



Early SSN Estimator User Guide for Altera Programmable Devices



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Use the early SSN estimator (ESE) to estimate the simultaneous switching noise (SSN) in your designs during the early design phase. This avoids going through extensive pre- and post-layout simulations. The early SSN estimator is a Microsoft Excel-based spreadsheet tool for calculating the worst-case quiet low/quiet high noise seen at the far end of the victim pin induced by multiple aggressors switching simultaneously.

The early SSN calculator assumes typical process, voltage, and temperature (PVT) conditions for the targeted device and the PCB board under development. The spreadsheet requires only basic design-specific information such as the I/O standard, current strength, slew rate, and number of simultaneous switching I/Os.

 The early SSN estimator models the SSN generated by inductive crosstalk. Current draw of the switching buffers may create power delivery network (PDN) resonance and cause PDN compression. PDN compression due to resonance is different from the SSN described here. Improving PDN design reduces PDN compression.

The results obtained through the spreadsheet tool are intended only as an estimate of the worst case noise and not as a specification. The actual results observed on your board may vary due to differences between your PCB design and the assumed typical design conditions used by the calculator. For designers who intend to get a very accurate noise estimate based on their specific PCB design, Altera recommends using a post-layout simulation approach, taking into account the various parameters such as board stackup, via breakout, power delivery network design, and trace spacing specific to the design.

This user guide describes how to use the early SSN estimator to estimate the far-end noise induced on the victim pin.

Application of the Tool

The purpose of the tool is to provide a rough estimate on the amount of SSN within the design during the early design phase. This spreadsheet tool is very useful when exploring the various “what-if” scenarios to study the impact on the observed noise seen using different drive strengths, various number of simultaneous switching I/Os, different VCCIO voltage standards, and various I/O settings.

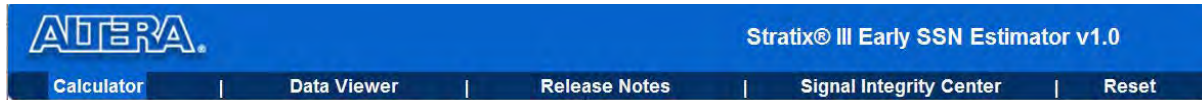
Setting up the Early SSN Estimator

The ESE spreadsheet consists of the following tabs ([Figure 1-1](#)):

- **Calculator**—the primary tab where you input the relevant design information to estimate the amount of SSN noise.
- **Data Viewer**—gives a schematic view of the noise profile of individual I/O standards as a function of the number of I/Os. The Data Viewer tab is independent of the Calculator tab. It only displays the noise profile of the I/O standard that is set in the Data Viewer tab regardless of the I/O standards selected for the various banks in the Calculator tab.

- **Release Notes**—contains information about the current version of the tool. It also lists the changes from the previous versions of the tool.
- **Signal Integrity Center**—provides a link to information dedicated exclusively to signal integrity on Altera’s website (www.altera.com).
- **Reset**—used to clear all the data that is entered into the Calculator tab.

Figure 1-1. Tabs in the ESE Tool



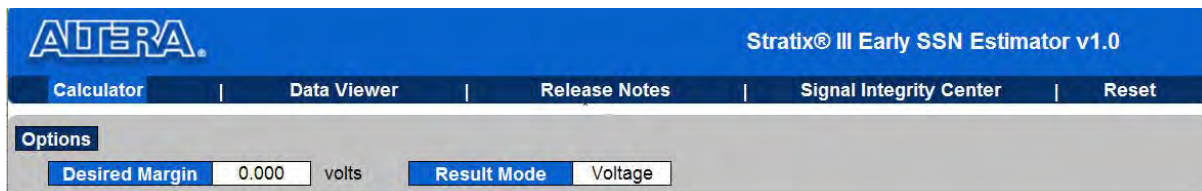
In the **Calculator** tab, there are two kinds of parameters:

- Global parameters
- Parameters Specific to I/O Bank

Global Parameters

[Figure 1-2](#) shows the global parameters (desired margin and result mode) listed under the **Options** section in the **Calculator** tab. The ESE calculates the far-end noise, assuming a worst-case placement of pins. Worst-case pin placement assumes that aggressor pins are packed as closely as possible to the worst-case victim pin.

