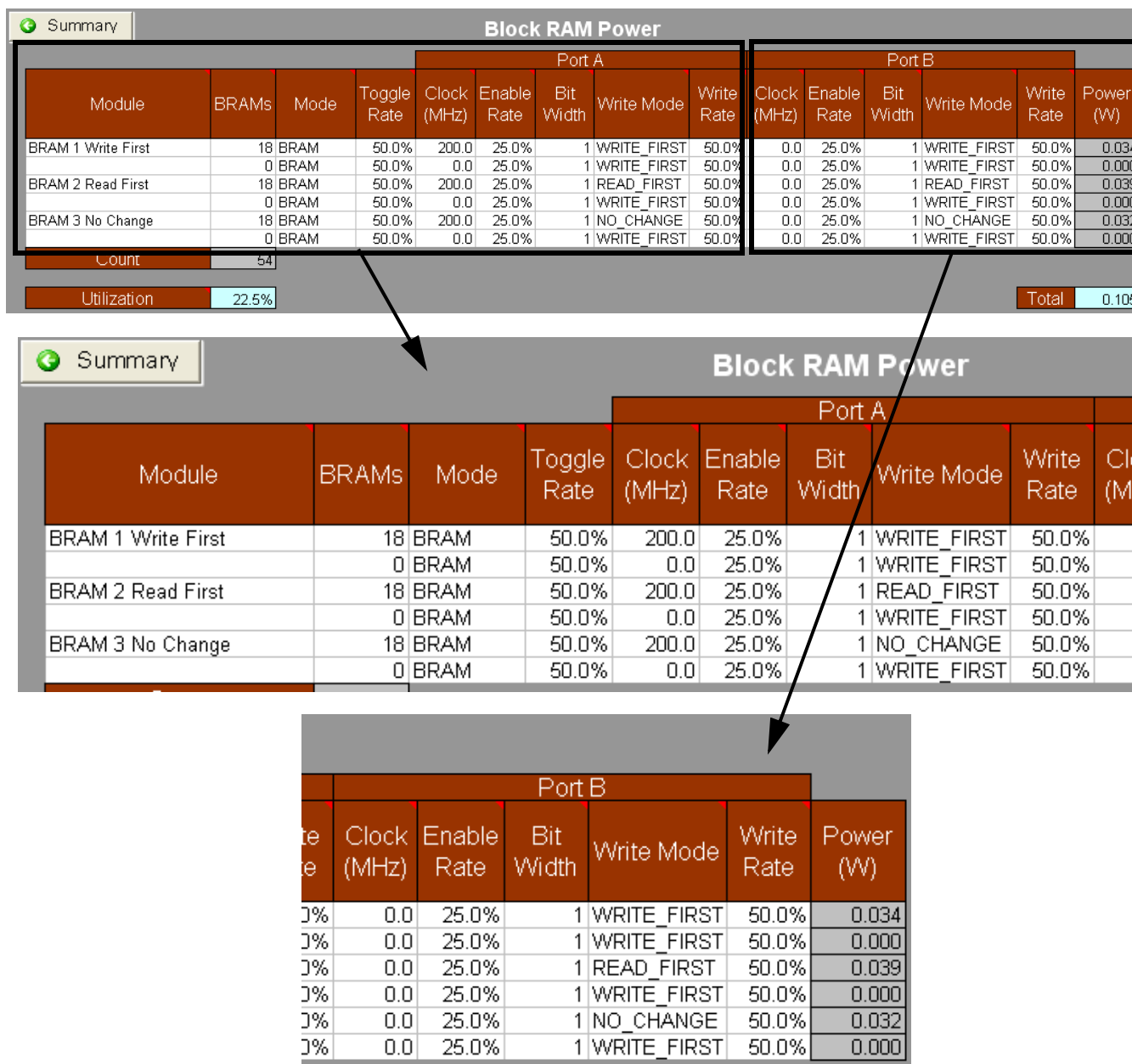


Figure 12: Block RAM Tab - Effect of Write Modes on Power Estimates

In addition, in Virtex-5, two 18k block RAMs can share the same site in place of a 36k block RAM. Two RAMB18s are the same as one RAMB36 block in terms of resource utilization and power consumption. Similarly, a cascaded pair of X1 RAMB36 block RAMs constituting a 72k memory occupies two RAMB36 sites.

