



Intel® Quartus® Prime Standard Edition User Guide

Scripting

Updated for Intel® Quartus® Prime Design Suite: **18.1**



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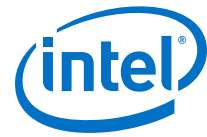


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1. Command Line Scripting

FPGA design software that easily integrates into your design flow saves time and improves productivity. The Intel® Quartus® Prime software provides you with a command-line executable for each step of the FPGA design flow to make the design process customizable and flexible.

The command-line executables are completely interchangeable with the Intel Quartus Prime GUI, allowing you to use the exact combination of tools that best suits your needs.

1.1. Benefits of Command-Line Executables

Intel Quartus Prime command-line executables give you precise control over each step of the design flow, reduce memory requirements, and improve performance.

You can group Intel Quartus Prime executable files into a script, batch file, or a makefile to automate design flows. These scripting capabilities facilitate the integration of Intel Quartus Prime software and other EDA synthesis, simulation, and verification software. Automatic design flows can perform on multiple computers simultaneously and easily archive and restore projects.

Command-line executables add flexibility without sacrificing the ease-of-use of the Intel Quartus Prime GUI. You can use the Intel Quartus Prime GUI and command-line executables at different stages in the design flow. For example, you might use the Intel Quartus Prime GUI to edit the floorplan for the design, use the command-line executables to perform place-and-route, and return to the Intel Quartus Prime GUI to perform debugging.

Command-line executables reduce the amount of memory required during each step in the design flow. Since each executable targets only one step in the design flow, the executables themselves are relatively compact, both in file size and the amount of memory used during processing. This memory usage reduction improves performance, and is particularly beneficial in design environments where heavy usage of computing resources results in reduced memory availability.

Related Information

[About Command-Line Executables](#)
in Intel Quartus Prime Help

1.2. Introductory Example

Create a new Intel Quartus Prime project, fit the design, and generate programming files with this example included with the Intel Quartus Prime software.

If installed, the tutorial design is located in the *<Intel Quartus Prime directory>/qdesigns/fir_filter* directory.



1. Ensure that *<Intel Quartus Prime directory>/quartus/bin* directory is in your PATH environment variable.
2. Copy the tutorial directory in a local folder.
3. In a console, type the four commands in the new project directory:

```
quartus_map filtref --source=filtref.bdf --family="Cyclone V"
quartus_fit filtref --part=EP3C10F256C8 --pack_register=minimize_area
quartus_asm filtref
quartus_sta filtref
```

- a. With the first instruction you create a new Intel Quartus Prime project named **filtref**, set the top-level file as *filtref.bdf*, set Cyclone® V as the target device family, and perform logic synthesis and technology mapping on the design files.
 - b. The second command performs place and route by fitting the **filtref** project into the specified device, and directs the Fitter to pack sequential and combinational functions into single logic cells to reduce device resource usage.
 - c. The third command creates a device programming image for the **filtref** project.
 - d. The last line performs basic timing analysis on the **filtref** project using the Intel Quartus Prime Timing Analyzer, reporting worst-case setup slack, worst-case hold slack, and other measurements.
4. Create a batch file or script file with the commands, like the UNIX shell script below:

```
#!/bin/sh
PROJECT=filtref
TOP_LEVEL_FILE=filtref.bdf
FAMILY="Cyclone V"
PART=EP3C10F256C8
PACKING_OPTION=minimize_area
quartus_map $PROJECT --source=$TOP_LEVEL_FILE --family=$FAMILY
quartus_fit $PROJECT --part=$PART --pack_register=$PACKING_OPTION
quartus_asm $PROJECT
quartus_sta $PROJECT
```

5. Execute the script and compile your project.

Related Information

[Intel Quartus Prime Scripting Reference Manual](#)

1.3. Command-Line Scripting Help

Help for command-line executables is available through different methods. You can access help built into the executables with command-line options. You can use the Intel Quartus Prime Command-Line and Tcl API Help browser for an easy graphical view of the help information.

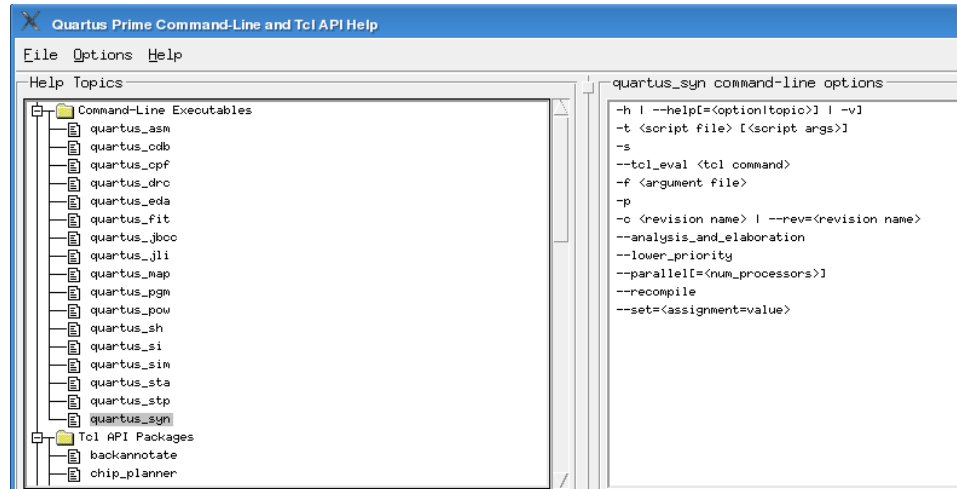
To use the Intel Quartus Prime Command-Line and Tcl API Help browser, type the following command:

```
quartus_sh --qhelp
```

This command starts the Intel Quartus Prime Command-Line and Tcl API Help browser, a viewer for information about the Intel Quartus Prime Command-Line executables and Tcl API.

Use the `-h` option with any of the Intel Quartus Prime Command-Line executables to get a description and list of supported options. Use the `--help=<option name>` option for detailed information about each option.

Figure 1. Intel Quartus Prime Command-Line and Tcl API Help Browser



1.4. Project Settings with Command-Line Options

The Intel Quartus Prime software command-line executables accept arguments to set project variables and access common settings.

To make assignments to an individual entity you can use the Intel Quartus Prime Tcl scripting API. On existing projects, you can also open the project in the Intel Quartus Prime GUI, change the assignment, and close the project. **The changed assignment is updated in the .qsf.** Any command-line executables that are run after this update use the updated assignment.

Related Information

- [Tcl Scripting](#) on page 18
- [Intel Quartus Prime Settings File \(.qsf\) Definition](#) in Intel Quartus Prime Help
- [Intel Quartus Prime Standard Edition Settings File Reference Manual](#)

1.4.1. Option Precedence

Project assignments follow a set of precedence rules. Assignments for a project can exist in three places:

- Intel Quartus Prime Settings File (.qsf)
- The compiler database
- Command-line options



The `.qsf` file contains all the project-wide and entity-level assignments and settings for the current revision for the project. The compiler database contains the result of the last compilation in the `/db` directory, and reflects the assignments at the moment when the project was compiled. Updated assignments first appear in the compiler database and later in the `.qsf` file.

Command-line options override any conflicting assignments in the `.qsf` file or the compiler database files. To specify whether the `.qsf` or compiler database files take precedence for any assignments not specified in the command-line, use the option `--read_settings_files`.

Table 1. Precedence for Reading Assignments

Option Specified	Precedence for Reading Assignments
<code>--read_settings_files = on</code> (Default)	<ol style="list-style-type: none"> 1. Command-line options 2. The <code>.qsf</code> for the project 3. Project database (db directory, if it exists) 4. Intel Quartus Prime software defaults
<code>--read_settings_files = off</code>	<ol style="list-style-type: none"> 1. Command-line options 2. Project database (db directory, if it exists) 3. Intel Quartus Prime software defaults

The `--write_settings_files` command-line option lists the locations to which assignments are written..

Table 2. Location for Writing Assignments

Option Specified	Location for Writing Assignments
<code>--write_settings_files = on</code> (Default)	<code>.qsf</code> file and compiler database
<code>--write_settings_files = off</code>	Compiler database

Any assignment not specified as a command-line option or found in the `.qsf` file or compiler database file is set to its default value.

The example assumes that a project named `fir_filter` exists, and that the analysis and synthesis step has been performed.

```
quartus_fit fir_filter --pack_register=off
quartus_sta fir_filter
mv fir_filter_sta.rpt fir_filter_1_sta.rpt
quartus_fit fir_filter --pack_register=minimize_area --
write_settings_files=off
quartus_sta fir_filter
mv fir_filter_sta.rpt fir_filter_2_sta.rpt
```

The first command, `quartus_fit fir_filter --pack_register=off`, runs the `quartus_fit` executable with no aggressive attempts to reduce device resource usage.

The second command, `quartus_sta fir_filter`, performs basic timing analysis for the results of the previous fit.

The third command uses the UNIX `mv` command to copy the report file output from `quartus_sta` to a file with a new name, so that the results are not overwritten by subsequent timing analysis.

The fourth command runs `quartus_fit` a second time, and directs it to attempt to pack logic into registers to reduce device resource usage. With the `--write_settings_files=off` option, the command-line executable does not update the `.qsf` to reflect the changed register packing setting. Instead, only the compiler database files reflect the changed setting. If the `--write_settings_files=off` option is not specified, the command-line executable updates the `.qsf` to reflect the register packing setting.

The fifth command reruns timing analysis, and the sixth command renames the report file, so that it is not overwritten by subsequent timing analysis.

