

# ***ACTmapVHDL Synthesis***

## *Methodology Guide*



Windows® & UNIX® Environments

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# Table of Contents

Introduction . . . . .	vii
Document Organization . . . . .	vii
Document Assumptions . . . . .	viii
Document Conventions . . . . .	viii
Designer Series Manuals . . . . .	ix
On-Line Help . . . . .	xi
1 ACTmap Design Flow . . . . .	1
Design Flow Illustrated . . . . .	1
Design Flow Overview . . . . .	2
2 Using ACTmap VHDL . . . . .	5
VHDL Naming Conventions and Keywords . . . . .	5
Declaring a Circuit. . . . .	6
Signals . . . . .	9
Operators . . . . .	14
Logic Conditions . . . . .	15
Repetitive Operations . . . . .	18
Attributes . . . . .	19
Instantiating Cells . . . . .	20
Creating Hierarchy. . . . .	22
Inferring ACTgen Macros . . . . .	24
Processes . . . . .	32
State Machine Design . . . . .	37
Supported Packages . . . . .	44
Using Procedures . . . . .	45
Limitations . . . . .	46
3 Advanced Optimization Techniques . . . . .	49
ACTmap VHDL Guidelines. . . . .	49
General Optimization Guidelines. . . . .	49
State Machine Optimization . . . . .	52
Setting Design Constraints . . . . .	53

Automatic I/O Insertion . . . . .	53
3200DX and 42MX. . . . .	54
Sequential Remapping . . . . .	54
Gated Macros . . . . .	56
Designing for Radiation Environments . . . . .	56
<b>A Using ACTmap in Batch Mode . . . . .</b>	<b>57</b>
Invoking ACTmap in Batch Mode . . . . .	57
Command Line Format. . . . .	58
Creating a Batch File. . . . .	58
Creating a Configuration File . . . . .	59
ACTmap Options . . . . .	60
Batch Mode Options Usage Examples . . . . .	62
<b>B Product Support . . . . .</b>	<b>71</b>
Actel U.S. Toll-Free Line . . . . .	71
Customer Service . . . . .	71
Customer Applications Center . . . . .	72
Guru Automated Technical Support . . . . .	72
Action Facts. . . . .	72
Web Site . . . . .	73
FTP Site. . . . .	73
Electronic Mail . . . . .	73
Worldwide Sales Offices . . . . .	74
<b>Glossary. . . . .</b>	<b>75</b>
<b>Index . . . . .</b>	<b>79</b>

---

## ***List of Figures***

ACTmap Design Flow . . . . .	1
Half Adder . . . . .	7
Half Adder . . . . .	8
3 Stage Shift Register . . . . .	16
CLKINT Symbol . . . . .	20
Full Adder Schematic . . . . .	22
Multiplexer Using an If Statement . . . . .	26
Multiplexer using a With or Case Statement . . . . .	27
2 to 1 Multiplexer . . . . .	33
Single Bit D Flip-Flop . . . . .	34
Multi-bit D Latch . . . . .	34
2 to 1 Multiplexer . . . . .	36
Latch Diagram . . . . .	36
Single Process FSM . . . . .	37
Mealy FSM . . . . .	40
Library Cells DFC1E and DFM7A before Remapping . . . . .	55
Library Cells DFC1E and DFM7A after Remapping . . . . .	56



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# Introduction

VHDL is a high-level description language for system and circuit design that supports various abstraction levels, including system design without regard to a specific technology. However, to achieve optimal performance and area from your target device, you must become familiar with the architecture of the device and code your design for the architecture.

The *ACTmap VHDL Synthesis Methodology Guide* contains information and techniques for using ACTmap VHDL to design an Actel device. This includes information about writing VHDL code for ACTmap, optimization techniques, and sample code. This guide also includes information about using the ACTmap VHDL Synthesis tool in batch mode. Refer to the *Designing with Actel* manual and the ACTmap on-line help for information about the ACTmap user interface. Refer to the *Actel HDL Coding Style Guide* for additional information about HDL coding.

## Document Organization

The *ACTmap VHDL Synthesis Methodology Guide* is divided into the following chapters:

**Chapter 1 - ACTmap Design Flow** describes the design flow for creating Actel designs with the ACTmap VHDL synthesis tool.

**Chapter 2 - Using ACTmap VHDL** describes how to write VHDL for use with the ACTmap VHDL synthesis tool.

**Chapter 3 - Advanced Optimization Techniques** contains information about the optimization features of ACTmap and describes how to implement optimization techniques in a design.

**Appendix A - Using ACTmap in Batch Mode** contains information about using command-line commands and command files in the ACTmap VHDL synthesis tool.

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

## Document Assumptions

The information in this guide is based on the following assumptions:

1. You have installed the Designer Series software, including ACTmap.
2. You are familiar with UNIX workstations and operating systems.
3. You are familiar with PCs and Windows operating environments.
4. You are familiar with FPGA design software, including design synthesis and simulation tools.

## Document Conventions

The following conventions are used throughout this manual:

Information that is meant to be input by the user is formatted as follows:

**keyboard input**

The contents of a file is formatted as follows:

file contents

VHDL code appear as follows, with VHDL keyword in bold:

```
entity actel is  
port (  
    a: in bit;  
    y: out bit);  
end actel;
```

Messages that are displayed on the screen appear as follows:

Screen Message
----------------

The <act\_fam> variable represents an Actel device family. To reference an actual family, substitute the name of the Actel device when you see this variable. Available families are act1, act2 (for ACT 2 and 1200XL devices), act3, 3200dx, 40mx, 42mx and 54sx.



## *Designer Series Manuals*

The Designer Series software includes printed and on-line manuals. The on-line manuals are in PDF format on the CD-ROM in the “/doc” directory. These manuals are also installed onto your system when you install the Designer software. To view the on-line manuals, you must have Adobe® Acrobat Reader® installed. Actel provides Reader on the Designer Series CD-ROM.

The Designer Series includes the following manuals, which provide additional information on designing Actel FPGAs:

*Designing with Actel.* This manual describes the design flow and user interface for the Actel Designer Series software, including information about using the ACTgen Macro Builder and ACTmap VHDL Synthesis software.

*Actel HDL Coding Style Guide.* This guide provides preferred coding styles for the Actel architecture and information about optimizing your HDL code for Actel devices.

*ACTmap VHDL Synthesis Methodology Guide.* This guide contains information, optimization techniques, and procedures to assist designers in the design of Actel devices using ACTmap VHDL.

*Silicon Expert User's Guide.* This guide contains information and procedures to assist designers in the use of Actel's Silicon Expert tool.

*Cadence® Interface Guide.* This guide contains information and procedures to assist designers in the design of Actel devices using Cadence CAE software and the Designer Series software.

*Mentor Graphics® Interface Guide.* This guide contains information and procedures to assist designers in the design of Actel devices using Mentor Graphics CAE software and the Designer Series software.

*MOTIVE™ Static Timing Analysis Interface Guide.* This guide contains information and procedures to assist designers in the use of the MOTIVE software to perform static timing analysis on Actel designs.

*Synopsys® Synthesis Methodology Guide.* This guide contains preferred HDL coding styles and information and procedures to assist designers in the design of Actel devices using Synopsys CAE software and the Designer Series software.

*Viewlogic® Powerview Interface Guide.* This guide contains information and procedures to assist designers in the design of Actel devices using Powerview CAE software and the Designer Series software.

*Viewlogic Workview® Office Interface Guide.* This guide contains information and procedures to assist designers in the design of Actel devices using Workview Office CAE software and the Designer Series software.

*VHDL Vital Simulation Guide.* This guide contains information and procedures to assist designers in simulating Actel designs using a Vital compliant VHDL simulator.

*Verilog® Simulation Guide.* This guide contains information and procedures to assist designers in simulating Actel designs using a Verilog simulator.

*Activator and APS Programming System Installation and User's Guide.* This guide contains information about how to program and debug Actel devices, including information about using the Silicon Explorer diagnostic tool for system verification.

*Silicon Sculptor User's Guide.* This guide contains information about how to program Actel devices using the Silicon Sculptor software and device programmer.

*Silicon Explorer Quick Start.* This guide contains information about connecting the Silicon Explorer diagnostic tool and using it to perform system verification.