Figure 1-2. Defining Global Parameters



Desired Margin

The desired margin sets the amount of margin that you want to allocate for non-SSN related items. This margin is applicable to all banks that are populated in the **Calculator** tab. By default, the ESE assumes that the entire noise margin is allocated to SSN. You can enter this value in either volts or percentage of noise margin, depending on the setting you chose in the Result Mode parameter.

Result Mode

The ESE can report results in two different formats: volts and percentage margin. The default format is to report both noise and margin in volts. In percentage margin mode, noise is reported as volts but the margin is expressed as a percentage of the total zero-noise margin. When the victim net is driven low, [Equation 1-1](#) is used. When driven high, [Equation 1-2](#) is used.

Equation 1-1. Victim Net Driven Low

$$V_{IL \text{ margin } (K)} = \left\{ 1 - \left[\frac{(QLN_{(K)} - QL)}{(V_{IL \text{ Max}(DC)} - QL)} \right] \right\} * 100 \text{ where}$$

$V_{IL \text{ margin } (K)}$ = Signal Margin Low when K aggressors are switching simultaneously

K = Number of I/Os switching simultaneously

$QLN_{(K)}$ = Quiet Low Noise when K aggressors are switching simultaneously

QL = Quiet Low Voltage (No aggressors switching)

$V_{IL \text{ Max}(DC)}$ = Receiver Maximum DC Input Low Voltage

Equation 1-2. Victim Net Driven High

$$V_{IH \text{ margin } (K)} = \left\{ 1 - \left[\frac{(QH - QHN_{(K)})}{(QH - V_{IH \text{ Min}(DC)})} \right] \right\} * 100 \text{ where}$$

$V_{IH \text{ margin } (K)}$ = Signal Margin High when K aggressors are switching simultaneously

K = Number of I/Os switching simultaneously

$QHN_{(K)}$ = Quiet High Noise when K aggressors are switching simultaneously

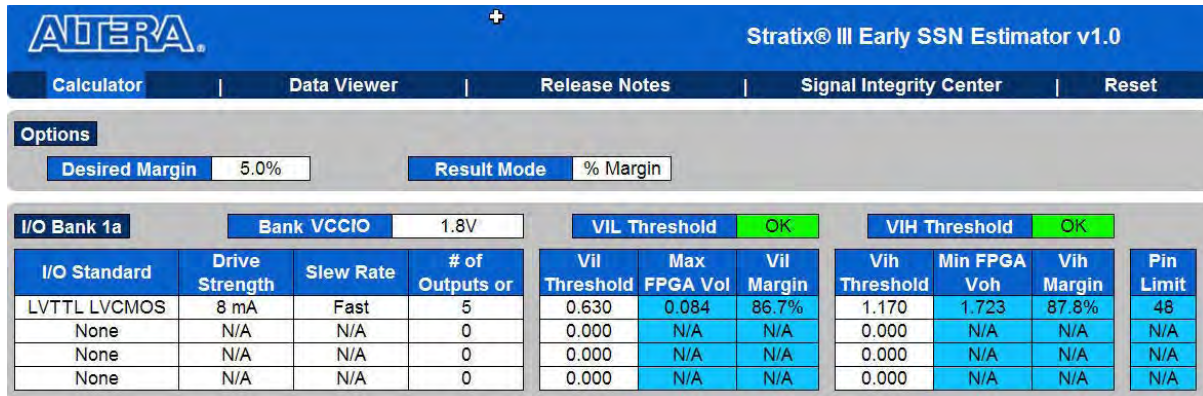
QH = Quiet High Voltage (No aggressors switching)

$V_{IH \text{ Min}(DC)}$ = Receiver Minimum DC Input High Voltage

Figure 1-3 shows the ESE calculations for Bank1a when five I/Os are switching simultaneously using LVTTTL18 8-mA drive strength with a fast slew rate interface. The example goes through the calculation to arrive at the V_{IL}/V_{IH} margin that is being reported by the ESE tool.