Use the options `--read_settings_files=off` and `--write_settings_files=off` (where appropriate) to optimize the way that the Intel Quartus Prime software reads and updates settings files.

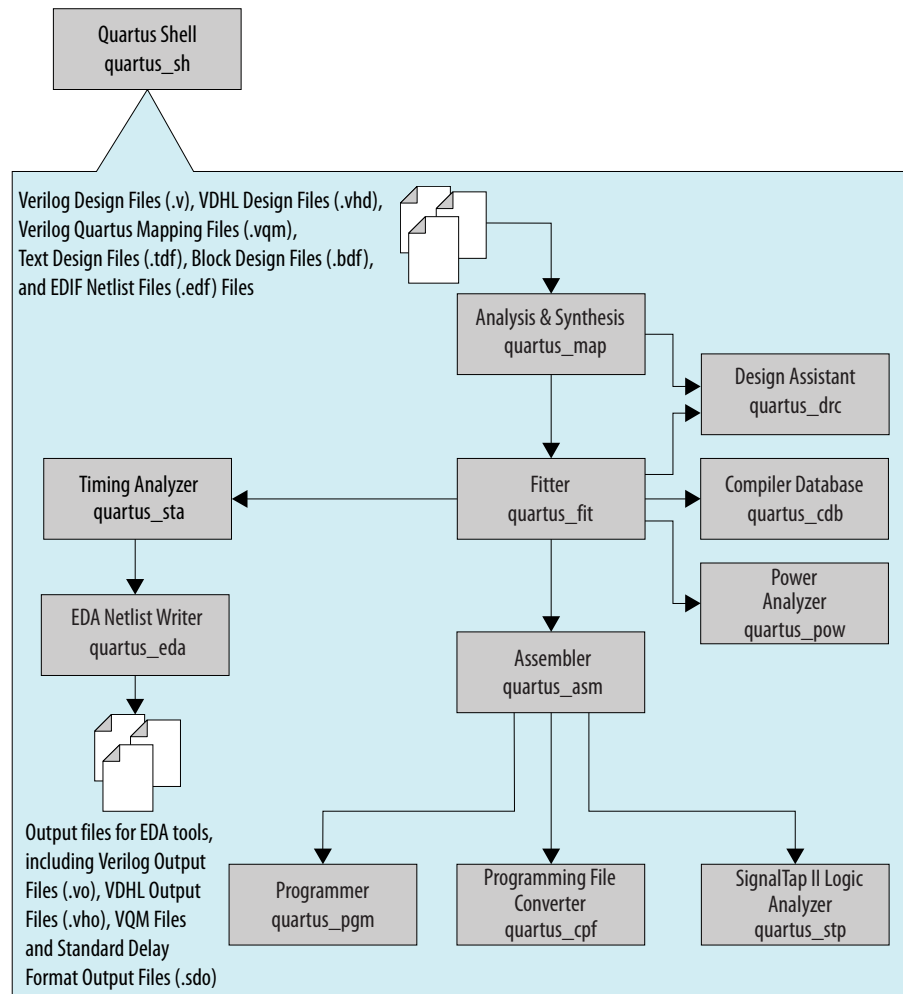
In this example, the `quartus_asm` executable does not read or write settings files:

```
quartus_map filtref --source=filtref --part=EP3C10F256C8
quartus_fit filtref --pack_register=off --read_settings_files=off
quartus_asm filtref --read_settings_files=off --write_settings_files=off
```

1.5. Compilation with `quartus_sh --flow`

The figure shows a typical Intel Quartus Prime FPGA design flow using command-line executables.

Figure 2. Typical Design Flow



Use the `quartus_sh` executable with the `--flow` option to perform a complete compilation flow with a single command. The `--flow` option supports the smart recompile feature and efficiently sets command-line arguments for each executable in the flow.

The following example runs compilation, timing analysis, and programming file generation with a single command:

```
quartus_sh --flow compile filtref
```

Tip: For information about specialized flows, type `quartus_sh --help=flow` at a command prompt.

1.6. Text-Based Report Files

Each command-line executable creates a text report file when it is run. These files report success or failure, and contain information about the processing performed by the executable.

Report file names contain the revision name and the short-form name of the executable that generated the report file, in the format `<revision>.<executable>.rpt`. For example, using the `quartus_fit` executable to place and route a project with the revision name **design_top** generates a report file named `design_top.fit.rpt`. Similarly, using the `quartus_sta` executable to perform timing analysis on a project with the revision name **fir_filter** generates a report file named `fir_filter.sta.rpt`.

As an alternative to parsing text-based report files, you can use the `::quartus::report` Tcl package.

Related Information

- [Text-Format Report File \(.rpt\) Definition](#)
in Intel Quartus Prime Help
- [::quartus::report](#)
in Intel Quartus Prime Help

1.7. Using Command-Line Executables in Scripts

You can use command-line executables in scripts that control other software, in addition to Intel Quartus Prime software. For example, if your design flow uses third-party synthesis or simulation software, and you can run this other software at the command prompt, you can group those commands with Intel Quartus Prime executables in a single script.

To set up a new project and apply individual constraints, such as pin location assignments and timing requirements, you must use a Tcl script or the Intel Quartus Prime GUI.

Command-line executables are very useful for working with existing projects, for making common global settings, and for performing common operations. For more flexibility in a flow, use a Tcl script. Additionally, Tcl scripts simplify passing data between different stages of the design flow.

For example, you can create a UNIX shell script to run a third-party synthesis software, place-and-route the design in the Intel Quartus Prime software, and generate output netlists for other simulation software.

This script shows a script that synthesizes a design with the Synopsys* Synplify software, simulates the design using the Mentor Graphics* ModelSim® software, and then compiles the design targeting a Cyclone V device.

```
#!/bin/sh
# Run synthesis first.
# This example assumes you use Synplify software
synplify -batch synthesize.tcl
# If your Quartus Prime project exists already, you can just
# recompile the design.
# You can also use the script described in a later example to
# create a new project from scratch
quartus_sh --flow compile myproject
# Use the quartus_sta executable to do fast and slow-model
# timing analysis
quartus_sta myproject --model=slow
quartus_sta myproject --model=fast
# Use the quartus_eda executable to write out a gate-level
# Verilog simulation netlist for ModelSim
quartus_eda my_project --simulation --tool=modelsim --format=verilog
```



```
# Perform the simulation with the ModelSim software
vlib cycloneV_ver
vlog -work cycloneV_ver /opt/quartusii/eda/sim_lib/cycloneV_atoms.v
vlib work
vlog -work work my_project.vo
vsim -L cycloneV_ver -t lps work.my_project
```

1.8. Common Scripting Examples

You can create scripts including command line executable to control common Intel Quartus Prime processes.

1.8.1. Create a Project and Apply Constraints

The command-line executables include options for common global project settings and commands. You can use a Tcl script to apply constraints such as pin locations and timing assignments. You can write a Tcl constraint file, or generate one for an existing project by clicking **Project > Generate Tcl File for Project**.

The example creates a project with a Tcl script and applies project constraints using the tutorial design files in the <Intel Quartus Prime *installation directory*> / qdesigns/fir_filter/ directory.

```
project_new filtref -overwrite
# Assign family, device, and top-level file
set_global_assignment -name FAMILY Cyclone
set_global_assignment -name DEVICE EP1C12F256C6
set_global_assignment -name BDF_FILE filtref.bdf
# Assign pins
set_location_assignment -to clk Pin_28
set_location_assignment -to clkx2 Pin_29
set_location_assignment -to d[0] Pin_139
set_location_assignment -to d[1] Pin_140
#
project_close
```

Save the script in a file called `setup_proj.tcl` and type the commands illustrated in the example at a command prompt to create the design, apply constraints, compile the design, and perform fast-corner and slow-corner timing analysis. Timing analysis results are saved in two files, `filtref_sta_1.rpt` and `filtref_sta_2.rpt`.

```
quartus_sh -t setup_proj.tcl
quartus_map filtref
quartus_fit filtref
quartus_asm filtref
quartus_sta filtref --model=fast --export_settings=off
mv filtref_sta.rpt filtref_sta_1.rpt
quartus_sta filtref --export_settings=off
mv filtref_sta.rpt filtref_sta_2.rpt
```

Type the following commands to create the design, apply constraints, and compile the design, without performing timing analysis:

```
quartus_sh -t setup_proj.tcl
quartus_sh --flow compile filtref
```

The `quartus_sh --flow compile` command performs a full compilation, and is equivalent to clicking the **Start Compilation** button in the toolbar.

1.8.2. Check Design File Syntax

The UNIX shell script example below assumes the Intel Quartus Prime software **fir_filter** tutorial project exists in the current directory. You can find the **fir_filter** project in the <Intel Quartus Prime directory>/qdesigns/fir_filter directory unless the Intel Quartus Prime software tutorial files are not installed.

The script checks the exit code of the `quartus_map` executable to determine whether there is an error during the syntax check. Files with syntax errors are added to the `FILES_WITH_ERRORS` variable, and when all files are checked, the script prints a message indicating syntax errors.