*Designer Series Development System Conversion Guide UNIX Environments.* This guide describes how to convert designs created in Designer Series versions 3.0 and 3.1 for UNIX to be compatible with later versions of Designer Series.

*Designer Series Development System Conversion Guide Windows Environments.* This guide describes how to convert designs created in Designer Series versions 3.0 and 3.1 for Windows to be compatible with later versions of Designer Series.

*FPGA Data Book and Design Guide.* This guide contains detailed specifications on Actel device families. Information such as propagation delays, device package pinout, derating factors, and power calculations are found in this guide.

*Macro Library Guide.* This guide provides descriptions of Actel library elements for Actel device families. Symbols, truth tables, and pin loading are included for all macros.

## *On-Line Help*

The Designer Series software comes with on-line help. On-line help specific to each software tool is available in Designer, ACTgen, ACTmap, Silicon Expert, and APSW.



# ACTmap Design Flow

This chapter illustrates and describes the design flow for creating Actel designs using the ACTmap VHDL synthesis tool and third party tools.

## Design Flow Illustrated

Figure 1-1 illustrates the design flow for creating an Actel device using the Designer Series, ACTmap, and 3rd party CAE software<sup>1</sup>.

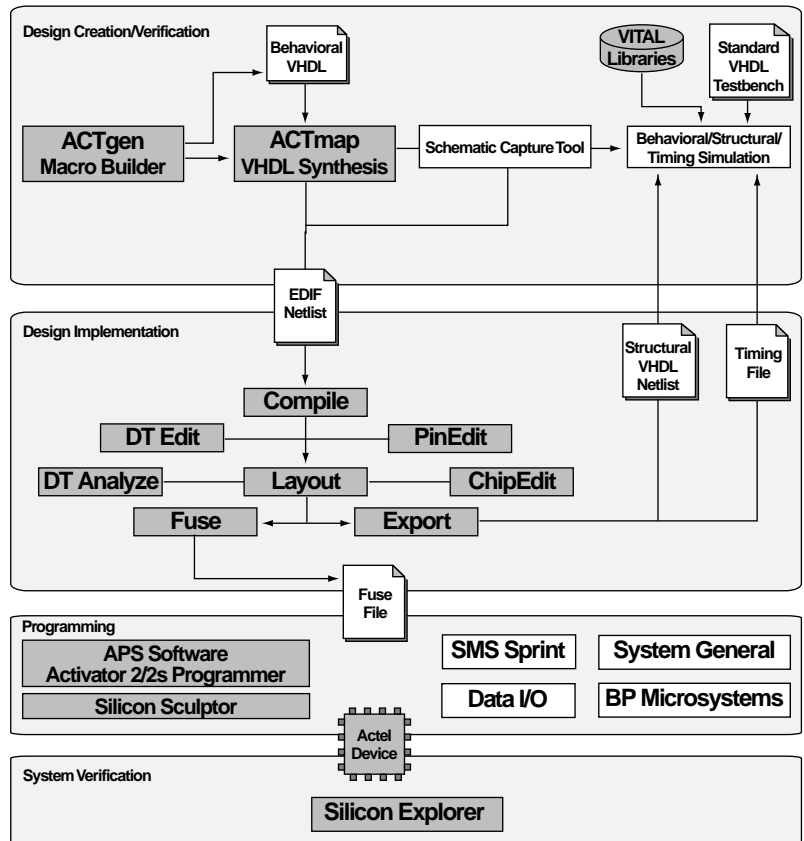


Figure 1-1. ACTmap Design Flow

1. Actel-specific utilities/tools are denoted by the grey boxes in Figure 1-1.

## Design Flow Overview

The ACTmap design flow has four main steps; design creation/verification, design implementation, programming, and system verification. These steps are described in detail in the following sections.

### **Design Creation/ Verification**

During design creation/verification, a design is captured in an RTL-level (behavioral) VHDL source file. After capturing the design, behavioral simulation of the VHDL file can be performed to verify that the VHDL code is correct. The code is then synthesized into an Actel gate-level (structural) VHDL netlist using ACTmap. After synthesis, structural simulation of the design can be performed. Finally, an EDIF netlist is generated for use in Designer or a third party CAE tool. A structural VHDL netlist is also generated for timing simulation.

#### ***VHDL Design Source Entry***

Enter your VHDL design source using a text editor or a context-sensitive VHDL editor. Your VHDL design source can contain RTL-level constructs as well as instantiations of structural elements, such as ACTgen macros. Refer to Chapter 2, “Using ACTmap VHDL” on page 5, for information about ACTmap VHDL coding techniques.

#### ***Behavioral Simulation***

Perform a behavioral simulation of your design before synthesis. Behavioral simulation verifies the functionality of your VHDL code. Typically, unit delays are used and a standard VHDL test bench can be used to drive simulation. Refer to the documentation included with your simulation tool for information about performing behavioral simulation.

#### ***Synthesis***

After you have created your behavioral VHDL design source, create a project in ACTmap and synthesize your design before placing and routing it in Designer. Synthesis transforms the behavioral VHDL file into a gate-level netlist and optimizes the design for a target technology. Refer to the *Designing with Actel* manual for information about synthesizing a design in ACTmap.

### **EDIF Netlist Generation**

After you have created, synthesized, and verified your design, you must generate an EDIF netlist for place and route in Designer. ACTmap also can be used to create symbols and wire files for use in Viewlogic tools. Most third party CAE tools can also import the EDIF netlist as a block for use in a schematic capture tool. Refer to the Actel Interface Guides and the documentation included with your CAE tools for information about importing EDIF blocks.

This EDIF netlist is also used to generate a structural VHDL netlist. Refer to the *Designing with Actel* manual for information about generating an EDIF netlist from ACTmap.

### **Structural VHDL Netlist Generation**

Generate a structural VHDL netlist from your EDIF netlist for use in structural and timing simulation by exporting it from ACTmap. Refer to the *Designing with Actel* manual for information about generating a structural netlist from ACTmap.

### **Structural Simulation**

Perform a structural simulation of your design before placing and routing it. Structural simulation verifies the functionality of your post-synthesis structural VHDL netlist. Default unit delays included in the compiled Actel VITAL libraries are used for every gate. Refer to the documentation included with your simulation tool for information about performing structural simulation.

## **Design Implementation**

During design implementation, a design is placed and routed using Designer. Additionally, static timing analysis can be performed in Designer with the DT Analyze tool. After place and route, post-layout (timing) simulation is performed.

### **Place and Route**

Use Designer to place and route your design. Make sure to specify GENERIC as the Edif Flavor and VHDL as the Naming Style when importing the EDIF netlist into Designer. Refer to the *Designing with Actel* manual for information about using Designer.

### **Timing Analysis**

Use the DT Analyze tool in Designer to perform static timing analysis on your design. Refer to the *Designer with Actel* manual for information on using DT Analyze.

### **Timing Simulation**

Perform a timing simulation of your design after placing and routing it. Timing simulation verifies that the design meets timing requirements. Timing simulation requires information extracted from Designer, which overrides default unit delays in the compiled Actel VITAL libraries. Refer to the documentation included with your simulation tool for information about performing timing simulation and the *Designing with Actel* manual for information about extracting timing information from Designer.

## **Programming**

Program a device with programming software and hardware from Actel or a supported 3rd party programming system. Refer to the *Designing with Actel* manual and the *Activator and APS Programming System Installation and User's Guide* or *Silicon Sculptor User's Guide* for information about programming an Actel device.

## **System Verification**

You can perform system verification on a programmed device using the Actel Silicon Explorer diagnostic tool. Refer to the *Activator and APS Programming System Installation and User's Guide* or *Silicon Explorer Quick Start* for information about using the Silicon Explorer.



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## *Using ACTmap VHDL*

This chapter provides descriptions and examples of how to write VHDL for use with the ACTmap VHDL synthesis tool. This includes information about VHDL naming conventions and keywords, about declaring circuits and signals in VHDL, and a description of supported operators. Also included is information about using logic conditions and repetitive operations, assigning attributes, and instantiating cells.

Other sections include how to create hierarchical designs for ACTmap, how to infer ACTgen macros, and information about writing processes. State machine design is described and guidelines for using procedures are also given. Finally, supported packages and limitations are listed.