Although each Altera device family has its own Early SSN tool, the methodology behind these tools is the same. The following examples use the Stratix III Early SSN tool.

Figure 1-3. V_{IL}/V_{IH} Margin Calculation



From Figure 1-3 for the victim driven low, the various parameters are as follows:

$$K = 5$$

$$QLN(5) = 0.084 \text{ V}$$

$$QL = 0$$

$$VIL \text{ max (DC)} = 0.630 \text{ V}$$

$$VIL \text{ margin (5)} = \{1 - [(0.084 - 0)/(0.63 - 0)]\} * 100 = 86.7\%$$

Similarly, for the victim driven high, the various parameters are as follows:

$$K = 5$$

$$QHN(5) = 1.723 \text{ V}$$

$$QH = 1.8 \text{ V}$$

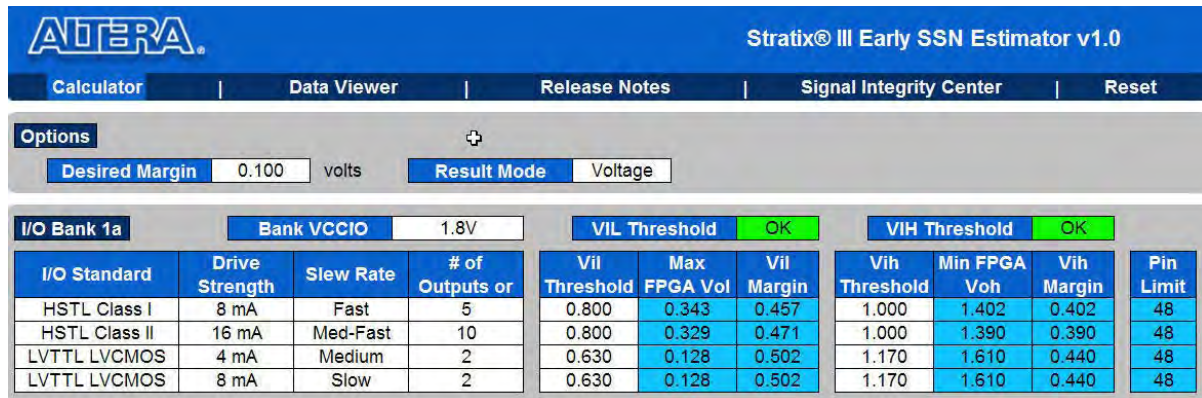
$$VIH \text{ min (DC)} = 1.17 \text{ V}$$

$$VIH \text{ margin (5)} = \{1 - [(1.8 - 1.723)/(1.8 - 1.17)]\} * 100 = 87.8\%$$

Parameters Specific to the I/O Bank

Figure 1-4 shows the ESE parameters for a given bank.

Figure 1-4. Parameters Specific to an I/O Bank



- **Bank VCCIO**—All pins in an I/O bank share a common VCCIO voltage. Sharing the VCCIO voltage restricts the combinations of legal I/O standards that can be present within an I/O bank. Selecting a VCCIO voltage automatically populates the I/O standard drop-down box with the set of I/O standards that are supported by the given VCCIO voltage.
- **I/O Standard**—The calculator supports up to four different I/O standards in a single bank. If the I/O standard you are interested in is not shown in the drop down box, ensure that the bank VCCIO voltage has been set correctly.
- **Drive Strength**—Altera devices support multiple drive strengths depending on the I/O standard. This drop down menu allows you to select valid values.
- **Slew Rate**—Altera programmable devices support the control of the output slew-rate that you can configure to balance noise and performance. A faster slew rate provides high-speed transitions for high-performance systems. A slow slew rate helps reduce system noise, but adds a nominal delay to rising and falling edges.