When options are not specified, the executable uses the project database values. If not specified in the project database, the executable uses the Intel Quartus Prime software default values. For example, the **fir_filter** project is set to target the Cyclone device family, so it is not necessary to specify the `--family` option.

```
#!/bin/sh
FILES_WITH_ERRORS=""
# Iterate over each file with a .bdf or .v extension
for filename in `ls *.bdf *.v`
do
# Perform a syntax check on the specified file
quartus_map fir_filter --analyze_file=$filename
# If the exit code is non-zero, the file has a syntax error
if [ $? -ne 0 ]
then
FILES_WITH_ERRORS="$FILES_WITH_ERRORS $filename"
fi
done
if [ -z "$FILES_WITH_ERRORS" ]
then
echo "All files passed the syntax check"
exit 0
else
echo "There were syntax errors in the following file(s)"
echo $FILES_WITH_ERRORS
exit 1
fi
```

1.8.3. Create a Project and Synthesize a Netlist Using Netlist Optimizations

This example creates a new Intel Quartus Prime project with a file `top.edf` as the top-level entity. The `--enable_register_retiming=on` and `--enable_wysiwyg_resynthesis=on` options cause `quartus_map` to optimize the design using gate-level register retiming and technology remapping.

The `--part` option causes `quartus_map` to target a device. To create the project and synthesize it using the netlist optimizations described above, type the command shown in this example at a command prompt.

```
quartus_map top --source=top.edf --enable_register_retiming=on
--enable_wysiwyg_resynthesis=on --part=EP3C10F256C8
```



1.8.4. Archive and Restore Projects

You can archive or restore an Intel Quartus Prime Archive File (.qar) with a single command. This makes it easy to take snapshots of projects when you use batch files or shell scripts for compilation and project management.

Use the `--archive` or `--restore` options for `quartus_sh` as appropriate. Type the command shown in the example at a command prompt to archive your project.

```
quartus_sh --archive <project name>
```

The archive file is automatically named `<project name>.qar`. If you want to use a different name, type the command with the `-output` option as shown in example the example.

```
quartus_sh --archive <project name> -output <filename>
```

To restore a project archive, type the command shown in the example at a command prompt.

```
quartus_sh --restore <archive name>
```

The command restores the project archive to the current directory and overwrites existing files.

Related Information

[Managing Intel Quartus Prime Projects](#)

1.8.5. Perform I/O Assignment Analysis

You can perform I/O assignment analysis with a single command. I/O assignment analysis checks pin assignments to ensure they do not violate board layout guidelines. I/O assignment analysis does not require a complete place and route, so it can quickly verify that your pin assignments are correct.

```
quartus_fit --check_ios <project name> --rev=<revision name>
```

1.8.6. Update Memory Contents Without Recompiling

You can use two commands to update the contents of memory blocks in your design without recompiling. Use the `quartus_cdb` executable with the `--update_mif` option to update memory contents from .mif or .hexout files. Then, rerun the assembler with the `quartus_asm` executable to regenerate the .sof, .pof, and any other programming files.

```
quartus_cdb --update_mif <project name> [--rev=<revision name>]  
quartus_asm <project name> [--rev=<revision name>]
```

The example shows the commands for a DOS batch file for this example. With a DOS batch file, you can specify the project name and the revision name once for both commands. To create the DOS batch file, paste the following lines into a file called `update_memory.bat`.

```
quartus_cdb --update_mif %1 --rev=%2  
quartus_asm %1 --rev=%2
```

To run the batch file, type the following command at a command prompt:

```
update_memory.bat <project name> <revision name>
```

1.8.7. Create a Compressed Configuration File

You can create a compressed configuration file in two ways. The first way is to run `quartus_cpf` with an option file that turns on compression.

To create an option file that turns on compression, type the following command at a command prompt:

```
quartus_cpf -w <filename>.opt
```

This interactive command guides you through some questions, then creates an option file based on your answers. Use `--option` to cause `quartus_cpf` to use the option file. For example, the following command creates a compressed `.pof` that targets an EPCS64 device:

```
quartus_cpf --convert --option=<filename>.opt --device=EPCS64 <file>.sof  
<file>.pof
```

Alternatively, you can use the Convert Programming Files utility in the Intel Quartus Prime software GUI to create a Conversion Setup File (`.cof`). Configure any options you want, including compression, then save the conversion setup. Use the following command to run the conversion setup you specified.

```
quartus_cpf --convert <file>.cof
```

1.8.8. Fit a Design as Quickly as Possible

This example assumes that a project called **top** exists in the current directory, and that the name of the top-level entity is **top**. The `--effort=fast` option causes the `quartus_fit` to use the fast fit algorithm to increase compilation speed, possibly at the expense of reduced f_{MAX} performance. The `--one_fit_attempt=on` option restricts the Fitter to only one fitting attempt for the design.

To attempt to fit the project called **top** as quickly as possible, type the command shown at a command prompt.

```
quartus_fit top --effort=fast --one_fit_attempt=on
```

1.8.9. Fit a Design Using Multiple Seeds

This shell script example assumes that the Intel Quartus Prime software tutorial project called **fir_filter** exists in the current directory (defined in the file `fir_filter.qpf`). If the tutorial files are installed on your system, this project exists in the `<Intel Quartus Prime directory>/qdesigns<quartus_version_number> / fir_filter` directory.

Because the top-level entity in the project does not have the same name as the project, you must specify the revision name for the top-level entity with the `--rev` option. The `--seed` option specifies the seeds to use for fitting.



A seed is a parameter that affects the random initial placement of the Intel Quartus Prime Fitter. Varying the seed can result in better performance for some designs.

After each fitting attempt, the script creates new directories for the results of each fitting attempt and copies the complete project to the new directory so that the results are available for viewing and debugging after the script has completed.

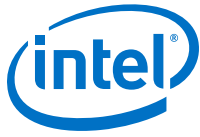
```
#!/bin/sh
ERROR_SEEDS=""
quartus_map fir_filter --rev=filtref
# Iterate over a number of seeds
for seed in 1 2 3 4 5
do
    echo "Starting fit with seed=$seed"
    # Perform a fitting attempt with the specified seed
    quartus_fit fir_filter --seed=$seed --rev=filtref
    # If the exit-code is non-zero, the fitting attempt was
    # successful, so copy the project to a new directory
    if [ $? -eq 0 ]
    then
        mkdir ../fir_filter-seed_$seed
        mkdir ../fir_filter-seed_$seed/db
        cp * ../fir_filter-seed_$seed
        cp db/* ../fir_filter-seed_$seed/db
    else
        ERROR_SEEDS="$ERROR_SEEDS $seed"
    fi
done
if [ -z "$ERROR_SEEDS" ]
then
    echo "Seed sweeping was successful"
    exit 0
else
    echo "There were errors with the following seed(s)"
    echo $ERROR_SEEDS
    exit 1
fi
```

Tip:

Use Design Space Explorer II (DSE) included with the Intel Quartus Prime software script (by typing `quartus_dse` at a command prompt) to improve design performance by performing automated seed sweeping.

1.9. The QFlow Script

A Tcl/Tk-based graphical interface called QFlow is included with the command-line executables. You can use the QFlow interface to open projects, launch some of the command-line executables, view report files, and make some global project assignments.



The QFlow interface can run the following command-line executables:

- quartus_map (Analysis and Synthesis)
- quartus_fit (Fitter)
- quartus_sta (Timing Analyzer)
- quartus_asm (Assembler)
- quartus_eda (EDA Netlist Writer)

To view floorplans or perform other GUI-intensive tasks, launch the Intel Quartus Prime software.

Start QFlow by typing the following command at a command prompt:

```
quartus_sh -g
```

Tip: The QFlow script is located in the <Intel Quartus Prime directory> / common/tcl/apps/qflow/ directory.

1.10. Document Revision History

Table 3. Document Revision History

Date	Version	Changes
2017.05.08	17.0.0	<ul style="list-style-type: none"> • Reorganized content on topics: Benefits of Command-Line Executables and Project Settings with Command-Line Options.
2015.11.02	15.1.0	Changed instances of <i>Quartus II</i> to <i>Intel Quartus Prime</i> .
2015.05.04	15.0.0	Remove descriptions of makefile support that was removed from software in 14.0.
December 2014	14.1.0	Updated DSE II commands.
June 2014	14.0.0	Updated formatting.
November 2013	13.1.0	Removed information about -silnet qmegawiz command
June 2012	12.0.0	Removed survey link.
November 2011	11.0.1	Template update.
May 2011	11.0.0	Corrected quartus_qpf example usage. Updated examples.
December 2010	10.1.0	Template update. Added section on using a script to regenerate megafuncion variations. Removed references to the Classic Timing Analyzer (quartus_tan). Removed Qflow illustration.
July 2010	10.0.0	Updated script examples to use quartus_sta instead of quartus_tan, and other minor updates throughout document.
November 2009	9.1.0	Updated Table 2-1 to add quartus_jli and quartus_jbcc executables and descriptions, and other minor updates throughout document.
March 2009	9.0.0	No change to content.
November 2008	8.1.0	Added the following sections:
continued...		

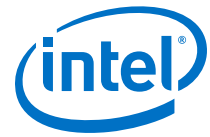


Date	Version	Changes
		<ul style="list-style-type: none"> • "The MegaWizard Plug-In Manager" on page 2-11 • "Command-Line Support" on page 2-12 • "Module and Wizard Names" on page 2-13 • "Ports and Parameters" on page 2-14 • "Invalid Configurations" on page 2-15 • "Strategies to Determine Port and Parameter Values" on page 2-15 • "Optional Files" on page 2-15 • "Parameter File" on page 2-16 • "Working Directory" on page 2-17 • "Variation File Name" on page 2-17 • "Create a Compressed Configuration File" on page 2-21 • Updated "Option Precedence" on page 2-5 to clarify how to control precedence • Corrected Example 2-5 on page 2-8 • Changed Example 2-1, Example 2-2, Example 2-4, and Example 2-7 to use the EP1C12F256C6 device • Minor editorial updates • Updated entire chapter using 8½" × 11" chapter template
May 2008	8.0.0	<ul style="list-style-type: none"> • Updated "Referenced Documents" on page 2-20. • Updated references in document.