### *VHDL Naming Conventions and Keywords*

There are naming conventions you must follow when writing VHDL code. Additionally, VHDL has reserved words that cannot be used for signal or entity names. This section lists the naming conventions and reserved keywords for each.

#### ***Naming Conventions***

The following naming conventions apply to VHDL designs:

- VHDL is not case sensitive.
- Two dashes "--" are used to begin comment lines.
- Names can use alphanumeric characters and the underscore "\_" character.
- Names must begin with an alphabetic letter.
- You may not use two underscores in a row, or use an underscore as the last character in the name.
- Spaces are not allowed within names.
- Object names must be unique. For example, you cannot have a signal named A and a bus named A(7 downto 0).
- An entity cannot have the same name as an Actel Library macro.

## Keywords

The following is a list of the VHDL reserved keywords that cannot be used for signal or entity names:

abs	downto	library	postponed	subtype
access	else	linkage	procedure	then
after	elsif	literal	process	to
alias	end	loop	pure	transport
all	entity	map	range	type
and	exit	mod	record	unaffected
architecture	file	nand	register	units
array	for	new	reject	until
assert	function	next	rem	use
attribute	generate	nor	report	variable
begin	generic	not	return	wait
block	group	null	rol	when
body	guarded	of	ror	while
buffer	if	on	select	with
bus	impure	open	severity	xnor
case	in	or	shared	xor
component	inertial	others	signal	
configuration	inout	out	sla	
constant	is	package	sra	
disconnect	label	port	srl	

## Declaring a Circuit

A circuit description consists of the interface defining the signal connections of the circuit and a description of the circuit's behavior or composition. The interface is referred to as an entity and the signal connections are ports. The section of code that defines the entity behavior or composition is referred to as the architecture. The entity in VHDL is equivalent to a symbol. The architecture is equivalent to a schematic.

## Entity Description

An entity consists of the entity name, the names of entity's ports, the direction of the ports (input, output, etc.), and a VHDL signal type for each of the ports. Below is an example entity description for a half adder, illustrated in Figure 2-1.

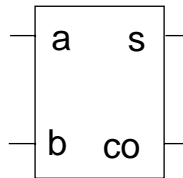


Figure 2-1. Half Adder

```

entity halfadder is
  port (a, b: in bit;
        s, co: out std_logic);
end halfadder;
  
```

## Architecture Description

The behavior or composition of the entity is described in the architecture section of code. The level of the VHDL description of the architecture can be behavioral, register transfer level (RTL), or structural.

A behavioral description describes how the system behaves in response to input signals without regard for hardware implementation.

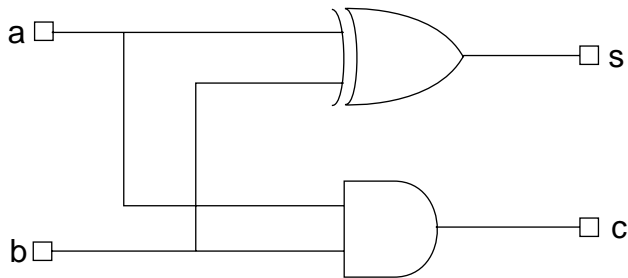
An RTL description defines the circuit behavior, much like a detailed block diagram describes traditional logic design. Clock and reset signals are defined, and data busses and storage devices (registers, counters, memory, etc.) have specific numbers of bits assigned. However, the level of abstraction used to describe the logic functions is higher than the gate-level details of a conventional schematic.

A structural description is used in the same manner as a netlist.

The structure of the design is described by components interconnected by signals. Regardless of the VHDL description level, the syntax of the architecture must have a type and an entity association, as in the following example:

```
architecture behavioral of example is  
    ... signals and constants are declared...  
begin  
    ... lines of code describing the behavior of entity exam-  
    ple...  
end example;
```

Below is an architectural description of the functionality of a half adder entity. The half adder is illustrated in Figure 2-2.



*Figure 2-2. Half Adder*

```
architecture behavioral of halfadder is  
begin  
    s <= a xor b;  
    c <= a and b;  
end behavioral;
```

## Signals

Signal declarations are made in the declaration section of the architecture. This is the section of code that appears after the architecture type and entity association have been defined and before the begin statement. Constants are also defined in the declaration section, often after the signals are declared.

As in a physical hardware system, signals can be single bits, such as a clock or a reset, or they can be busses of a specified width. All signals are declared with both a name and a data type. VHDL by itself does not predefine characteristics of signals such as logic states or driving strengths. Instead it makes provisions for doing so by means of VHDL files grouped together into packages and libraries, which are normally shipped with VHDL simulators or synthesis tools. This section lists the data types that ACTmap supports.

## **Enumerated Types**

Types that have a fixed number of unique states are called enumerated types. You can choose to use one of the standard types or define your own.

### ***Bit and Boolean***

The bit and boolean types are standard enumerated types defined as part of ACTmap VHDL and have two states each.

- bit can be '0' or '1'  
`signal a: bit;`
- boolean can be true or false  
`signal a: boolean;`

### ***User-Defined***

Enumerated types are often defined by the user for a specific purpose, such as declaring the states of a state machine. Each state of the defined type must be a unique identifier. The enumerated type must be defined using the following syntax before a signal can be declared of that type.

```
type speedtype is (stop, fast, faster);
```

Once a signal of type speedtype is defined, it can only contain one of the three values. Below is an example of a signal defined as type speedtype:

```
signal speed: speedtype;
```

The following example shows how user defined types are defined and used.

```
architecture behavioral of drive is  
  signal light: bit_vector(0 to 1);  
  type speedtype is (stop, fast, faster);  
  signal speed: speedtype;  
  
  constant red: bit_vector(0 to 1) := "00";  
  constant yellow: bit_vector(0 to 1) := "01";  
  constant green: bit_vector(0 to 1) := "10";  
  
begin  
  with light select  
    speed <= stop when red;  
    fast when green,  
    faster when others;  
end behavioral;
```

## Std\_Logic

Two state types are often not sufficient for most simulations. For unknown values and varying signal strengths, a 9-state logic system, often referred to as MVL9, was adopted as a standard by IEEE. This standard enumerated type is called `std_logic`. The following states are defined:

- U for uninitialized
- X for unknown
- Z for tri-state
- W for weak strength
- H for high (resistive) - used for open collector outputs
- L for low (resistive) - used for open emitter outputs
- - for don't care

**Note:** During VHDL compilation, ACTmap treats '0' and 'L' as low, '1' and 'H' as high, and 'U', 'X', 'W' and '-' as don't care.

## Std\_Ulogic

Actel does not recommend using the `std_ulogic` data type. ACTmap, ACTgen, and Designer do not have the capability to write VHDL netlists using the `std_ulogic` data type. All VHDL netlists are written using the `std_logic` data type. Test benches written using the `std_ulogic` data types generally do not work with gate-level VHDL netlists created by the Designer Series tools.

## Vectors

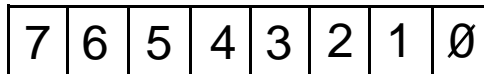
Busses or multibit signals are referred to as vectors. The data types `bit` and `std_logic` are definable as vectors. When vectors are defined, a range for the vector array must be declared. The range can be either ascending or descending. For an ascending range, the most significant bit is on the left and is defined using the "to" keyword as follows:

```
signal databus: std_logic_vector(0 to 7);
```

0	1	2	3	4	5	6	7
---	---	---	---	---	---	---	---

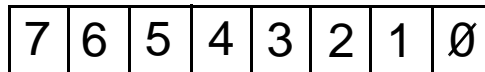
For descending range, the most significant bit is on the right, and is defined using the “downto” keyword as follows:

```
signal databus: std_logic_vector(7 downto 0);
```



To use the entire vector, use the name of the vector as shown:

```
databus
```

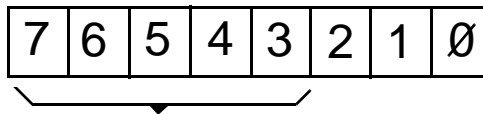


Individual bits of a bus or register are used as shown:

```
databus(4) -- for bit 4
```

A portion of a bus or register is referred to as a slice and is used as shown:

```
databus(7 downto 3)
```



```
Databus (7 downto 3)= "slice"
```

**Note:** The “to” or “downto” statement of the slice must agree with the to or downto statement of the vector declaration.