The **slew rate control** option is not available for all Altera programmable devices. For example, Stratix II GX devices do not offer the slew rate option.

- **Number of Outputs or Bidirectional Pins**—The ESE tool models simultaneously switching outputs-induced SSN. Switching inputs are not modeled because the ESE has no information on what device is driving an FPGA input. Enter the number of outputs or bidirectional pins that correspond to your selected I/O standard and drive strength.
- **$V_{IL(DC)}$ / $V_{IH(DC)}$ Thresholds**—The ESE bases its margin estimates on the input thresholds of the receiving device. By default, the $V_{IL(DC)}$ and $V_{IH(DC)}$ parameters are automatically populated with their I/O standard-specific values when you select an I/O standard. You can manually change the values to any threshold values.

Not all banks shown in the ESE tool are available in all Altera programmable devices. The number of I/O banks available and bank size depends on the device density.

Interpreting Early SSN Estimator Results

The ESE reports four types of results for use in guiding your early I/O design—output low/high voltages, input threshold margins, margin okay indicators, and maximum pin limit—as shown in [Figure 1-4](#).

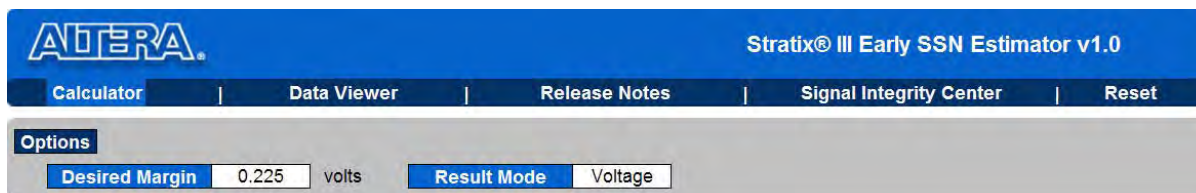
- Max FPGA V_{OL} —The maximum voltage output low parameter reports the highest voltage that an FPGA pin can output when driving a low value, taking into account SSN-induced noise.
- Min FPGA V_{OH} —The minimum voltage output high parameter reports the lowest voltage that an FPGA pin can output when driving a high value, taking into account SSN-induced noise.
- V_{IL} Margin/ V_{IH} Margin—This parameter indicates how much additional noise the output can tolerate before violating the $V_{IL(DC)}$ voltage input low or $V_{IH(DC)}$ voltage input high thresholds at the receiver.
- V_{IL}/V_{IH} Threshold Indicator—These indicators are a quick way to verify if all the I/O standards of a given bank have sufficient margin. If all the checks pass, the indicators are green. If any margin is violated, the indicators are red.
- Pin Limit—The pin limit indicates the maximum number of pins of the corresponding I/O standard that you can use without violating noise margins, assuming that all other I/O standard pin counts are held constant. For an I/O standard, if the number of outputs switching is less than or equal to the pin limit indicated, the V_{IL}/V_{IH} threshold indicators are green.

This tutorial describes how you can add ten 1.8-V LVTTTL pins to a bank filled with ten 1.8-V SSTL Class I 12 mA and ten 1.8-V SSTL Class II 16 mA drivers. In this tutorial you are targeting a voltage margin of 225 mV to account for other non-SSN related items. Use the ESE to determine if you might have problems.

Step 1: Configure the Global Parameters


1. Configure result mode to display the results in **Voltage**.
2. Enter a desired margin of 0.225 volts, as shown in [Figure 2-1](#).

Figure 2-1. Global Parameters Configuration



Step 2: Assign I/O Standards to the Corresponding Bank

1. Set the I/O Bank 1a VCCIO to **1.8 V**.
2. Select the I/O Standard **SSTL Class I** in row one.
3. Select a drive strength of **12 mA**.
4. Select **Fast** slew rate.

 Not all Altera device families have the **slew rate control** option.

5. Enter **10** as the number of output pins.
6. Select the I/O Standard **SSTL Class II** in row two.
7. Select a drive strength of **16 mA**.
8. Select **Fast** slew rate.