Related Information

Documentation Archive

For previous versions of the *Intel Quartus Prime Handbook*, search the documentation archives.



2. Tcl Scripting

You can use Tcl scripts to control the Intel Quartus Prime software and to perform a wide range of functions, such as compiling a design or scripting common tasks.

For example, use Tcl scripts to perform the following tasks:

- Manage an Intel Quartus Prime project
- Make assignments
- Define design constraints
- Make device assignments
- Compile your design
- Perform timing analysis
- Access reports

Tcl scripts also facilitate project or assignment migration. For example, when designing in different projects with the same prototype or development board, you can write a script to automate reassignment of pin locations in each new project. The Intel Quartus Prime software can also generate a Tcl script based on all the current assignments in the project, which aids in switching assignments to another project.

The Intel Quartus Prime software Tcl commands follow the EDA industry Tcl application programming interface (API) standards for command-line options. This simplifies learning and using Tcl commands. If you encounter an error with a command argument, the Tcl interpreter includes help information showing correct usage.

This chapter includes sample Tcl scripts for automating tasks in the Intel Quartus Prime software. You can modify these example scripts for use with your own designs. You can find more Tcl scripts in the Design Examples section of the Support area on the Altera website.

Related Information

[Tcl Design Examples](#)

2.1. Tool Command Language

Tcl (pronounced "tickle") stands for Tool Command Language, and is the industry-standard scripting language. Tcl supports control structures, variables, network socket access, and APIs.

With Tcl, you can work seamlessly across most development platforms. Synopsys, Mentor Graphics, and Intel software products support the Tcl language.



By combining Tcl commands and Intel Quartus Prime API functions, you can create your own procedures and automate your design flow. Run Intel Quartus Prime software in batch mode, or execute individual Tcl commands interactively in the Intel Quartus Prime Tcl shell.

Intel Quartus Prime software supports Tcl/Tk version 8.5, supplied by the Tcl DeveloperXchange.

2.2. Intel Quartus Prime Tcl Packages

The Intel Quartus Prime software groups Tcl commands into packages by function.

Table 4. Intel Quartus Prime Tcl Packages

Package Name	Package Description
backannotate	Back annotate assignments
chip_planner	Identify and modify resource usage and routing with the Chip Editor
database_manager	Manage version-compatible database files
device	Get device and family information from the device database
external_memif_toolkit	Interact with external memory interfaces and debug components
fif	Contains the set of Tcl functions for using the Fault Injection File (FIF) Driver
flow	Compile a project, run command-line executables, and other common flows
incremental_compilation	Manipulate design partitions and Logic Lock (Standard) regions, and settings related to incremental compilation
insystem_memory_edit	Read and edit memory contents in Intel devices
insystem_source_probe	Interact with the In-System Sources and Probes tool in an Intel device
iptclgen	Generate memory IP
jtag	Control the JTAG chain
logic_analyzer_interface	Query and modify the Logic Analyzer Interface output pin state
misc	Perform miscellaneous tasks such as enabling natural bus naming, package loading, and message posting
partial_reconfiguration	Contain the set of Tcl functions for performing partial reconfiguration
project	Create and manage projects and revisions, make any project assignments including timing assignments
report	Get information from report tables, create custom reports
rtl	Traverse and query the RTL netlist of your design
sdc	Specify constraints and exceptions to the Timing Analyzer
sdc_ext	Intel-specific SDC commands
simulator	Configure and perform simulations
sta	Contain the set of Tcl functions for obtaining advanced information from the Timing Analyzer
stp	Run the Signal Tap Logic Analyzer
synthesis_report	Contain the set of Tcl functions for the Dynamic Synthesis Report tool
tdc	Obtain information from the Timing Analyzer

To keep memory requirements as low as possible, only the minimum number of packages load automatically with each Intel Quartus Prime executable. To run commands from other packages, load those packages beforehand.

Run your scripts with executables that include the packages you use in the scripts. For example, to use commands in the `sdc_ext` package, you must use the `quartus_sta` executable because `quartus_sta` is the only executable with support for the `sdc_ext` package.

The following command prints lists of the packages loaded or available to load for an executable, to the console:

```
<executable name> --tcl_eval help
```

For example, type the following command to list the packages loaded or available to load by the `quartus_fit` executable:

```
quartus_fit --tcl_eval help
```

2.2.1. Loading Packages

To load an Intel Quartus Prime Tcl package, use the `load_package` command as follows:

```
load_package [-version <version number>] <package name>
```

This command is similar to `package require`, but it allows to alternate between different versions of an Intel Quartus Prime Tcl package.

Related Information

[Command Line Scripting](#) on page 4

2.3. Intel Quartus Prime Tcl API Help

Intel Quartus Prime Tcl help allows easy access to information about the Intel Quartus Prime Tcl commands.

- This command opens the Intel Quartus Prime Command-Line and Tcl API help browser, which documents all commands and options in the Intel Quartus Prime Tcl API. At a system command prompt, access the Intel Quartus Prime Tcl API Help by typing:

```
quartus_sh --qhelp
```

- The Tcl API Help can be accessed from the Tcl console as well. At a Tcl prompt, type

```
help
```

to access the help information. The output is:

```
tcl> help
-----
Available Intel Quartus Prime Tcl Packages:
-----
Loaded          Not Loaded
-----
```



```

::quartus::device      ::quartus::external_memif_toolkit
::quartus::misc        ::quartus::iptclgen
::quartus::project     ::quartus::design
                      ::quartus::rtm
                      ::quartus::partial_reconfiguration
                      ::quartus::report
                      ::quartus::names
                      ::quartus::incremental_compilation
                      ::quartus::flow

* Type "help -tcl"
to get an overview on Intel Quartus Prime Tcl usages.

* Type "help <package name>"
to view a list of Tcl commands available for
the specified Intel Quartus Prime Tcl package.

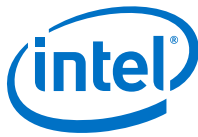
```

The Tcl console provides help options that display specific information:

Table 5. Help Options Available in the Intel Quartus Prime Tcl Environment

Help Command	Description
help	Displays complete list of available Intel Quartus Prime Tcl packages.
help -tcl	Explains how to load Tcl packages and access command-line help.
help -pkg <package_name> [-version <version number>]	<p>Displays help commands of the Intel Quartus Prime package that you specify, including the list of available Tcl commands.</p> <ul style="list-style-type: none"> If you do not specify -version, the Intel Quartus Prime software loads the latest version of the package. If the package is not loaded, the Intel Quartus Prime software displays the help for the latest version of the package. <p>Examples:</p> <pre> help -pkg ::quartus::project help -pkg project help -pkg project -version 1.0 </pre>
<command_name> -h or <command_name> -help	<p>Displays the short help of a Intel Quartus Prime Tcl command in a loaded package. Examples:</p> <pre> project_open -h project_open -help </pre>
package require ::quartus::<package name>[<version>]	<p>Loads a specific version of an Intel Quartus Prime Tcl package. If you do not specify -version, the Intel Quartus Prime software loads the latest version of the package.</p> <p>Example:</p> <pre> package require ::quartus::project 1.0 </pre> <p>This command is similar to the load_package command</p>
load_package <package name> [-version <version number>]	<p>Allows you to alternate between different versions of the same package.</p> <p>Example:</p> <pre> load_package ::quartus::project -version 1.0 </pre>

continued...



Help Command	Description
<pre>help -cmd <command_name> [-version <version>]</pre> or <pre><command_name> -long_help</pre>	Displays the complete help text for an Intel Quartus Prime Tcl command. If you do not specify <code>-version</code> , the Intel Quartus Prime software loads the latest version of the package. Examples: <pre>project_open -long_help</pre> <pre>help -cmd project_open</pre> <pre>help -cmd project_open -version 1.0</pre>
<pre>help -examples</pre>	Displays examples of Intel Quartus Prime Tcl usage.
<pre>help -quartus</pre>	To view help on the predefined global Tcl array that contains project information and information about the Intel Quartus Prime executable that is currently running.
<pre>quartus_sh --qhelp</pre>	Launches the Tk viewer for Intel Quartus Prime command-line help and display help for the command-line executables and Tcl API packages.
<pre>help -timequestinfo</pre>	To view help on the predefined global <pre>"TimeQuestInfo"</pre> Tcl array that contains delay model information and speed grade information of a Timing Analyzer design that is currently running.

The Tcl API help is also available in Intel Quartus Prime online help. Search for the command or package name to find details about that command or package.

2.3.1. Command-Line Options

You can use any of the following command line options with executables that support Tcl:

Table 6. Command-Line Options Supporting Tcl Scripting

Command-Line Option	Description
<code>--script=<script file> [<script args>]</code>	Run the specified Tcl script with optional arguments.
<code>-t <script file> [<script args>]</code>	Run the specified Tcl script with optional arguments. The <code>-t</code> option is the short form of the <code>--script</code> option.
<code>--shell</code>	Open the executable in the interactive Tcl shell mode.
<code>-s</code>	Open the executable in the interactive Tcl shell mode. The <code>-s</code> option is the short form of the <code>--shell</code> option.
<code>--tcl_eval <tcl command></code>	Evaluate the remaining command-line arguments as Tcl commands. For example, the following command displays help for the project package: <code>quartus_sh --tcl_eval help -pkg project</code>



2.3.1.1. Run a Tcl Script

Running an executable with the `-t` option runs the specified Tcl script. You can also specify arguments to the script. Access the arguments through the `argv` variable, or use a package such as `cmdline`, which supports arguments of the following form:

```
-<argument name> <argument value>
```

The `cmdline` package is included in the `<Intel Quartus Prime directory> / common/tcl/packages` directory.