## Integer Types

An integer type defines the set of integer values in its range. When designing arithmetic behavior, it is very helpful to work with integer types. VHDL pre-defines an integer type called “integer” that covers a range of integer values that can be represented in two’s complement with 32 bits:

```
signal s32_int: integer;
```

An object can also be defined to be a sub-range of an integer:

```
signal s4_int: integer range 0 to 15;
```

## Constants

Similar to a signal declaration, constants can be declared and given names. The following is an example of a constant declaration:

```
constant yellow: bit_vector := "01";
```

In this example, the name of the constant is yellow and it is a bit\_vector whose value is always “01.” The constant declaration uses a similar syntax to the signal declaration with the addition of the “:=” and the assigned value of the constant. Binary values of vectors are always enclosed in double quotes as shown, and are referred to as bit string literals. You can, but you do not need to, specify how many bits are in the constant with a to or downto statement.

## Operators

The standard logical and arithmetic operations that are supported by ACTmap are shown in Table 2-1.

*Table 2-1. Supported Arithmetic Operators*

Type	Symbol	Operation	Operand Type
Arithmetic	+	addition	integer, bit_vector, std_logic_vector
	-	subtraction	integer, bit_vector, std_logic_vector
	*	multiplication	integer, bit_vector, std_logic_vector
Logical	and	logical and	bit, boolean
	or	logical or	bit, boolean
	nand	logical nand	bit, boolean
	nor	logical nor	bit, boolean
	xor	logical exclusive-or	bit, boolean
	not	logical compliment	bit, boolean
Relational	=	equal	any type
	/=	not equal	any type
	<	less than	any type
	>	greater than	any type
	<=	less than or equal	any type
	>=	greater than or equal	any type

Table 2-1. Supported Arithmetic Operators (Continued)

Type	Symbol	Operation	Operand Type
Concatenation	&	concatenation	bit, bit_vector, std_logic, std_logic_vector

The following guidelines should be used when using the operators in your VHDL design:

- Parentheses must be included where the intended function may be ambiguous. The expression “a and b or not (c)” could be interpreted as “a and (b or not(c))” or “(a and b) or not(c)”, which are not equivalent. For example:

```
y <= (a and b) or not (c);
```

- The following example would mean a signal assignment without the if keyword. Within the if statement, the operator means less than or equal.

```
if databus_1 <= databus_2 then
```

## Logic Conditions

The various means of testing for logic conditions include the if, when, select, and case statements. If and case statements are used only in processes. Select and when statements are used only outside of processes.

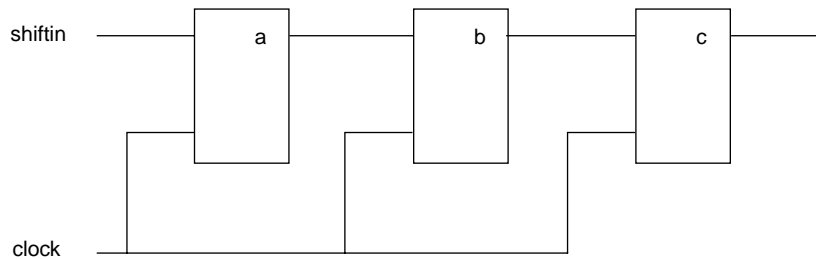
### If Statement

An if statement is a conditional statement that may only be used in a process. The syntax for an if statement is as follows:

```
if condition then
    some action;
elsif condition 2 then
```

```
    some action;  
end if;
```

The following is an example of an if-then-else statement that synthesizes a 3 stage shift register and is illustrated in Figure 2-3:



*Figure 2-3. 3 Stage Shift Register*

```
if (reset = '1') then  
    a <= '0';  
    b <= '0';  
    c <= '0';  
elsif (clock'event and clock = '1') then  
    a <= shiftin;  
    b <= a;  
    c <= b;  
end if;
```

## **When Statement**

A when statement is a conditional state assignment that synthesizes as combinatorial logic. The syntax for a when statement is as follows:

```
signal <= 'value' when condition  
    else 'value';
```

Below is an example of a when statement that synthesizes as an N bit “greater than” comparator:

```
signal <= '1' when databus > register  
    else '0';
```

## Select Statement

A select statement is a selected signal assignment that synthesizes into combinatorial logic. The syntax for a select statement is as follows:

```
with signal select
    target output <= waveform 1
when condition 1,
    waveform 2 when condition 2,
    waveform N when condition N;
```

Below is an example of a select statement that synthesizes as a four to one multiplexer controlled by “sel,” a two-bit control signal, whereby “y” is switched to one of the four data lines:

```
with sel select
    y <= a when "00",
    b when "01",
    c when "10",
    d when "11";
```

## Case Statement

A case statement is a selected signal assignment within a process. The syntax for a case statement is as follows:

```
case state is
    when condition 1 => target output <= waveform 1;
    when condition 2=> target output <= waveform 2;
    when condition N=> target output <= waveform N;
    when others => target output <= default waveform;
end case;
```

Below is an example of a case statement that synthesizes the same logic as the select code above when used within an unclocked process:

```
case sel is
    when "00" => y <= a;
    when "01" => y <= b;
    when "10" => y <= c;
    when others => y <= d;
end case;
```

Case statements must specify all possible cases. The “when others =>” statement should be added to VHDL case statements using `std_logic` data types. The following error message is displayed in ACTmap if all cases are not specified in a case statement:

ERROR : (VHP_0812). Line 29. A value is missing in case
---

## Repetitive Operations

Repetitive structures are declared with a generate statement.

### ***If-Generate Statement***

The if-generate statement is supported for static (non-dynamic) conditions.

```
loop label: if condition generate
    loop actions;
end generate;
```

### ***For-Generate Statement***

The for-generate statement is supported for static (non-dynamic) conditions.

```
loop label: for variable in start condition to end condition
generate
    loop actions;
end generate;
```

### ***For-Generate Loop***

For component instantiations, function or procedure calls inside a for-generate loop, a block statement has to be used inside the loop to be accepted by the ACTmap VHDL Compiler. The following is an example of a for generate loop inside a block statement:

```
entity example is
...
end example;

architecture arch of example is
    component small
```

```

...
end component;
...
for all: small use entity work.small(arch);
begin
  loop1: for i in 0 to 3 generate
  - begin block statement
    block1: block
    begin
      instance1: small port map ( a(i), b(i), s(i) );
    end block; -this line is added
  end generate loop1;
end arch;

```

## Attributes

The ACTmap VHDL Compiler uses the “donttouch” attribute to control synthesis of the described circuit. The “donttouch” attribute directs ACTmap not to optimize a given instance. Before the attribute can be used, it must first be declared with a type. The attribute can only be attached to instances of previously optimized macros or modules.

The syntax for declaring the donttouch attribute is as follows:

```
attribute donttouch : string;
```

The syntax for attaching the “donttouch” attribute is as follows:

```
attribute donttouch of instance label: label is "attribute
value";
```

Below is an example of adding the value true to the donttouch attribute:

```

for instance actgen_1:
attribute donttouch : string;
attribute donttouch of actgen_1: label is "true";

```

**Note:** The value of the attribute is not important in this case.

## Instantiating Cells

In order to instantiate an entity into a VHDL description, you must first declare a component for it. If you use a component instantiation in your VHDL design, ACTmap tries to find the definition of that component. There are three possibilities for defining an instantiated cell:

1. The component is a cell in the specified Actel macro library.
2. The component has a matching entity in the VHDL source file.
3. The component has no definition.

### Library Macros

Components in the Actel macro library are considered black boxes during synthesis since there is no entity/architecture description for them. Actel library cells defined in the VHDL code are not optimized in VHDL Compiler, but are treated as black boxes.

When the optimized EDIF netlist is written, the contents for each macro is completed. An added benefit is that the time needed for optimization of the whole circuit can be reduced, since ACTmap does not have to optimize the implementation of the dedicated functions.

**Note:** Components found in the specified Actel macro library do not need component statements. ACTmap maintains a compiled version of these component statements.