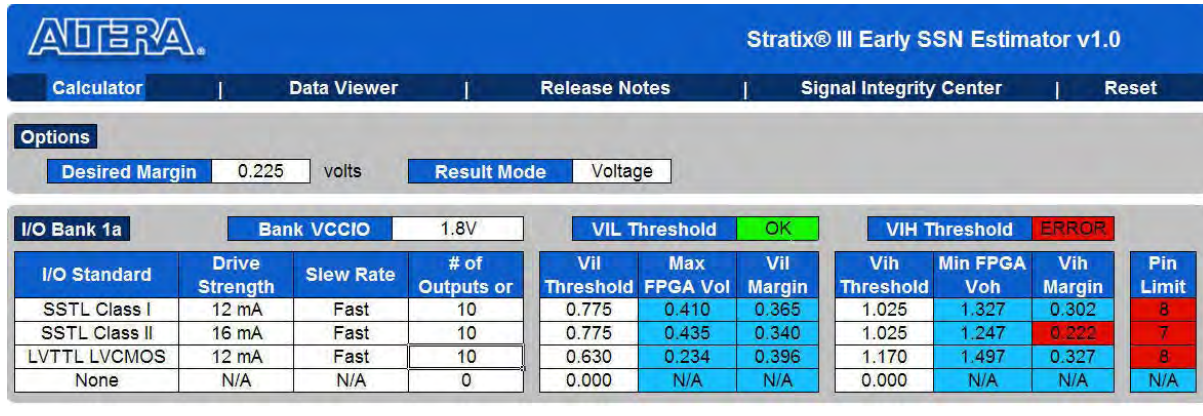
 Not all Altera device families have the **slew rate control** option.

9. Enter **10** as the number of output pins.
10. Select the I/O standard **LVTTTL** in row three.
11. Select a drive strength of **12 mA**.
12. Select **Fast** slew rate.

 Not all Altera device families have the **slew rate control** option.

13. Enter **10** as the number of output pins, as shown in [Figure 2-2](#).

Figure 2-2. Local Parameters Assignment



Step 3: Interpret the Results

- The V_{IH} threshold indicator is red, indicating that a margin has been violated.
- The V_{IH} margin for SSTL Class II is 0.222 V (less than the 0.225 V that you want for your design). This is highlighted in red to indicate that it is lower than the desired margin.
- The pin limit for SSTL Class II is seven pins. This means that if the number of outputs for SSTL Class II is reduced to seven, the margin will no longer be violated.
- The pin limit for LVTTTL is eight pins. This means that only eight LVTTTL pins can be safely combined with ten SSTL Class I and ten SSTL Class II pins under the entered drive strengths and slew rate for the given desired margin of 0.225 V that you set.

Step 4: Fixing the Problem

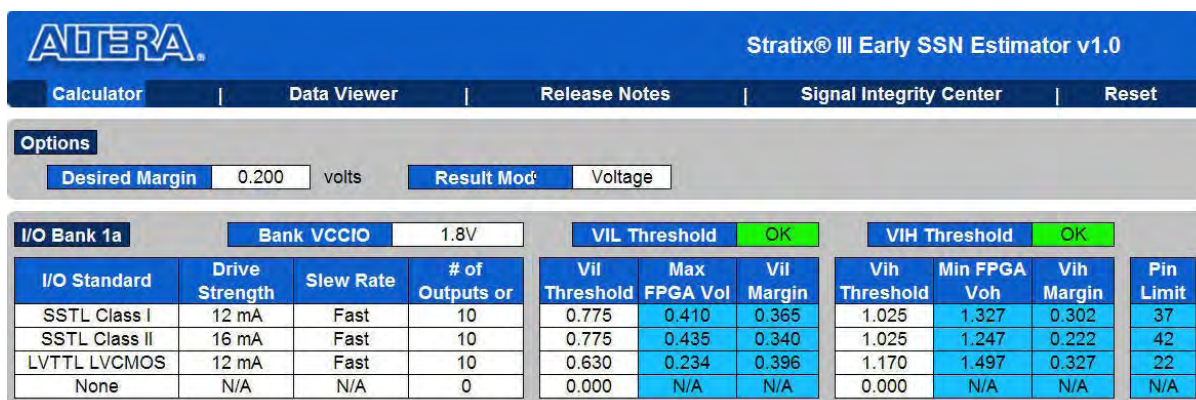
There are multiple approaches to fix the issue.