For example, to run a script called `myscript.tcl` with one argument, `Stratix®`, type the following command at a system command prompt:

```
quartus_sh -t myscript.tcl Stratix
```

2.3.1.2. Interactive Shell Mode

Running an executable with the `-s` option starts an interactive Tcl shell. For example, to open the Intel Quartus Prime Timing Analyzer executable in interactive shell mode, type:

```
quartus_sta -s
```

Commands you type in the Tcl shell are interpreted when you press Enter. To run a Tcl script in the interactive shell type:

```
source <script name>
```

If a command is not recognized by the shell, it is assumed to be external and executed with the `exec` command.

2.3.1.3. Evaluate as Tcl

Running an executable with the `--tcl_eval` option causes the executable to immediately evaluate the remaining command-line arguments as Tcl commands. This can be useful if you want to run simple Tcl commands from other scripting languages.

For example, the following command runs the Tcl command that prints out the commands available in the project package.

```
quartus_sh --tcl_eval help -pkg project
```

2.3.2. The Intel Quartus Prime Tcl Console Window

To run Tcl commands directly in the Intel Quartus Prime **Tcl Console** window, click **View > Utility Windows**. By default, the **Tcl Console** window is docked in the bottom-right corner of the Intel Quartus Prime GUI. All Tcl commands typed in the **Tcl Console** are interpreted by the Intel Quartus Prime Tcl shell.

Note:

Some shell commands such as `cd`, `ls`, and others can be run in the Tcl Console window, with the Tcl `exec` command. However, for best results, run shell commands and Intel Quartus Prime executables from a system command prompt outside of the Intel Quartus Prime software GUI.

Tcl messages appear in the **System** tab (**Messages** window). Errors and messages written to `stdout` and `stderr` also are shown in the Intel Quartus Prime **Tcl Console** window.

2.4. End-to-End Design Flows

You can use Tcl scripts to control all aspects of the design flow, including controlling other software, when the other software also includes a scripting interface.

Typically, EDA tools include their own script interpreters that extend core language functionality with tool-specific commands. For example, the Intel Quartus Prime Tcl interpreter supports all core Tcl commands, and adds numerous commands specific to the Intel Quartus Prime software. You can include commands in one Tcl script to run another script, which allows you to combine or chain together scripts to control different tools. Because scripts for different tools must be executed with different Tcl interpreters, it is difficult to pass information between the scripts unless one script writes information into a file and another script reads it.

Within the Intel Quartus Prime software, you can perform many different operations in a design flow (such as synthesis, fitting, and timing analysis) from a single script, making it easy to maintain global state information and pass data between the operations. However, there are some limitations on the operations you can perform in a single script due to the various packages supported by each executable.

There are no limitations on running flows from any executable. Flows include operations found in

Processing ► Start in the Intel Quartus Prime GUI, and are also documented as options for the `execute_flow` Tcl command. If you can make settings in the Intel Quartus Prime software and run a flow to get your desired result, you can make the same settings and run the same flow in a Tcl script.

2.5. Creating Projects and Making Assignments

You can create a script that makes all the assignments for an existing project, and then use the script at any time to restore your project settings to a known state.

Click **Project ► Generate Tcl File for Project** to automatically generate a `.tcl` file containing your assignments. You can source this file to recreate your project, and you can add other commands to this file, such as commands for compiling the design. This file is a good starting point to learn about project management and assignment commands.

To commit the assignments you create or modify to the `.qsf` file, you use the `export_assignments` or `project_close` commands. However, when you run the `execute_flow` command, Intel Quartus Prime software automatically commits the assignment changes to the `.qsf` file. To prevent this behavior, specify the `-dont_export_assignments` logic option.



Example 1. Create and Compile a Project

The following example creates a project, makes assignments, and compiles the design. The example uses the `fir_filter` tutorial design files in the `qdesigns` installation directory. Run this script in the `fir_filter` directory, with the `quartus_sh` executable.

```
load_package flow
# Create the project and overwrite any settings
# files that exist
project_new fir_filter -revision filtref -overwrite
# Set the device, the name of the top-level BDF,
# and the name of the top-level entity
set_global_assignment -name FAMILY Cyclone
set_global_assignment -name DEVICE EP1C6F256C6
set_global_assignment -name BDF_FILE filtref.bdf
set_global_assignment -name TOP_LEVEL_ENTITY filtref
# Add other pin assignments here
set_location_assignment -to clk Pin_G1
# compile the project
execute_flow -compile
project_close
```

Related Information

- [Intel Quartus Prime Standard Edition Settings File Reference Manual](#)
- [Interactive Shell Mode](#) on page 23

2.6. Compiling Designs

You can run the Intel Quartus Prime command-line executables from Tcl scripts. Use the included `flow` package to run various Intel Quartus Prime compilation flows, or run each executable directly.

2.6.1. The flow Package

The `flow` package includes two commands for running Intel Quartus Prime command-line executables, either individually or together in standard compilation sequence.

- The `execute_module` command allows you to run an individual Intel Quartus Prime command-line executable.
- The `execute_flow` command allows you to run some or all the executables in commonly-used combinations.

Use the `flow` package instead of system calls to run Intel Quartus Prime executables from scripts or from the Intel Quartus Prime Tcl Console.

2.6.2. Compile All Revisions

You can use a simple Tcl script to compile all revisions in your project. Save the following script in a file called `compile_revisions.tcl` and type the following to run it:

```
quartus_sh -t compile_revisions.tcl <project name>
```

Compile All Revisions

```
load_package flow
project_open [lindex $quartus(args) 0]
set original_revision [get_current_revision]
foreach revision [get_project_revisions] {
    set_current_revision $revision
    execute flow -compile
}
set_current_revision $original_revision
project_close
```

2.7. Reporting

You can extract information from the Compilation Report to evaluate results. The Intel Quartus Prime Tcl API provides easy access to report data so you do not have to write scripts to parse the text report files.

If you know the exact report cell or cells you want to access, use the `get_report_panel_data` command and specify the row and column names (or *x* and *y* coordinates) and the name of the appropriate report panel. You can often search for data in a report panel. To do this, use a loop that reads the report one row at a time with the `get_report_panel_row` command.

Column headings in report panels are in row 0. If you use a loop that reads the report one row at a time, start with row 1 to skip column headings. The `get_number_of_rows` command returns the number of rows in the report panel, including the column heading row. Since the number of rows includes the column heading row, continue your loop if the loop index is less than the number of rows.

Report panels are hierarchically arranged and each level of hierarchy is denoted by the string `"|"` in the panel name. For example, the name of the Fitter Settings report panel is `Fitter|Fitter Settings` because it is in the `Fitter` folder. Panels at the highest hierarchy level do not use the `"|"` string. For example, the Flow Settings report panel is named `Flow Settings`.

The following Tcl code prints a list of all report panel names in your project. You can run this code with any executable that includes support for the report package.

Print All Report Panel Names

```
load_package report
project_open myproject
load_report
set panel_names [get_report_panel_names]
foreach panel_name $panel_names {
    post_message "$panel_name"
}
```

2.7.1. Saving Report Data in csv Format

You can create a Comma Separated Value (`.csv`) file from any Intel Quartus Prime report to open with a spreadsheet editor.

The following Tcl code shows a simple way to create a `.csv` file with data from the Fitter panel in a report.



Create .csv Files from Reports

```
load_package report
project_open my-project
load_report
# This is the name of the report panel to save as a CSV file
set panel_name "Fitter||Fitter Settings"
set csv_file "output.csv"
set fh [open $csv_file w]
set num_rows [get_number_of_rows -name $panel_name]
# Go through all the rows in the report file, including the
# row with headings, and write out the comma-separated data
for { set i 0 } { $i < $num_rows } { incr i } {
    set row_data [get_report_panel_row -name $panel_name \
        -row $i]
    puts $fh [join $row_data ","]
}
close $fh
unload_report
```

You can modify the script to use command-line arguments to pass in the name of the project, report panel, and output file to use. You can run this script example with any executable that supports the report package.

2.8. Timing Analysis

The Intel Quartus Prime Timing Analyzer includes support for industry-standard SDC commands in the `sdc` package.

The Intel Quartus Prime software includes comprehensive Tcl APIs and SDC extensions for the Timing Analyzer in the `sta`, and `sdc_ext` packages. The Intel Quartus Prime software also includes a `tdc` package that obtains information from the Timing Analyzer.

Related Information

[Intel Quartus Prime Standard Edition Settings File Reference Manual](#)

2.9. Automating Script Execution

You can configure scripts to run automatically at various points during compilation. Use this capability to automatically run scripts that perform custom reporting, make specific assignments, and perform many other tasks.

The following three global assignments control when a script is run automatically:

- `PRE_FLOW_SCRIPT_FILE` —before a flow starts
- `POST_MODULE_SCRIPT_FILE` —after a module finishes
- `POST_FLOW_SCRIPT_FILE` —after a flow finishes

A module is another term for an Intel Quartus Prime executable that performs one step in a flow. For example, two modules are Analysis and Synthesis (`quartus_map`), and timing analysis (`quartus_sta`).