The following example, illustrated in Figure 2-4, instantiates the ACT 3 “clkint” macro:

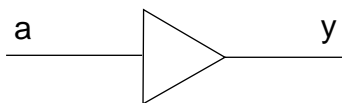


Figure 2-4. CLKINT Symbol

```
clkint_1: clkint port map (signal_a, signal_y);
```



Port mapping may be positional as in the example or it may be done by name. In positional mapping, the signals are associated to the ports by the order the ports are declared in the component declaration. In name mapping, explicitly specify the name of the port followed by the signal tied to it. For name mapping, use any port order. Positional and name mapping are functionally identical. The following is an example of a component instantiation for the clkint macro using name mapping:

```
clkint_1: clkint port map (a => signal_a, y => signal_y);
```

## ACTgen Macros

Use the following procedure to instantiate an ACTgen macro into a VHDL description:

- 1. Invoke ACTgen.**
- 2. Select the family, macro type, and macro options.**
- 3. Generate your macro as a VHDL description.** Make sure you specify VHDL as the Netlist/CAE Format when generating the macro.
- 4. Add a component declaration in the entity of your VHDL description for the macro.** For example:

```
entity cnt4 is
  port(
    data : in std_logic_vector (3 downto 0);
    enable, sload, aclr, clock : in std_logic;
    q : out std_logic_vector (3 downto 0));
end cnt4;
```

- 5. Instantiate the macro into your VHDL description using a port map statement.** For example:

```
u1 : cnt4 port map (signaldata => data, signalenable =>
  enable, signalsload => sload, signalaclr => aclr,
  signalclock => clock, signalq => q);
```

- 6. Compile your VHDL description.** Refer to “Implementing a Hierarchical Project” in the *Designing with Actel* manual for information about compiling a VHDL description in ACTmap.

Refer to the *Designing With Actel* manual or the ACTgen on-line help for information about using ACTgen.

## Creating Hierarchy

Up to this point, the discussions have focussed on logic circuits that most likely would be part of a single VHDL entity or functional block of logic. These blocks should generally be limited in size so that they can be synthesized and simulated relatively quickly. Most FPGA designs consist of multiple entities or logic blocks. Hierarchical designs can be created using a structural VHDL description.

Consider the schematic of a full adder that consists of two half adders, shown in Figure 2-5.

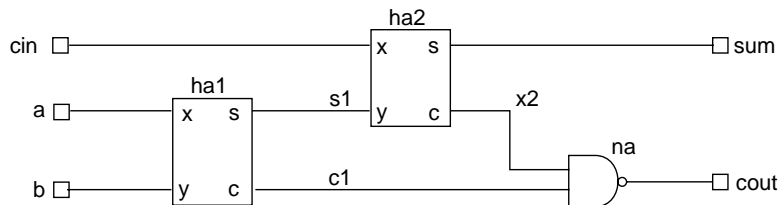


Figure 2-5. Full Adder Schematic

This design uses two separate instances of half adders, designated as components “ha1” and “ha2.” Like any other schematic, the actual signals connected to the component pins may have different names than the individual entity’s port names. Without this capability, you would not be able to use an entity more than once in a design.

The following is the entity and architecture description for the half adder logic block:

```
entity halfadder is
  port (x, y: in bit;
        s, c: out bit);
end halfadder ;

architecture behavioral of halfadder is
begin
  s <= x xor y;
  c <= x and y;
end behavioral;
```

The architecture of the full adder, top-level logic block, is a structural VHDL interconnection of the entity components and signals. The architecture consists of two parts: the declaration and instantiation sections.

### ***Declaration Section***

The declaration section includes Signal declarations for signals such as “c1” that are internal to the full adder entity, component declarations for the “parts” used, constant declarations, if needed, and configuration declarations to bind all instances to the desired architecture description.

### ***Instantiation Section***

The instantiation section includes Component Instances, such as “ha1,” “ha2,” etc., with their specific signal connections defined in a port map declaration.

The entity and architecture for a full adder are as follows:

```
architecture structural of fulladder is
signal c1, c2, s1: bit;

component halfadder
  port (
    x, y: in bit;
    s, c: out bit);
end component;

begin
  ha1: halfadder port map (a, b, s1, c1);
  ha2: halfadder port map (x=>c1, y=>s1, s=>sum, c=>c2);
  cout <= c1 nand c2;
end structural;
```

**Note:** Notice that instance “ha1” was instantiated using positional mapping, and instance “ha2” was instantiated using name mapping.

## Inferring ACTgen Macros

Macros such as counters, multiplexers, adders and subtractors can be described in your VHDL code and created using the ACTgen Macro Builder. This section describes how to infer different types of ACTgen macros.

### Counters

ACTmap recognizes counters from the VHDL specification and calls ACTgen to generate an optimized counter for the final design. The following guidelines apply to the previous example for inferring a counter:

- The data\_load and the data signals can be of type bit\_vector, std\_logic\_vector, or unsigned.
- The reset, sload, and updown signals are optional. However, when used they must be a simple name comparison to '1' or '0'.
- The data must be set to a constant value upon reset.
- The count may only increment by one.
- An ACTgen macro will not be inferred correctly if the count enable and asynchronous load signals both exist.

Counters, including those requiring an asynchronous reset, a synchronous load, count enable, and up-down count facilities, can be inferred with the following general counter template:

```
library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;

entity gencount is
  generic ( msb : integer := 7);
  port (
    clk: in    std_logic ;
    reset: in   std_logic ;
    sload: in   std_logic ;
    updown: in  std_logic;
    load_data: in std_logic_vector ( msb downto 0);
    data: inout std_logic_vector ( msb downto 0));
end gencount;
```

```

architecture template of gencount is
    signal data: std_logic_vector (msb downto 0);
begin
    counter_1: process (clk, reset, sload)
    begin
        if ( reset = '0' ) then
            data <= "00000000";
        elsif ( clk'event and clk = '1' ) then
            if (load = '0') then
                data <= load_data;
            elsif (updown = '1') then
                data <= data + '1' ;
            else
                data <= data - '1';
            end if;
        end if;
    end process counter_1;
end template;

```

## **Multiplexers**

ACTmap recognizes multiplexers from the VHDL specification and calls ACTgen to generate optimized macros for the final design. From 2 to 32 inputs may be multiplexed with busses of up to 24 bits for every input in ACT 1 and 40MX and busses up to 32 bits for every input in all other device families. There are three templates that may be used to infer multiplexers in VHDL and generate them with the ACTgen Macro Builder.

The following guidelines apply to the examples for inferring a multiplexer:

- If more than half of the data inputs are constant values, the macro block is not inferred, because simplifications are possible in the netlist due to this constant value.
- Although `std_logic_vector` is allowed in the template, the “-” (don’t care value) is not considered.
- When using “if” or “case” statements to infer a multiplexer, some values of the selector may be unspecified (no “else” or no “when others” statement). An extra latch is generated to keep the value if the selector reaches these unspecified values.

### Multiplexer Using an If Statement

In this example, a 6 to 1 multiplexer, illustrated in Figure 2-6, is generated by ACTgen. Some logic is generated and connected to the selection port of the multiplexer in order to select the correct inputs according to the values of signals “a,” “b,” “c,” and “d.”