Information on power consumed by the built-in ECC and FIFO logic is also available in XPE. For more information on Virtex-5 block RAM (True dual-port/Simple dual-port), ECC, CASC (a pair of cascaded block RAMs) and FIFO operations, please refer to the [Virtex-5 FPGA User Guide](#).

## DCM, PMCD, and PLL Tabs

The Digital Clock Manager (DCM) in a Xilinx FPGA is used to implement features such as a delay locked loop, a digital frequency synthesizer, a digital phase shifter, or a digital spread spectrum. Modeling power consumption for this component involves only two parameters: the clock frequency of the CLKIN port (**Clock (MHz)**) and the frequency mode to which the instantiated DCM is set (**Freq Mode**). More information regarding DCM feature can be find in the [FPGA User Guide](#) for the applicable FPGA device family.

Figure 13 shows the **DCM Power** tab and the effect of frequency mode and clock frequency on power estimates.

Name	Clock (MHz)	Freq Mode	V <sub>CCINT</sub> (W)	V <sub>CCAUX</sub> (W)	V <sub>CCAUXQ</sub> (W)	
DCM 1	150.0	Low	0.018	0.030	0.033	
		Low	0.000	0.000	0.000	
DCM 2	500.0	High	0.039	0.100	0.044	
		Low	0.000	0.000	0.000	
Subtotal			0.057	0.130	0.078	
Utilization		16.7%		Total		0.265

Figure 13: DCM Power Tab - Effect of Frequency Mode and Clock Frequency on Power Estimates

The PMCD (Phase-Matched Clock Divider) block, which is unique to the Virtex-4 FPGAs, can also be modeled by entering the input clock frequency. Figure 14 shows the **PMCD Power** Tab and the effect of clock frequency on power estimates. For detailed PMCD information, see the [Virtex-4 FPGA User Guide](#).

Name	Clock (MHz)	V <sub>CCINT</sub> (W)	V <sub>CCAUX</sub> (W)	V <sub>CCAUXQ</sub> (W)		
PMCD 1	150.0	0.001	0.003	0.014		
	0.0	0.000	0.000	0.000		
PMCD 2	500.0	0.003	0.010	0.014		
	0.0	0.000	0.000	0.000		
	0.0	0.000	0.000	0.000		
	0.0	0.000	0.000	0.000		
	0.0	0.000	0.000	0.000		
Subtotal		0.005	0.013	0.028		
Utilization		25.0%		Total		0.045

Figure 14: PMCD Power Tab - Effect of Clock Frequency on Power Estimates

The PLL (Phase-Locked Loop) is unique to the Virtex-5 devices. The multiply and divide factors are used to set the VCO output of the PLL. Each tap from the PLL has a divide factor and each used output clock should have the appropriate factor to obtain the actual clock frequency from VCO. For detailed PLL information, see the *Virtex-5 FPGAs User Guide*.

Figure 15 shows the **PLL Power** tab.