A flow is a series of modules that the Intel Quartus Prime software runs with predefined options. For example, compiling a design is a flow that typically consists of the following steps (performed by the indicated module):

1. Analysis and Synthesis (quartus_map)
2. Fitter (quartus_fit)
3. Assembler (quartus_asm)
4. Timing Analyzer (quartus_sta)

Other flows are described in the help for the `execute_flow` Tcl command. In addition, many commands in the **Processing** menu of the Intel Quartus Prime GUI correspond to this design flow.

To make an assignment automatically run a script, add an assignment with the following form to the `.qsf` for your project:

```
set_global_assignment -name <assignment name> <executable>:<script name>
```

The Intel Quartus Prime software runs the scripts.

```
<executable> -t <script name> <flow or module name> <project name> <revision name>
```

The first argument passed in the `argv` variable (or `quartus(args)` variable) is the name of the flow or module being executed, depending on the assignment you use. The second argument is the name of the project and the third argument is the name of the revision.

The last process, current project, and current revision are passed to the script by the Intel Quartus Prime software and can be accessed by the following commands:

```
set process [lindex $quartus(args) 0]
set project [lindex $quartus(args) 1]
set revision [lindex $quartus(args) 2]

project_open $project -revision $revision
```

When you use the `POST_MODULE_SCRIPT_FILE` assignment, the specified script is automatically run after every executable in a flow. You can use a string comparison with the module name (the first argument passed in to the script) to isolate script processing to certain modules.

2.9.1. Execution Example

To illustrate how automatic script execution works in a complete flow, assume you have a project called **top** with a current revision called **rev_1**, and you have the following assignments in the `.qsf` for your project.

```
set_global_assignment -name PRE_FLOW_SCRIPT_FILE quartus_sh:first.tcl
set_global_assignment -name POST_MODULE_SCRIPT_FILE quartus_sh:next.tcl
set_global_assignment -name POST_FLOW_SCRIPT_FILE quartus_sh:last.tcl
```

When you compile your project, the `PRE_FLOW_SCRIPT_FILE` assignment causes the following command to be run before compilation begins:

```
quartus_sh -t first.tcl compile top rev_1
```



Next, the Intel Quartus Prime software starts compilation with analysis and synthesis, performed by the `quartus_map` executable. After the Analysis and Synthesis finishes, the `POST_MODULE_SCRIPT_FILE` assignment causes the following command to run:

```
quartus_sh -t next.tcl quartus_map top rev_1
```

Then, the Intel Quartus Prime software continues compilation with the Fitter, performed by the `quartus_fit` executable. After the Fitter finishes, the `POST_MODULE_SCRIPT_FILE` assignment runs the following command:

```
quartus_sh -t next.tcl quartus_fit top rev_1
```

Corresponding commands are run after the other stages of the compilation. When the compilation is over, the `POST_FLOW_SCRIPT_FILE` assignment runs the following command:

```
quartus_sh -t last.tcl compile top rev_1
```

2.9.2. Controlling Processing

The `POST_MODULE_SCRIPT_FILE` assignment causes a script to run after every module. Because the same script is run after every module, you might have to include some conditional statements that restrict processing in your script to certain modules.

For example, if you want a script to run only after timing analysis, use a conditional test like the following example. It checks the flow or module name passed as the first argument to the script and executes code when the module is `quartus_sta`.

Restrict Processing to a Single Module

```
set module [lindex $quartus(args) 0]
if [string match "quartus_sta" $module] {
    # Include commands here that are run
    # after timing analysis
    # Use the post-message command to display
    # messages
    post_message "Running after timing analysis"
}
```

2.9.3. Displaying Messages

Because of the way the Intel Quartus Prime software runs the scripts automatically, you must use the `post_message` command to display messages, instead of the `puts` command. This requirement applies only to scripts that are run by the three assignments listed in "Automating Script Execution".

Related Information

- [The `post_message` Command](#) on page 31
- [Automating Script Execution](#) on page 27

2.10. Other Scripting Features

The Intel Quartus Prime Tcl API includes other general-purpose commands and features described in this section.

2.10.1. Natural Bus Naming

The Intel Quartus Prime software supports natural bus naming. Natural bus naming allows you to use square brackets to specify bus indexes in HDL, without including escape characters to prevent Tcl from interpreting the square brackets as containing commands. For example, one signal in a bus named `address` can be identified as `address[0]` instead of `address\[0\]`. You can take advantage of natural bus naming when making assignments.

```
set_location_assignment -to address[10] Pin_M20
```

The Intel Quartus Prime software defaults to natural bus naming. You can turn off natural bus naming with the `disable_natural_bus_naming` command. For more information about natural bus naming, type the following at an Intel Quartus Prime Tcl prompt:

```
enable_natural_bus_naming -h
```

2.10.2. Short Option Names

You can use short versions of command options, if they are unambiguous. For example, the `project_open` command supports two options: `-current_revision` and `-revision`.

You can use any of the following abbreviations of the `-revision` option:

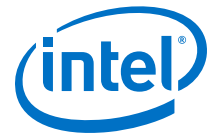
- `-r`
- `-re`
- `-rev`
- `-revi`
- `-revis`
- `-revisio`

You can use an extremely short option such as `-r` because in the case of the `project_open` command no other option starts with the letter `r`. However, the `report_timing` command includes the options `-recovery` and `-removal`. You cannot use `-r` or `-re` to shorten either of those options, because the abbreviation is not unique.

2.10.3. Collection Commands

Some Intel Quartus Prime Tcl functions return very large sets of data that are inefficient as Tcl lists. These data structures are referred to as collections. The Intel Quartus Prime Tcl API uses a collection ID to access the collection.

There are two Intel Quartus Prime Tcl commands for working with collections, `foreach_in_collection` and `get_collection_size`. Use the `set` command to assign a collection ID to a variable.



2.10.3.1. The `foreach_in_collection` Command

The `foreach_in_collection` command is similar to the `foreach` Tcl command. Use it to iterate through all elements in a collection. The following example prints all instance assignments in an open project.

`foreach_in_collection` Example

```
set all_instance_assignments [get_all_instance_assignments -name *]
foreach_in_collection asgn $all_instance_assignments {
    # Information about each assignment is
    # returned in a list. For information
    # about the list elements, refer to Help
    # for the get-all-instance-assignments command.
    set to [lindex $asgn 2]
    set name [lindex $asgn 3]
    set value [lindex $asgn 4]
    puts "Assignment to $to: $name = $value"
}
```

Related Information

`foreach_in_collection (::quartus::misc)`
In Intel Quartus Prime Help

2.10.3.2. The `get_collection_size` Command

Use the `get_collection_size` command to get the number of elements in a collection. The following example prints the number of global assignments in an open project.

`get_collection_size` Example

```
set all_global_assignments [get_all_global_assignments -name *]
set num_global_assignments [get_collection_size $all_global_assignments]
puts "There are $num_global_assignments global assignments in your project"
```

2.10.4. The `post_message` Command

To print messages that are formatted like Intel Quartus Prime software messages, use the `post_message` command. Messages printed by the `post_message` command appear in the **System** tab of the **Messages** window in the Intel Quartus Prime GUI, and are written to standard output when scripts are run. Arguments for the `post_message` command include an optional message type and a required message string.

The message type can be one of the following:

- `info` (default)
- `extra_info`
- `warning`
- `critical_warning`
- `error`

If you do not specify a type, Intel Quartus Prime software defaults to `info`.

With the Intel Quartus Prime software in Windows, you can color code messages displayed at the system command prompt with the `post_message` command. Add the following line to your `quartus2.ini` file:

```
DISPLAY_COMMAND_LINE_MESSAGES_IN_COLOR = on
```

The following example shows how to use the `post_message` command.

```
post_message -type warning "Design has gated clocks"
```

2.10.5. Accessing Command-Line Arguments

The global variable `quartus(args)` is a list of the arguments typed on the command-line following the name of the Tcl script.

Example 2. Simple Command-Line Argument Access

The following Tcl example prints all the arguments in the `quartus(args)` variable:

```
set i 0
foreach arg $quartus(args) {
    puts "The value at index $i is $arg"
    incr i
}
```

Example 3. Passing Command-Line Arguments to Scripts

If you copy the script in the previous example to a file named `print_args.tcl`, it displays the following output when you type the following at a command prompt.

```
quartus_sh -t print_args.tcl my_project 100MHz
The value at index 0 is my_project
The value at index 1 is 100MHz
```

2.10.5.1. The cmdline Package

You can use the `cmdline` package included with the Intel Quartus Prime software for more robust and self-documenting command-line argument passing. The `cmdline` package supports command-line arguments with the form `-<option><value>`.

cmdline Package

```
package require cmdline
variable ::argv0 $::quartus(args)
set options {
    { "project.arg" "" "Project name" }
    { "frequency.arg" "" "Frequency" }
}
set usage "You need to specify options and values"
array set optshash [::cmdline::getoptions ::argv $options $usage]
puts "The project name is $optshash(project)"
puts "The frequency is $optshash(frequency)"
```

If you save those commands in a Tcl script called `print_cmd_args.tcl` you see the following output when you type the following command at a command prompt.



Passing Command-Line Arguments for Scripts

```
quartus_sh -t print_cmd_args.tcl -project my_project -frequency 100MHz
The project name is my_project
The frequency is 100MHz
```

Virtually all Intel Quartus Prime Tcl scripts must open a project. You can open a project, and you can optionally specify a revision name with code like the following example. The example checks whether the specified project exists. If it does, the example opens the current revision, or the revision you specify.