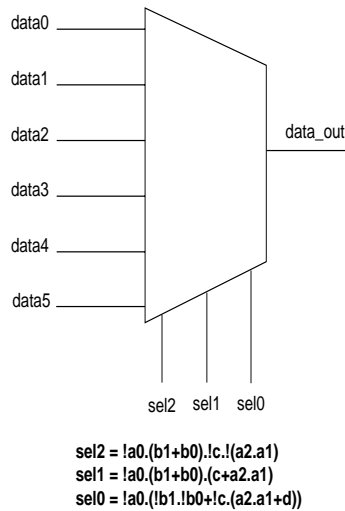


Figure 2-6. Multiplexer Using an If Statement

```

library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;

entity genmx1 is
port (
    data0: in    bit_vector(11 downto 0);
    data1: in    bit_vector(11 downto 0);
    data2: in    bit_vector(11 downto 0);
    data3: in    bit_vector(11 downto 0);
    data4: in    bit_vector(11 downto 0);
    data5: in    bit_vector(11 downto 0);
    data_out: out bit_vector(11 downto 0);
    a: in    bit_vector(2 downto 0);
    b: in    bit_vector(1 downto 0);
    c: in    bit;
    d: in    bit);
end genmx1;

```

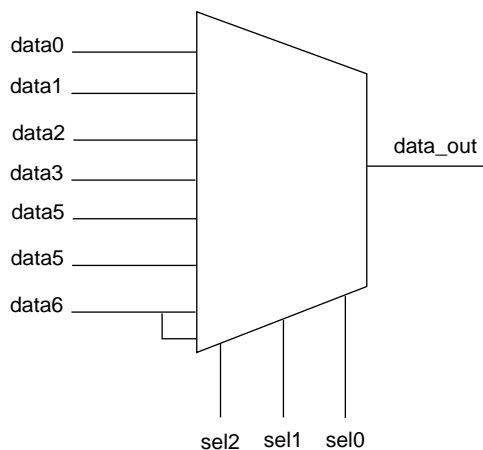
```

architecture template of genmx1 is
begin
    mux: process
    (a,b,c,d,data0,data1,data2,data3,data4,data5)
    begin
        if ( a(0) = '0' ) then
            data_out <= data0;
        elsif ( b = '0' ) then
            data_out <= data1;
        elsif ( c = '1' ) then
            data_out <= data2;
        elsif ( a(2 downto 1) = "11" ) then
            data_out <= data3;
        elsif ( d = '0' ) then
            data_out <= data4;
        else
            data_out <= data5;
        end if;
    end process mux;
end template;

```

### ***Multiplexer Using a With Statement***

In this example, an 8 to 1 multiplexer, illustrated in Figure 2-7, is generated by ACTgen. The “sel” signals are connected to the selection ports directly.



*Figure 2-7. Multiplexer using a With or Case Statement*

```
library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;

entity genmx2 is
port (
    data0: in    bit_vector(11 downto 0);
    data1: in    bit_vector(11 downto 0);
    data2: in    bit_vector(11 downto 0);
    data3: in    bit_vector(11 downto 0);
    data4: in    bit_vector(11 downto 0);
    data5: in    bit_vector(11 downto 0);
    data6: in    bit_vector(11 downto 0);
    data_out: out bit_vector(11 downto 0);
    sel: in     bit_vector(2 downto 0));
end genmx2;

architecture template of genmx2 is
begin
    with sel select
        data_out <= data6 when "110" | "111",
        data2 when "010";
        data1 when "001";
        data5 when "101";
        data0 when "000";
        data3 when "011";
        data4 when others;
end template;
```

### ***Multiplexer Using a Case Statement***

In this example, an 8 to 1 multiplexer, illustrated in Figure 2-7, is generated by ACTgen. The “sel” signals are connected to the selection ports directly.

```
library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;

entity genmx3 is
port (
    data0: in    bit_vector(11 downto 0);
    data1: in    bit_vector(11 downto 0);
    data2: in    bit_vector(11 downto 0);
    data3: in    bit_vector(11 downto 0);
    data4: in    bit_vector(11 downto 0);
    data5: in    bit_vector(11 downto 0);
```



```

        data6: in      bit_vector(11 downto 0);
        data_out: out bit_vector(11 downto 0);
        sel: in       bit_vector(2 downto 0));
    end genmx3;

architecture template of genmx3 is
begin
    mux: process (data0,data1,data2,data3,data4,data5,data6,sel)
    begin
        case sel is
            when "110" | "111" =>
                data_out <= data6;
            when "010"=>
                data_out <= data2;
            when "001"=>
                data_out <= data1;
            when "101"=>
                data_out <= data5;
            when "000"=>
                data_out <= data0;
            when "011"=>
                data_out <= data3;
            when others =>
                data_out <= data4;
        end case;
    end process;
end template;

```

## **Adders and Subtractors**

ACTmap recognizes adders and subtractors from the VHDL specification and calls ACTgen to generate optimized macros for the final design. The following guidelines apply when inferring adders and subtractors:

- The data\_a, data\_b, and data\_out signals can be of type bit\_vector, std\_logic\_vector, or unsigned.
- The output data, “data\_out,” must have a size equal to the input data busses, “data\_a” and “data\_b.”

Adders and subtractors can be inferred by using the following subtractor example (to infer an adder, change the “-” operator to “+”):

```

library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;

```

```
entity gensub is
  generic ( msb : integer := 7);
  port (
    data_a: in std_logic_vector ( msb downto 0);
    data_b: in std_logic_vector ( msb downto 0);
    data_out: inout std_logic_vector ( msb downto 0));
end gensub;

architecture template of gensub is
begin
  data _out <= data_a - data_b;
end template;
```

## Multipliers

ACTmap recognizes multipliers from the VHDL specification and calls ACTgen to generate optimized macros for the final design. The following guidelines apply when inferring multipliers:

- the “A” and “B” signals can be of type bit\_vector, std\_logic\_vector, or unsigned.
- An ACTgen macro is inferred when “A \* B” is found (if both “A” and “B” are not a constant).
- An ACTgen macro is only inferred if the following constraints are met;  $2 \leq \text{WidthA} \leq 29$ ,  $2 \leq \text{WidthB} \leq 29$ , and  $\text{WidthA} + \text{WidthB} \leq 32$ .
- If  $\text{WidthA} < 2$  or  $\text{WidthB} < 2$ , ACTmap does not work.
- If  $\text{WidthA} > 29$ , or  $\text{WidthB} > 29$ , or  $\text{WidthA} + \text{WidthB} > 32$ , which is beyond the ACTgen limitation, ACTmap does not infer an ACTgen macro. Library based synthesis is employed instead.
- Although in ACTgen WidthA must be greater than or equal to WidthB, this limitation does not apply when inferring a multiplier.

Multipliers can be inferred by using the following example:

```
library IEEE;
use IEEE.std_logic_1164.all;
use IEEE.std_logic_unsigned.all;

entity testmultiplier is
```

```

    port (a : in std_logic_vector ( 3 downto 0 ) ;
          b : in std_logic_vector ( 4 downto 0 ) ;
          product : out std_logic_vector ( 8 downto 0 ) ) ;
end testmultiplier;

architecture template of testmultiplier is
begin
    product <= a * b ;
end template;

```

## ***Incrementers and Decrementers***

ACTmap recognizes incrementers and decrementers from the VHDL specification and calls ACTgen to generate optimized macros for the final design. The following guidelines apply when inferring incrementers and decrementers:

- The “a” and “p” signals can be of type `bit_vector`, `std_logic_vector`, or unsigned.
- An ACTgen macro is inferred when  $p \leq a + 1$ ,  $p \leq a - 1$ ,  $a \leq a + 1$ , and  $a \leq a - 1$ , when the width of “a” and “p” is  $1 < \text{width} < 32$ .
- An ACTgen macro is inferred when “a + 1” or “a - 1” is found in a top level VHDL specification, function, procedure, and hierarchy model.

Incrementers and decrementers can be inferred by using the following example:

```

library IEEE;
use IEEE.std_logic_1164.all;
use IEEE.std_logic_unsigned.all;

entity testinc is
port (s : in std_logic;
      a : in std_logic_vector(7 downto 0 ) ;
      p : out std_logic_vector(7 downto 0));
end testinc;

architecture template of testinc is
begin
    proc: process(s, a)
    begin
        if (s = '1') then
            p <= a + 1 ;

```

```
        else
            p <= a - 1 ;
        end if;
    end process;
end template;
```

## Processes

Processes are sections of sequentially executed statements. While in the dataflow syntax, all statements are executed concurrently. In a process, the order of the statements does not matter. Processes resemble the sequential coding style of high-level programming languages.

A process can be called from the dataflow section of VHDL code. Each process is a sequentially executed program, but all processes run concurrently. Processes communicate with each other via signals that are declared in the declaration section of the architecture. The signals that the process waits for are included in the sensitivity list of the process. During the normal flow of a VHDL simulation, the process waits for a change to occur on one of the signals in the sensitivity list. It executes the statements between the begin and the end of the process.