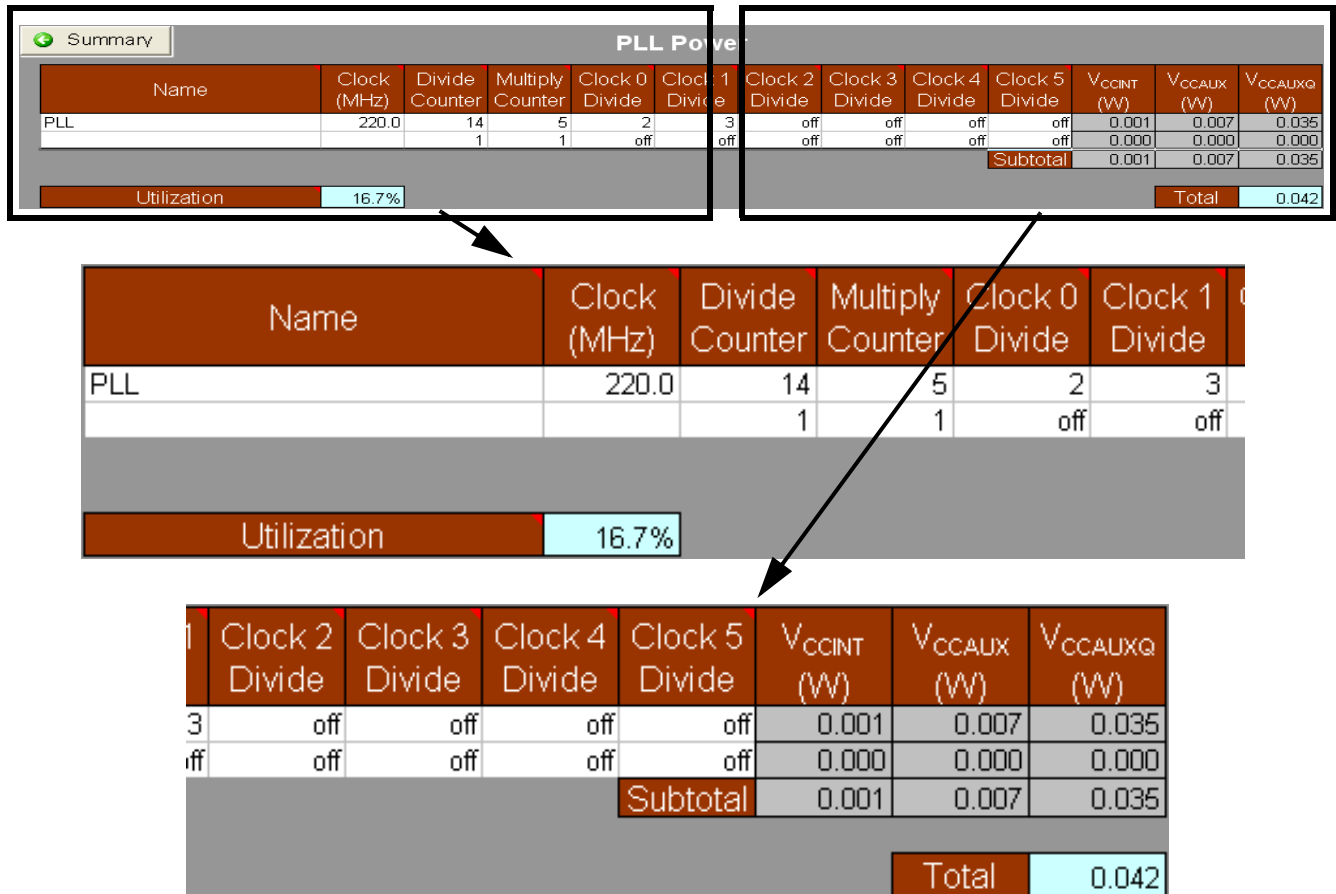


Figure 15: PLL Power Tab

## MULT and DSP48 Tabs

This section shows the data entries required for the block multiplier section and is used to estimate how much power each module consumes.

### Multiplier

Block multipliers are available in Spartan-3A and Spartan-3E FPGAs. The toggle rate column in Figure 16 represents the average toggle rate of the outputs.

Multiplier Power				
Module	Multipliers	Clock (MHz)	Toggle Rate	Power (W)
Mult1	1	150.0	12.5%	0.002
	0	0.0	12.5%	0.000
Mult2	1	150.0	25.0%	0.005
	0	0.0	12.5%	0.000
Mult3	1	150.0	37.5%	0.007
	0	0.0	12.5%	0.000
<b>Count</b>	<b>3</b>			
<b>Utilization</b>	<b>15.0%</b>		<b>Total</b>	<b>0.014</b>

Figure 16: Multiplier Power Tab

### DSP Slices

DSP48 slices are available in Virtex-4 FPGAs and DSP48E slices are available in Virtex-5 FPGAs. DSP48A slices are available in Spartan-3A DSP devices. A DSP slice consists of an optionally pipelined multiplier-accumulator with dedicated input/output cascaded buses. For random input data, DSP48 operation should be modeled at 50% data toggle rate. CE rate must be factored into the data toggle rate, for example, if random data (50% data toggle rate) is input into the DSP48 slice but the DSP48 slice is clock-enabled only 50% of the time, the data toggle rate should be scaled by the CE rate such that data toggle rate is 25%.

Figure 17 shows the DSP48 Power Tab and the effect of toggle rate on power estimates.

Summary		DSP48 Power				
Module	DSP48 Slices	Clock (MHz)	Toggle Rate	MREG Used?	Power (W)	
DSP Random	10	100.0	50.0%	Yes	0.030	
DSP Default TR	10	100.0	12.5%	Yes	0.008	
DSP Max Frequency	10	500.0	12.5%	Yes	0.038	
DSP No MREG	10	100.0	12.5%	No	0.009	
<b>Count</b>	<b>40</b>					
<b>Utilization</b>	<b>41.7%</b>			<b>Total</b>	<b>0.084</b>	

Figure 17: DSP48 Power Tab - Effect of Clock, Toggle Rate, and MREG on Power Estimates

Other than toggle rate and clock frequency, the multiplier and MREG also affect the power in Virtex-5 DSP48E slices. If the multiplier is not used, the DSP slice can still be used for add/subtract/accumulate or logic unit operations, which consume less power. If the multiplier is used, the MREG attribute determines whether the multiplier output is registered (MREG = 1 leads to reduced power consumption) or unregistered.