Full-Featured Method to Open Projects

```
package require cmdline
variable ::argv0 ${quartus(args)}
set options { \
{ "project.arg" "" "Project Name" } \
{ "revision.arg" "" "Revision Name" } \
}
array set optshash [::cmdline::getoptions ::argv0 $options]
# Ensure the project exists before trying to open it
if {[project_exists $optshash(project)]} {
    if {[string equal "" $optshash(revision)]} {
        # There is no revision name specified, so default
        # to the current revision
        project_open $optshash(project) -current_revision
    } else {
        # There is a revision name specified, so open the
        # project with that revision
        project_open $optshash(project) -revision \
            $optshash(revision)
    }
} else {
    puts "Project $optshash(project) does not exist"
    exit 1
}
# The rest of your script goes here
```

If you do not require this flexibility or error checking, you can use just the `project_open` command.

Simple Method to Open Projects

```
set proj_name [lindex $argv 0]
project_open $proj_name
```

2.10.6. The `quartus()` Array

The global `quartus()` Tcl array includes other information about your project and the current Intel Quartus Prime executable that might be useful to your scripts. The scripts in the preceding examples parsed command line arguments found in `quartus(args)`. For information on the other elements of the `quartus()` array, type the following command at a Tcl prompt:

```
help -quartus
```

2.11. The Intel Quartus Prime Tcl Shell in Interactive Mode Example

This section presents how to make project assignments and then compile the finite impulse response (FIR) filter tutorial project with the `quartus_sh` interactive shell.

This example assumes you already have the `fir_filter` tutorial design files in a project directory.

1. To run the interactive Tcl shell, type the following at the system command prompt:

```
quartus_sh -s
```

2. Create a new project called `fir_filter`, with a revision called `filtref` by typing:

```
project_new -revision filtref fir_filter
```

Note:

- If the project file and project name are the same, the Intel Quartus Prime software gives the revision the same name as the project.
- If a `.qpf` file for this project already exists, the Intel Quartus Prime software will display an error stating that the project already exists.

Because the revision named `filtref` matches the top-level file, all design files are automatically picked up from the hierarchy tree.

3. Set a global assignment for the device:

```
set_global_assignment -name family <device family name>
```

To learn more about assignment names that you can use with the `-name` option, refer to Intel Quartus Prime Help.

Note: For assignment values that contain spaces, enclose the value in quotation marks.

4. To compile a design, use the `::quartus::flow` package, which properly exports the new project assignments and compiles the design with the proper sequence of the command-line executables. First, load the package:

```
load_package flow
```

It returns:

```
1.1
```

5. To perform a full compilation of the FIR filter design, use the `execute_flow` command with the `-compile` option:

```
execute_flow -compile
```

This command compiles the FIR filter tutorial project, exporting the project assignments and running `quartus_map`, `quartus_fit`, `quartus_asm`, and `quartus_sta`. This sequence of events is the same as selecting **Processing ► Start Compilation** in the Intel Quartus Prime GUI.

6. When you are finished with a project, close it with the `project_close` command.
7. To exit the interactive Tcl shell, type `exit` at a Tcl prompt.



2.12. The tclsh Shell

On the UNIX and Linux operating systems, the tclsh shell included with the Intel Quartus Prime software is initialized with a minimal `PATH` environment variable. As a result, system commands might not be available within the tclsh shell because certain directories are not in the `PATH` environment variable.

To include other directories in the path searched by the tclsh shell, set the `QUARTUS_INIT_PATH` environment variable before running the tclsh shell. Directories in the `QUARTUS_INIT_PATH` environment variable are searched by the tclsh shell when you execute a system command.

2.13. Tcl Scripting Basics

The core Tcl commands support variables, control structures, and procedures. Additionally, there are commands for accessing the file system and network sockets, and running other programs. You can create platform-independent graphical interfaces with the Tk widget set.

Tcl commands are executed immediately as they are typed in an interactive Tcl shell. You can also create scripts (including the examples in this chapter) in files and run them with the Intel Quartus Prime executables or with the tclsh shell.

2.13.1. Hello World Example

The following shows the basic "Hello world" example in Tcl:

```
puts "Hello world"
```

Use double quotation marks to group the words `hello` and `world` as one argument. Double quotation marks allow substitutions to occur in the group. Substitutions can be simple variable substitutions, or the result of running a nested command. Use curly braces `{ }` for grouping when you want to prevent substitutions.

2.13.2. Variables

Assign a value to a variable with the `set` command. You do not have to declare a variable before using it. Tcl variable names are case-sensitive.

```
set a 1
```

To access the contents of a variable, use a dollar sign (`"$"`) before the variable name. The following example prints `"Hello world"` in a different way.

```
set a Hello  
set b world  
puts "$a $b"
```

2.13.3. Substitutions

Tcl performs three types of substitution:

- Variable value substitution
- Nested command substitution
- Backslash substitution

2.13.3.1. Variable Value Substitution

Variable value substitution, refers to accessing the value stored in a variable with a dollar sign (“\$”) before the variable name.

2.13.3.2. Nested Command Substitution

Nested command substitution refers to how the Tcl interpreter evaluates Tcl code in square brackets. The Tcl interpreter evaluates nested commands, starting with the innermost nested command, and commands nested at the same level from left to right. Each nested command result is substituted in the outer command.

```
set a [string length foo]
```

2.13.3.3. Backslash Substitution

Backslash substitution allows you to quote reserved characters in Tcl, such as dollar signs (“\$”) and braces (“{ }”). You can also specify other special ASCII characters like tabs and new lines with backslash substitutions. A backslash before a character tells the TCL interpreter to treat the next character as a literal if the character is not the last character on the line.

```
puts "This is a \$ special character"

puts "This is a\
$ special character and line continuation"

puts "This is backslash \is ignored"

puts "This is backslash\
continued on next line"
```

2.13.4. Arithmetic

Use the `expr` command to perform arithmetic calculations. Use curly braces (“{ }”) to group the arguments of this command for greater efficiency and numeric precision.

```
set a 5
set b [expr { $a + sqrt(2) }]
```

The Intel Quartus Prime software supports all standard Tcl boolean and arithmetic operators, such as `&&` (AND), `||` (OR), `!` (NOT), and comparison operators such as `<` (less than), `>` (greater than), and `==` (equal to).



2.13.5. Lists

A Tcl list is a series of values. Supported list operations include creating lists, appending lists, extracting list elements, computing the length of a list, sorting a list, and more.

```
set a { 1 2 3 }
```

You can use the `lindex` command to extract information at a specific index in a list. Indexes are zero-based. You can use the index `end` to specify the last element in the list, or the index `end-<n>` to count from the end of the list. For example, to print the second element (at index 1) in the list stored in `a` use the following code.

```
puts [lindex $a 1]
```

The `llength` command returns the length of a list.

```
puts [llength $a]
```

The `lappend` command appends elements to a list. If a list does not already exist, the list you specify is created. The list variable name is not specified with a dollar sign (“\$”).

```
lappend a 4 5 6
```

2.13.6. Arrays

Arrays are similar to lists except that they use a string-based index. Tcl arrays are implemented as hash tables. You can create arrays by setting each element individually or with the `array set` command.

To set an element with an index of `Mon` to a value of `Monday` in an array called `days`, use the following command:

```
set days(Mon) Monday
```

The `array set` command requires a list of index/value pairs. This example sets the array called `days`:

```
array set days { Sun Sunday Mon Monday Tue Tuesday \
                Wed Wednesday Thu Thursday Fri Friday Sat Saturday }
```

```
set day_abbreviation Mon
puts $days($day_abbreviation)
```

Use the `array names` command to get a list of all the indexes in a particular array. The index values are not returned in any specified order. The following example is one way to iterate over all the values in an array.

```
foreach day [array names days] {
    puts "The abbreviation $day corresponds to the day\
name $days($day)"
}
```

Arrays are a very flexible way of storing information in a Tcl script and are a good way to build complex data structures.

2.13.7. Control Structures

Tcl supports common control structures, including if-then-else conditions and `for`, `foreach`, and `while` loops. The position of the curly braces as shown in the following examples ensures the control structure commands are executed efficiently and correctly. The following example prints whether the value of variable `a` positive, negative, or zero.

If-Then-Else Structure

```
if { $a > 0 } {
    puts "The value is positive"
} elseif { $a < 0 } {
    puts "The value is negative"
} else {
    puts "The value is zero"
}
```

The following example uses a `for` loop to print each element in a list.

For Loop

```
set a { 1 2 3 }
for { set i 0 } { $i < [llength $a] } { incr i } {
    puts "The list element at index $i is [lindex $a $i]"
}
```

The following example uses a `foreach` loop to print each element in a list.

foreach Loop

```
set a { 1 2 3 }
foreach element $a {
    puts "The list element is $element"
}
```

The following example uses a `while` loop to print each element in a list.

while Loop

```
set a { 1 2 3 }
set i 0
while { $i < [llength $a] } {
    puts "The list element at index $i is [lindex $a $i]"
    incr i
}
```

You do not have to use the `expr` command in boolean expressions in control structure commands because they invoke the `expr` command automatically.

2.13.8. Procedures

Use the `proc` command to define a Tcl procedure (known as a subroutine or function in other scripting and programming languages). The scope of variables in a procedure is local to the procedure. If the procedure returns a value, use the `return` command to return the value from the procedure. The following example defines a procedure that multiplies two numbers and returns the result.



Simple Procedure

```
proc multiply { x y } {  
    set product [expr { $x * $y }]  
    return $product  
}
```

The following example shows how to use the `multiply` procedure in your code. You must define a procedure before your script calls it.