Processes are labeled and use the following syntax:

```
label: process (sensitivity list)
begin
... lines of code describing the behavior of the process ...
end process label;
```

The actions described in the process can be of two forms; a clocked process that is synthesized into clocked or sequential logic, or an unclocked process that produces combinatorial logic. Clocked processes always include the clock signals in the sensitivity list.

There are two types of expressions that can be used to infer clocked logic, a 'event attribute or a function call. For example:

```
(clk'event and clk='1')      --rising edge 'event attribute
(clk'event and clk='0')      --falling edge 'event attribute
rising_edge(clock)            --rising edge function call
falling_edge(clock)           --falling edge function call
```

A clock signal cannot use the rising edge procedure if it has been defined as type bit. In order to use the rising edge procedure, the clock must be defined as type std\_logic. The following error message is displayed in ACTmap if a rising edge is not properly defined:

ERROR : (VHP\_0808). Line 17. rising\_edge can not have such operands in this context.

## Inferring Multiplexers

The following example, illustrated in Figure 2-8, infers a 2 to 1 multiplexer:

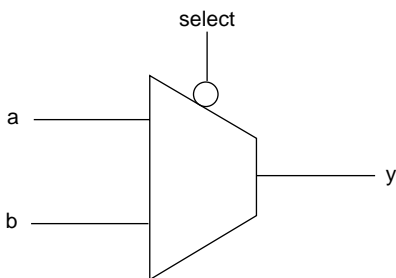


Figure 2-8. 2 to 1 Multiplexer

```
architecture behavioral of mx2 is
begin
  mx2_1: process (a, b, select)
  begin
    if (select = '0') then
      y <= a;
    else
      y <= b;
    end if;
  end process mx2_1;
end behavioral;
```

## Inferring Flip-Flops

The following example, illustrated in Figure 2-9, infers a single bit D flip-flop with an active low asynchronous clear:

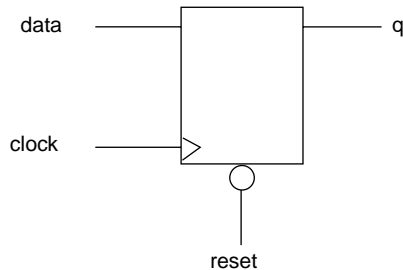


Figure 2-9. Single Bit D Flip-Flop

```
architecture behavioral of flipflop is
begin
  dff_1: process (clock, reset)
  begin
    if (reset = '0') then
      q <= '0';
    elsif (clock'event and clock = '1') then
      q <= data;
    end if;
  end process dff_1;
end behavioral;
```

## Inferring Latches

The following example, illustrated in Figure 2-10, infers a multi-bit D latch with an active high enable and an active low asynchronous clear:

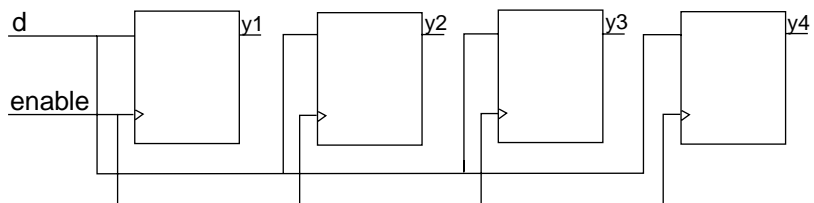


Figure 2-10. Multi-bit D Latch

```
architecture behavioral of latches is
begin
  dlc_1: process (enable, reset, d)

```

```

begin
  if (reset = '0') then
    y <= "0000";
  elsif (enable = '1') then
    y <= d;
  end if;
end process dlc_1;
end behavioral;

```

## Incomplete Sensitivity Lists

Incomplete sensitivity lists in a process may cause differences in the pre and post synthesis behavior. The following example demonstrates the incorrect way to synthesize a three-input AND gate, because the signal “c” is not in the sensitivity list. Therefore, the variable “y” is not re-evaluated when c changes.

```

architecture behavioral of tand3 is
begin
  and3_1: process (a, b)
  begin
    if (reset = '0') then
      y <= a and b and c;
    end process and3_1;
  end behavioral;

```

The correct method to synthesize a three-input and gate is as follows:

```

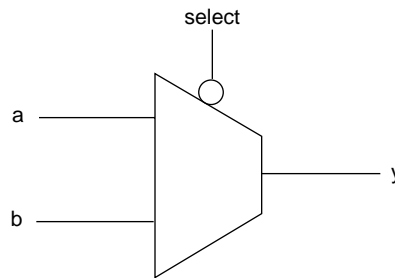
architecture behavioral of tand3 is
begin
  and3_1: process (a, b, c)
  begin
    if (reset = '0') then
      y <= a and b and c;
    end process and3_1;
  end behavioral;

```

**Note:** ACTmap does not always correctly report missing signals in the sensitivity list of a process. To avoid erroneous results during simulation, make sure that all sensitivity lists do not have missing signals.

## **Incomplete Construct Value Specification**

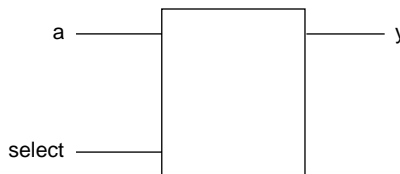
The if then else and case statements can infer latches instead of multiplexers if all possible states or values are not specified. The following example, illustrated in Figure 2-11, infers a 2 to 1 multiplexer:



*Figure 2-11. 2 to 1 Multiplexer*

```
if (select = '0') then
    y <= a;
else
    y <= b;
end if;
```

If you do not specify the else statement, a latch, illustrated in Figure 2-12, is inferred:



*Figure 2-12. Latch Diagram*

```
if (select) then
    y <= a;
end if;
```



## State Machine Design

A state machine is a sequencer that is organized as a finite set of states. Each state represents one set of actions, such as enabling a counter to increment or generating an acknowledge output. Almost all states also contain a method of transferring control to another state based on certain conditions. Any state that does not have a means of going to another state would have to be the last state of the state machine, and the system would remain in this state forever. Transferring between states can be conditional (based on the values of other signals in the system) or non-conditional.

There are many ways to describe a finite state machine (FSM) in VHDL. The important point is that the synthesis tool should optimize the corresponding logic in an efficient way for both speed and area. This is done by applying optimized automatic state assignments. This section describes three types of FSM, the single-process, the double process, and a user defined FSM.

### Single Process FSM

Figure 2-13 illustrates a single-process FSM that controls a traffic light. The sensitivity list of the process contains only two signals: the clock and the reset signals. To describe the transitions between states, a case statement identifies which state is considered. In the case statement, all state register values have to be enumerated in when statements. The state registers may be assigned conditionally in an if statement or not. The conditions are boolean expressions of the input ports.

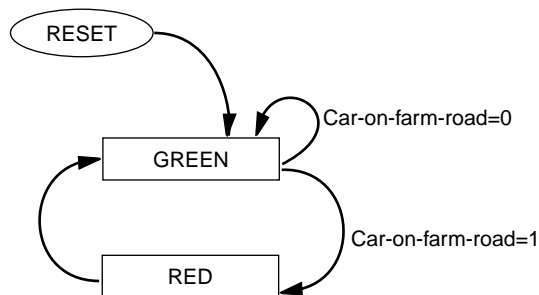


Figure 2-13.

```
library ieee;
```

```
use ieee.std_logic_1164.all;

entity light is
  port (
    clock: in std_logic;
    reset: in std_logic;
    car_on_farm_road: in std_logic;
    set_green_on_highway: out std_logic);
end tlight;

architecture state_machine of light is
  type state_type is (red, green);
  signal next_state: state_type;
begin
  sequencer: process (reset, clock)
  begin
    if (reset = '0') then
      next_state <= green;
      set_green_on_highway <= '1';
    elsif (clock'event and clock = '1') then
      case next_state is
        when green =>
          set_green_on_highway <= '1';
          if (car_on_farm_road = '1') then
            next_state <= red;
          else
            next_state <= green;
          end if;
        when red =>
          set_green_on_highway <= '0';
          next_state <= green;
        end case;
      end if;
    end process sequencer;
  end state_machine;
```

## **Double Process FSM**

A common approach to describing an FSM uses two processes. One process defines registers or synchronization. The other process describes the combinatorial logic to define the next state and the outputs.