Figure 18 shows the DSP48E Power Tab illustrating the effect of MREG and MULT usage on power estimates.

Summary		DSP48E Power					
Name	DSP Slices	Clock (MHz)	Toggle Rate	MREG Used?	MULT Used?	Power (W)	
DSP Random	10	100.0	50.0%	Yes	Yes	0.018	
DSP Default Toggle Rate	10	100.0	12.5%	Yes	Yes	0.005	
DSP Max Frequency	10	500.0	12.5%	Yes	Yes	0.023	
DSP No MREG	10	100.0	12.5%	No	Yes	0.005	
DSP No MULT	10	100.0	12.5%		No	0.003	
<b>Count</b>	<b>50</b>						
<b>Utilization</b>	<b>78.1%</b>			<b>Total</b>	<b>0.053</b>		

Figure 18: DSP48E Power Tab - Effect of MREG and MULT Usage on Power Estimates



## MGT and GT Tabs

This section describes the data entries required for the block RocketIO MGT (Multi-Gigabit Transceiver) tabs which are used to estimate how much power the MGTs consume.

MGTs are available in the Virtex-4 and Virtex-5 architectures. The MGT block requires separate, well filtered, power supplies. The supply nomenclature and the voltages are different for each of the families.

For Virtex-5 devices two types of MGTs are supported: GTP and GTX.

- GTP operates up to 3.75Gb/s. GTP transceivers are available in the LXT and SXT members of the Virtex-5 family.
- GTX operates up to 6.50Gb/s. GTX transceivers are available in the FXT members of the Virtex-5 family.

For details on MGTs, see these User Guides:

- [Virtex-4 RocketIO Multi-Gigabit Transceiver User Guide](#)
- [Virtex-5 RocketIO GTX Transceiver User Guide](#)
- [Virtex-5 RocketIO GTP Transceiver User Guide](#)

The power supplies used for Virtex-5 MGTs (GTP and GTX) and the primary parameter defining the current are shown in [Table 2](#).

**Table 3: MGTs and the Power Supplies that Typically Power Them**

Supply Name	Description	Parameter	Nominal Voltage
VCCINT	Used to power PCS (Digital/Logic section of the MGT). Same supply as used for fabric	TX/RXUSRCLK	1.00V
MGTAVCC	Used to power high speed digital logic for PMA (Analog section of the MGT)	Data Rate or VCO Frequency	1.00V
MGTAVCC_PLL	Used to power the PMA PLL. (GTP uses 1.20V and GTX uses 1.00V)	VCO Frequency	1.00/1.20V
MGCAVTTTX	Termination supply for Transmitter	TX Amplitude	1.20V
MGCAVTTX	Termination supply for Receiver	None	1.20V

The XPE spreadsheet automatically selects the correct MGT type (GTP or GTX) depending on the device chosen in the **Summary** tab. Each MGT comprises a Transceiver, both Transmitter and Receiver.

[Figure 19](#) shows the GT tab for an FX70T device. The resulting power for each of the five supplies is shown to the right of the spreadsheet. To simplify the choices, pop-down menus are provided with parameter preferred or required values.