First Approach

Reduce the amount of margin that you want to allocate for non-SSN-related items from 225 mV to 200 mV, as shown in [Figure 2-3](#).

The pin limit for LVTTTL increased from 8 to 22, thereby allowing you to implement your design with ten SSTL Class II I/Os and ten SSTL Class II I/Os, along with ten LVTTTL output pins.

Figure 2-3. First Approach

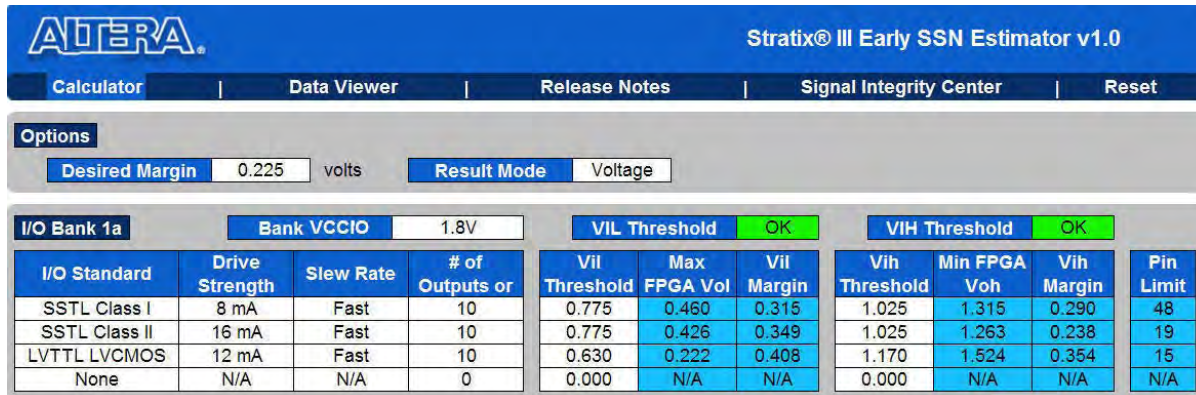


Second Approach

If the timing margin allows, reduce the current drive strength for the SSTL Class I buffers from 12 mA to 8 mA, keeping the desired voltage margin at 225 mV for non-SSN-related items, as shown in Figure 2-4.

This decrease in drive strength reduces the SSN sufficiently to allow you to implement your design with ten SSTL Class I and ten SSTL Class II I/Os, along with ten LVTTTL I/Os with sufficient margin.

Figure 2-4. Second Approach



Third Approach

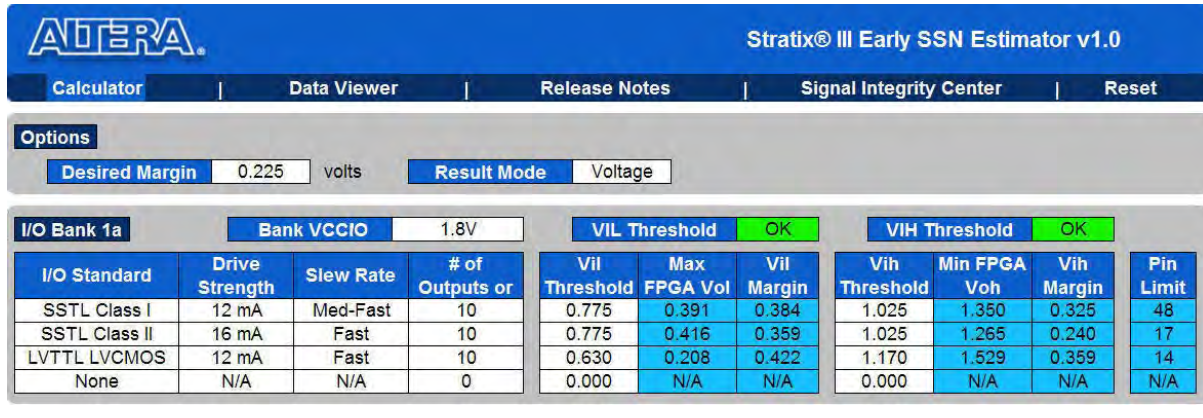
If the design allows, change the slew rate control SSTL Class I I/O to medium-fast, keeping the desired voltage margin at 225 mV for non-SSN related items, as shown in Figure 2-5.