Using a Procedure

```
proc multiply { x y } {  
    set product [expr { $x * $y }]  
    return $product  
}  
set a 1  
set b 2  
puts [multiply $a $b]
```

Define procedures near the beginning of a script. If you want to access global variables in a procedure, use the `global` command in each procedure that uses a global variable.

Accessing Global Variables

```
proc print_global_list_element { i } {  
    global my_data  
    puts "The list element at index $i is [lindex $my_data $i]"  
}  
set my_data { 1 2 3}  
print_global_list_element 0
```

2.13.9. File I/O

Tcl includes commands to read from and write to files. You must open a file before you can read from or write to it, and close it when the read and write operations are done.

To open a file, use the `open` command; to close a file, use the `close` command. When you open a file, specify its name and the mode in which to open it. If you do not specify a mode, Tcl defaults to read mode. To write to a file, specify `w` for write mode.

Open a File for Writing

```
set output [open myfile.txt w]
```

Tcl supports other modes, including appending to existing files and reading from and writing to the same file.

The `open` command returns a file handle to use for read or write access. You can use the `puts` command to write to a file by specifying a file handle.

Write to a File

```
set output [open myfile.txt w]  
puts $output "This text is written to the file."  
close $output
```

You can read a file one line at a time with the `gets` command. The following example uses the `gets` command to read each line of the file and then prints it out with its line number.

Read from a File

```
set input [open myfile.txt]
set line_num 1
while { [gets $input line] >= 0 } {
    # Process the line of text here
    puts "$line_num: $line"
    incr line_num
}
close $input
```

2.13.10. Syntax and Comments

Arguments to Tcl commands are separated by white space, and Tcl commands are terminated by a newline character or a semicolon. You must use backslashes when a Tcl command extends more than one line. The backslash (\) must be the last character in the line to designate line extension. If the backslash is followed by any other character including a space, that character is treated as a literal.

Tcl uses the hash or pound character (#) to begin comments. The # character must begin a comment. If you prefer to include comments on the same line as a command, be sure to terminate the command with a semicolon before the # character. The following example is a valid line of code that includes a `set` command and a comment.

```
set a 1;# Initializes a
```

Without the semicolon, the command is invalid because the `set` command does not terminate until the new line after the comment.

The Tcl interpreter counts curly braces inside comments, which can lead to errors that are difficult to track down. The following example causes an error because of unbalanced curly braces.

```
# if { $x > 0 } {
if { $y > 0 } {
    # code here
}
```

2.13.11. External References

For more information about Tcl, refer to the following sources:

- Brent B. Welch and Ken Jones, and Jeffery Hobbs, *Practical Programming in Tcl and Tk* (Upper Saddle River: Prentice Hall, 2003)
- John Ousterhout and Ken Jones, *Tcl and the Tk Toolkit* (Boston: Addison-Wesley Professional, 2009)
- Mark Harrison and Michael McLennan, *Effective Tcl/Tk Programming: Writing Better Programs in Tcl and Tk* (Boston: Addison-Wesley Professional, 1997)



Related Information

www.tcl.tk

Tcl Developer Xchange

2.14. Tcl Scripting Revision History

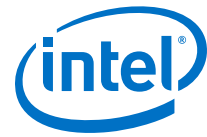
Table 7. Document Revision History

Date	Version	Changes
2015.11.02	15.1.0	<ul style="list-style-type: none">Changed instances of <i>Quartus II</i> to <i>Intel Quartus Prime</i>.Updated the list of Tcl packages in the <i>Intel Quartus Prime Tcl Packages</i> section.Updated the <i>Intel Quartus Prime Tcl API Help</i> section:<ul style="list-style-type: none">Updated the Tcl Help Output
June 2014	14.0.0	Updated the format.
June 2012	12.0.0	<ul style="list-style-type: none">Removed survey link.
November 2011	11.0.1	<ul style="list-style-type: none">Template updateUpdated supported version of Tcl in the section "Tool Command Language."minor editorial changes
May 2011	11.0.0	Minor updates throughout document.
December 2010	10.1.0	Template update Updated to remove tcl packages used by the Classic Timing Analyzer
July 2010	10.0.0	Minor updates throughout document.
November 2009	9.1.0	<ul style="list-style-type: none">Removed LogicLock example.Added the incremental_compilation, insystem_source_probe, and rtl packages to Table 3-1 and Table 3-2.Added quartus_map to table 3-2.
March 2009	9.0.0	<ul style="list-style-type: none">Removed the "EDA Tool Assignments" sectionAdded the section "Compile All Revisions" on page 3-9Added the section "Using the tclsh Shell" on page 3-20
November 2008	8.1.0	Changed to 8½" × 11" page size. No change to content.
May 2008	8.0.0	Updated references.

Related Information

Documentation Archive

For previous versions of the *Intel Quartus Prime Handbook*, search the documentation archives.



A. Intel Quartus Prime Standard Edition User Guides

Refer to the following user guides for comprehensive information on all phases of the Intel Quartus Prime Standard Edition FPGA design flow.

Related Information

- [Intel Quartus Prime Standard Edition User Guide: Getting Started](#)
Introduces the basic features, files, and design flow of the Intel Quartus Prime Standard Edition software, including managing Intel Quartus Prime Standard Edition projects and IP, initial design planning considerations, and project migration from previous software versions.
- [Intel Quartus Prime Standard Edition User Guide: Platform Designer](#)
Describes creating and optimizing systems using Platform Designer (Standard), a system integration tool that simplifies integrating customized IP cores in your project. Platform Designer (Standard) automatically generates interconnect logic to connect intellectual property (IP) functions and subsystems.
- [Intel Quartus Prime Standard Edition User Guide: Design Recommendations](#)
Describes best design practices for designing FPGAs with the Intel Quartus Prime Standard Edition software. HDL coding styles and synchronous design practices can significantly impact design performance. Following recommended HDL coding styles ensures that Intel Quartus Prime Standard Edition synthesis optimally implements your design in hardware.
- [Intel Quartus Prime Standard Edition User Guide: Design Compilation](#)
Describes set up, running, and optimization for all stages of the Intel Quartus Prime Standard Edition Compiler. The Compiler synthesizes, places, and routes your design before generating a device programming file.
- [Intel Quartus Prime Standard Edition User Guide: Design Optimization](#)
Describes Intel Quartus Prime Standard Edition settings, tools, and techniques that you can use to achieve the highest design performance in Intel FPGAs. Techniques include optimizing the design netlist, addressing critical chains that limit retiming and timing closure, and optimization of device resource usage.
- [Intel Quartus Prime Standard Edition User Guide: Programmer](#)
Describes operation of the Intel Quartus Prime Standard Edition Programmer, which allows you to configure Intel FPGA devices, and program CPLD and configuration devices, via connection with an Intel FPGA download cable.
- [Intel Quartus Prime Standard Edition User Guide: Partial Reconfiguration](#)
Describes Partial Reconfiguration, an advanced design flow that allows you to reconfigure a portion of the FPGA dynamically, while the remaining FPGA design continues to function. Define multiple personas for a particular design region, without impacting operation in other areas.



- [Intel Quartus Prime Standard Edition User Guide: Third-party Simulation](#)
Describes RTL- and gate-level design simulation support for third-party simulation tools by Aldec*, Cadence*, Mentor Graphics, and Synopsys that allow you to verify design behavior before device programming. Includes simulator support, simulation flows, and simulating Intel FPGA IP.
- [Intel Quartus Prime Standard Edition User Guide: Third-party Synthesis](#)
Describes support for optional synthesis of your design in third-party synthesis tools by Mentor Graphics, and Synopsys. Includes design flow steps, generated file descriptions, and synthesis guidelines.
- [Intel Quartus Prime Standard Edition User Guide: Debug Tools](#)
Describes a portfolio of Intel Quartus Prime Standard Edition in-system design debugging tools for real-time verification of your design. These tools provide visibility by routing (or “tapping”) signals in your design to debugging logic. These tools include System Console, Signal Tap logic analyzer, Transceiver Toolkit, In-System Memory Content Editor, and In-System Sources and Probes Editor.
- [Intel Quartus Prime Standard Edition User Guide: Timing Analyzer](#)
Explains basic static timing analysis principals and use of the Intel Quartus Prime Standard Edition Timing Analyzer, a powerful ASIC-style timing analysis tool that validates the timing performance of all logic in your design using an industry-standard constraint, analysis, and reporting methodology.
- [Intel Quartus Prime Standard Edition User Guide: Power Analysis and Optimization](#)
Describes the Intel Quartus Prime Standard Edition Power Analysis tools that allow accurate estimation of device power consumption. Estimate the power consumption of a device to develop power budgets and design power supplies, voltage regulators, heat sink, and cooling systems.
- [Intel Quartus Prime Standard Edition User Guide: Design Constraints](#)
Describes timing and logic constraints that influence how the Compiler implements your design, such as pin assignments, device options, logic options, and timing constraints. Use the Pin Planner to visualize, modify, and validate all I/O assignments in a graphical representation of the target device.
- [Intel Quartus Prime Standard Edition User Guide: PCB Design Tools](#)
Describes support for optional third-party PCB design tools by Mentor Graphics and Cadence*. Also includes information about signal integrity analysis and simulations with HSPICE and IBIS Models.
- [Intel Quartus Prime Standard Edition User Guide: Scripting](#)
Describes use of Tcl and command line scripts to control the Intel Quartus Prime Standard Edition software and to perform a wide range of functions, such as managing projects, specifying constraints, running compilation or timing analysis, or generating reports.