GTX_DUAL Power												
Name	GTXs	Data Rate (Gb/s)	Operational Mode	Data Path	TX O/P	VCO (GHz)	V <sub>CCINT</sub> Power (W)	MGTAV <sub>CC</sub> Power (W)	MGTAV <sub>CCPLL</sub> Power (W)	MGTAV <sub>TTTX</sub> Power (W)	MGTAV <sub>TTRX</sub> Power (W)	
	4	3.20	Transceiver	10	500	3.2	0.080	0.234	0.154	0.104	0.097	
	4	6.50	Transceiver	10	800	3.25	0.163	0.236	0.156	0.109	0.097	
		3.20	Transceiver	10	800	1.6	0.000	0.000	0.000	0.000	0.000	
		3.20	Transceiver	10	800	1.6	0.000	0.000	0.000	0.000	0.000	
		3.20	Transceiver	10	800	1.6	0.000	0.000	0.000	0.000	0.000	
		3.20	Transceiver	10	800	1.6	0.000	0.000	0.000	0.000	0.000	
		3.20	Transceiver	10	800	1.6	0.000	0.000	0.000	0.000	0.000	
		3.20	Transceiver	10	800	1.6	0.000	0.000	0.000	0.000	0.000	
		3.20	Transceiver	10	800	1.6	0.000	0.000	0.000	0.000	0.000	
		3.20	Transceiver	10	800	1.6	0.000	0.000	0.000	0.000	0.000	
		3.20	Transceiver	10	800	1.6	0.000	0.000	0.000	0.000	0.000	
		3.20	Transceiver	10	800	1.6	0.000	0.000	0.000	0.000	0.000	
		3.20	Transceiver	10	800	1.6	0.000	0.000	0.000	0.000	0.000	
Count	8						0.243	0.470	0.310	0.213	0.194	
Utilization	100.0%						Total	1.429				
Unused GTX_DUALs	Grounded											

Figure 19: GT Power Tab Illustrating the Effect of Data Rate and TX O/P Usage on Power Estimates

User defined columns and rows in the spreadsheet are.

- **GTXs**

You can select up to the maximum number of available GTX transceivers for the chosen device (**Count**). The FX70T device has 8 GTX\_DUAL or 16 GTXs which represent 100% of the MGT resources (**Utilization**).

- **Data Rate (GHz)**

Although the device can operate over a wide range of datarates up to 6.50Gb/s, the most popular data rates have been included in the tool. Select the data rate closest to your application. More power is consumed by the MGTs at higher data rates.

- **Operational Mode**

By using power management capability built into the device, the MGT can be operated as a Transceiver (both Transmitter and Receiver), a Transmitter only, or a Receiver only. Note that the Virtex-5 MGT uses a shared PLL architecture so the PLL supply will indicate the same current if either the Transmitter or the Receiver is used.

- **Data Path**

The datapath is the byte width of data used in the PCS; either 8 or 10bits. Along with the data rate, this parameter is used to determine TX and RX USRCLK frequency which determines the PCS power.

- **TX O/P**

The TX amplitude can be adjusted on the MGT to suit a particular application (channel attenuation). **TX O/P** is the differential output voltage and corresponds to eight settings, 0-7, on the TXDIFFCTRL port. **TX O/P** only affects the MGTAVTTTX supply.

- **VCO (GHz)**

For GTX the PLL operates in the range 1.50-3.25GHz. The VCO frequency is automatically selected when you enter the data rate. Typically VCO frequency = Data Rate / 2.

Some data rates allow for two values of VCO frequency. For example, Data Rate = 3.2Gb/s permits the VCO to be operated at either 3.20GHz or 1.60GHz. Operating the

VCO at higher frequencies may results in lower jitter, but operating the VCO at lower frequency will result in lower power for the MGTAVCC\_PLL supply.

• **Unused GTX\_DUALs**

Use **Unused GTP/X\_DUALs** to specify how you wish the unused GTP/X transceivers to be powered. Selections are either **Powered** or **Grounded**.

- ◆ **Powered** - Use this setting if you intend to power up the unused GTX transceivers. This setting is required if you use Clock Forwarding since the MGTCLK requires filtered power to provide a copy of the clock to the used GTs.
- ◆ **Grounded** - Use this option for the lowest GTP or GTX power. With the exception of AVCC for GTP, the supplies for the unused GTPs or GTXs can be connected to GROUND. For GTP, AVCC is required to be powered up to maintain the functionality of the Boundary Scan Chain. For GTX all supplies can be grounded without affecting the functionality of the Bound.

**Note:** For Virtex-5 LXT and SXT devices, XPE assumes that you require the Boundary Scan Chain to be functional and the AVCC supply will show static current.

For details on how to connect unused GTP and GTX transceivers, see the applicable User Guide:

- [Virtex-5 RocketIO GTX Transceiver User Guide](#)
- [Virtex-5 RocketIO GTP Transceiver User Guide](#)

## EMAC and TEMAC Tabs

The Virtex-4 and Virtex-5 device families contain Tri-Mode Embedded Ethernet Media Access Controller (MAC) blocks, which are used in Ethernet applications. The Ethernet MACs are paired within a TEMAC block, share a common host and DCR interface, but are independently configurable to meet all common Ethernet system connectivity needs.