Changing the slew rate setting from fast to medium-fast reduces the SSN sufficiently to allow you to implement your design with ten SSTL Class I and ten SSTL Class II I/Os, along with ten LVTTTL I/Os with sufficient margin.



Not all Altera device families have slew rate control option.

Figure 2-5. Third Approach



Revision History

The following table shows the revision history for this user guide.

Date	Version	Changes Made
November 2009	1.0	Initial release.

How to Contact Altera

For the most up-to-date information about Altera® products, see the following table.

Contact <i>(Note 1)</i>	Contact Method	Address
Technical support	Website	www.altera.com/support
Technical training	Website	www.altera.com/training
	Email	custrain@altera.com
Altera literature services	Email	literature@altera.com
Non-technical support (General) (Software Licensing)	Email	nacomp@altera.com
	Email	authorization@altera.com








Note:

(1) You can also contact your local Altera sales office or sales representative.

Typographic Conventions

The following table shows the typographic conventions that this document uses.

Visual Cue	Meaning
Bold Type with Initial Capital Letters	Command names, dialog box titles, checkbox options, and dialog box options are shown in bold, initial capital letters. Example: Save As dialog box.
bold type	External timing parameters, directory names, project names, disk drive names, file names, file name extensions, and software utility names are shown in bold type. Examples: t_{MAX} , \qdesigns directory, d: drive, chiptrip.gdf file.
<i>Italic Type with Initial Capital Letters</i>	Document titles are shown in italic type with initial capital letters. Example: <i>AN 75: High-Speed Board Design</i> .
<i>Italic type</i>	Internal timing parameters and variables are shown in italic type. Examples: <i>t_{PIA}</i> , <i>n + 1</i> . Variable names are enclosed in angle brackets (< >) and shown in italic type. Example: <file name>, <project name>.pdf file.
Initial Capital Letters	Keyboard keys and menu names are shown with initial capital letters. Examples: Delete key, the Options menu.

Visual Cue	Meaning
"Subheading Title"	References to sections within a document and titles of on-line help topics are shown in quotation marks. Example: "Typographic Conventions."
Courier type	Signal and port names are shown in lowercase Courier type. Examples: <code>data1</code> , <code>tdi</code> , <code>input</code> . Active-low signals are denoted by suffix <code>n</code> , e.g., <code>resetn</code> . Anything that must be typed exactly as it appears is shown in Courier type. For example: <code>c:\qdesigns\tutorial\chiptrip.gdf</code> . Also, sections of an actual file, such as a Report File, references to parts of files (e.g., the AHDL keyword <code>SUBDESIGN</code>), as well as logic function names (e.g., <code>TRI</code>) are shown in Courier.
1., 2., 3., and a., b., c., etc.	Numbered steps are used in a list of items when the sequence of the items is important, such as the steps listed in a procedure.
	Bullets are used in a list of items when the sequence of the items is not important.
	The checkmark indicates a procedure that consists of one step only.
	The hand points to information that requires special attention.
	A caution calls attention to a condition or possible situation that can damage or destroy the product or the user's work.
	A warning calls attention to a condition or possible situation that can cause injury to the user.
	The angled arrow indicates you should press the Enter key.
	The feet direct you to more information on a particular topic.