For TEMAC information, see the [Virtex-4 FPGA Embedded Tri-Mode Ethernet MAC User Guide](#) or the [Virtex-5 FPGA Embedded Tri-Mode Ethernet MAC User Guide](#).

In XPE, the Virtex-4 spreadsheet contains an **EMAC** tab and the Virtex-5 spreadsheet contains a **TEMAC** tab. For power estimation, you need only enter the operating clock frequency of the EMAC (See [Figure 20](#)). You will need to know the mode and operating speed to obtain the correct clock frequency.

Summary			TEMAC Power		
Name	Core Clock (MHz)	Power (W)			
1Gbps_Ethernet	125.0	0.019			
		0.000			
		0.000			
		0.000			
<b>Utilization</b>	25.0%	0.019			

Figure 20: TEMAC Power Tab

## PCIE Tab

The Virtex-5 device family contains Integrated Endpoint Block for PCI Express® designs (integrated Endpoint block). The Virtex-5 FPGA Integrated Endpoint block provides the full functionality of the Transaction Layer, the Data Link Layer, the Physical Layer, and the Configuration.

Space as per the *PCI Express® Base Specification Revision 1.1*. The integrated Endpoint block has two synchronous clock domains: core\_clk and user\_clk. The user\_clk domain allows user logic in the fabric to run at a slower speed than the integrated Endpoint block in x1, x2, or x4 modes. For power estimation you need to enter the core and user clock frequencies and the number of lanes used (See [Figure 21](#)).

For detailed PCIE information, see the *Virtex-5 FPGA Integrated Endpoint Block for PCI Express Designs User Guide*.

PCI Express Power				
Name	Core Clock (MHz)	User Clock (MHz)	Number of Lanes	Power (W)
PCI Express	250.0	62.5	2	0.309
			1	0.000
			1	0.000
			1	0.000
Utilization		33.3%	Total	
			0.309	

Figure 21: PCIE Power Tab

## PPC405 and PPC440 (PowerPC) Tabs

The Virtex-4 and Virtex-5 device families contain high-performance PowerPC® microprocessor embedded blocks.

The Virtex-4 device family contains 32-bit PowerPC® 405 microprocessors. For power estimation the main components of the PPC405 embedded processor block are the processor, the processor local bus (PLB), and the on-chip memory (OCM). In the **PPC** tab (See [Figure 22](#)), you will need to set the correct clock frequencies for the processor, PLB, DCR (Device Control Register), and the OCM.

For detailed PPC405 information, see the *PowerPC 405 Processor Block Reference Guide*.

Processor Power						
Name	PPC Clock (MHz)	PLB Clock (MHz)	DCR Clock (MHz)	OCM Clock (MHz)	Power (W)	
PPC405	100.0	100.0	100.0	100.0	0.038	
	0.0	0.0	0.0	0.0	0.000	
Utilization	50.0%				Total	0.038

Figure 22: PPC405 Power Tab

The Virtex-5 device family contains PowerPC 440 microprocessors. For power estimation the main components of the PPC440 embedded processor block are the processor, the interconnect crossbar including its interfaces, and the DMA controllers. In the **PPC440** tab (See Figure 23), you will need to set the correct clock frequencies for the processor, interconnect crossbar, and any DMA controllers used. Selecting **Maximum** for the **Process** in the **Summary** tab of XPE will estimate the worst case power consumption of the processor embedded block.

For detailed PPC440 information, see the *Embedded Processor Block in Virtex-5 FPGAs Reference Guide*.

PPC440 Power								
Name	PPC440 Clock (MHz)	Interconnect Clock (MHz)	DMA 0 Clock (MHz)	DMA 1 Clock (MHz)	DMA 2 Clock (MHz)	DMA 3 Clock (MHz)	Power (W)	
PPC440	250.0	125.0	125.0				0.414	
							0.000	
Utilization	50.0%						Total	0.414

Figure 23: PPC440 Power Tab

## Conclusion

The ability to estimate power consumption in a design is imperative for board layout and device reliability. The means of doing so is difficult, however, with a little thought and effort, accurate power estimation may be made early in the design cycle. The Xilinx Power Estimator tool is designed for ease of use with Spartan-3 Generation, Virtex-4, and Virtex-5 FPGAs.

For an analysis of the steps performed in using XPE to do a power analysis, see the following document:

*WP353: Seven Steps to an Accurate Worst-Case Power Analysis Using Xilinx Power Estimator (XPE)*

The XPE spreadsheets are available on the Xilinx website at: <http://www.xilinx.com/power>.