The first process sets the current state and the registered outputs of the FSM. This process is triggered by the clock and the reset signals. Therefore, it is executed when either signal changes. The FSM must be

triggered on the clock edge. You can trigger on either a rising or falling edge. It is not necessary to have a reset, but if a reset signal exists, it must be asynchronous. It may be active high or active low. The process should use the following template:

```

registers: process (clock, reset)
begin
    if (reset = <'1','0'>) then
        ... reset the value of the state ...
        ... optionally reset the registered outputs ...
    elsif (clock'event and clock = <'1','0'>) then
        ... Set the new FSM state ...
        ... Assign values to the registered outputs ...
    end if;
end process registers;

```

Another process updates the present state with the next state and takes care of any combinatorial logic. The process is sensitive to all of the input signals and the signal that maintains the current state. It must also include all the internal signals that affect the output of the process. A case statement typically calculates the next state and the outputs as in the following template:

```

transitions : process (clock, reset)
begin
    ... Assign default values to all unregistered outputs ...
    case present_state is
        when state_0 =>
            output <= <value>;
            next_state <= <value>;
        when state_1 => ...;
        .
        .
        .
        when others => ...;
    end case;
end process registers;

```

**Note:** A value must be assigned to all unregistered outputs for each state. If you do not assign output values, the FSM maintains the previous values and creates unnecessary latches during synthesis. To avoid this problem, assign a default value to all unregistered outputs at the beginning of this process before the case

statement. Default assignments of an if statement within a case statement must be declared explicitly.

The following is an example of a simple Mealy FSM using two processes. Figure 2-14 and Table 2-2 illustrate the example:

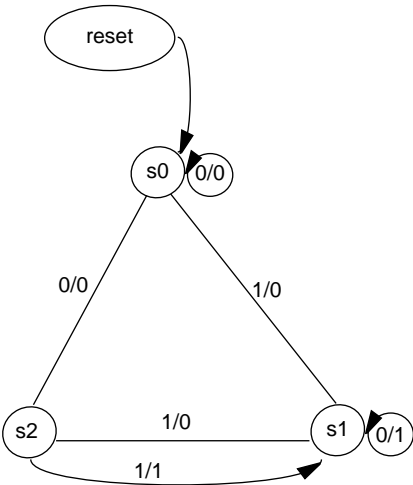


Figure 2-14. Mealy FSM

Table 2-2. Mealy FSM State Table

Present State	Next State		Output	
	x=0	x=1	x=0	x=1
s0	s0	s1	0	0
s1	s1	s2	1	0
s2	s0	s1	0	1

```
library ieee;
use ieee.std_logic_1164.all;
```

```
entity mealy is
  port (
    a: in std_logic;
    clock: in std_logic;
    reset: in std_logic;
    z: out std_logic);
end mealy;

architecture state_machine of mealy is
  type state_type is (s0, s1, s2);
  signal current_state, next_state: state_type;
begin
  registers: process (reset, clock)
  begin
    if (reset = '0') then
      current_state <= s0;
    else
      if (clock'event and clock = '1') then
        current_state <= next_state;
      end if;
    end if;
  end process registers;

  combinatorial: process (current_state)
  begin
    case current_state is
      when s0 =>
        if (a = '0') then
          z <= '0';
          next_state <= s0;
        else
          z <= '0';
          next_state <= s1;
        end if;
      when s1 =>
        if (a = '0') then
          z <= '1';
          next_state <= s1;
        else
          z <= '0';
          next_state <= s2;
        end if;
      when s2 =>
        if (a = '0') then
          z <= '0';
          next_state <= s0;
        else
          z <= '1';
```

```
        next_state <= s1;
    end if;
end case;
end process combinatorial;
end state_machine;
```

## User Defined FSM

An FSM can also be defined to your specification. Each state is defined as a constant with a unique value. Below is an example of a counter defined as an FSM using user-defined states:

```
entity count4c is
    port (
        reset: in bit;
        clock: in bit;
        s : out bit_vector(3 downto 0);
        load_data : in bit_vector(3 downto 0);
        load : in bit;
        enable : in bit);
end count4c;

architecture state_machine of count4c is
    signal state, next_state: bit_vector(3 downto 0);
    -- usually this can be an integer
    constant state0: bit_vector ( 3 downto 0) := "1111";
    constant state1: bit_vector ( 3 downto 0) := "1110";
    constant state2: bit_vector ( 3 downto 0) := "1101";
    constant state3: bit_vector ( 3 downto 0) := "1100";
    constant state4: bit_vector ( 3 downto 0) := "1011";
    constant state5: bit_vector ( 3 downto 0) := "1010";
    constant state6: bit_vector ( 3 downto 0) := "1001";
    constant state7: bit_vector ( 3 downto 0) := "1000";
    constant state8: bit_vector ( 3 downto 0) := "0111";
    constant state9: bit_vector ( 3 downto 0) := "0110";
    constant statea: bit_vector ( 3 downto 0) := "0101";
    constant stateb: bit_vector ( 3 downto 0) := "0100";
    constant statec: bit_vector ( 3 downto 0) := "0011";
    constant stated: bit_vector ( 3 downto 0) := "0010";
    constant statee: bit_vector ( 3 downto 0) := "0001";
    constant statef: bit_vector ( 3 downto 0) := "0000";
begin
    sequential: process (clock, reset)
    begin
        if (reset = '1') then
            state <= state0;
        elsif (clock'event and clock = '1') then
```

```

        if ( load = '1' ) then
            state <= load_data;
        elsif ( enable = '1' ) then
            state <= next_state;
        else
            state <= state;
        end if;
    end if;
end process sequential;

combinatorial: process (state)
begin
    case state is
        when state0 =>
            next_state <= state1;
            s <= x"0";
        when state1 =>
            next_state <= state2;
            s <= x"1";
        when state2 =>
            next_state <= state3;
            s <= x"2";
        when state3 =>
            next_state <= state4;
            s <= x"3";
        when state4 =>
            next_state <= state5;
            s <= x"4";
        when state5 =>
            next_state <= state6;
            s <= x"5";
        when state6 =>
            next_state <= state7;
            s <= x"6";
        when state7 =>
            next_state <= state8;
            s <= x"7";
        when state8 =>
            next_state <= state9;
            s <= x"8";
        when state9 =>
            next_state <= statea;
            s <= x"9";
        when statea =>
            next_state <= stateb;
            s <= x"a";
        when stateb =>
            next_state <= statec;

```

```
s <= x"b";
when statec =>
    next_state <= stated;
    s <= x"c";
when stated =>
    next_state <= statee;
    s <= x"d";
when statee =>
    next_state <= statef;
    s <= x"e";
when statef =>
    next_state <= state0;
    s <= x"f";
when others => null;
end case;
end process combinatorial;
end state_machine;
```

## Supported Packages

There are a number of operations in VHDL that occur regularly. An example is translation of vectors to integers and back. For this reason, ACTmap provides packages that define attributes, functions and procedures that are often used. Using the functions and procedures reduces the amount of initial circuitry that is generated, compared to writing the behavior explicitly in a user-defined function or procedure. This reduces the time for compilation and also could result in a smaller circuit implementation due to improved optimization.

### **Actel Component Packages**

Users instantiating Actel macros in their designs do not need to declare the Actel components. ACTmap maintains a compiled version of the component. The VHDL source for these packages is located in the “<actel\_install\_directory>/lib/actel/vhdl/<act\_fam>” directory. The macro component declarations are included by using the following use statement:

```
library <act_fam>;
use <act_fam>.components.all;
```



**Note:** The component package for the Actel family being targeted should be compiled before the VHDL code referencing the components.

### **IEEE Packages**

ACTmap supports the following IEEE packages:

- std\_logic\_1164
- std\_logic\_unsigned
- std\_logic\_arith

The textio package is not supported.

## *Using Procedures*

This section lists guidelines to follow when using procedures in ACTmap.

### **Intermediate Signals**

When using procedures, ACTmap requires the use of intermediate signals.

The following example does not work:

```
user_procedure(conv_integer(aaa));
```

The procedure should be written as follows:

```
int_aaa <= conv_integer(aaa);  
user_procedure(int_aaa);
```

### **Inout Parameters Not Supported**

ACTmap does not support the use of inout parameters for procedures. The parameters must be either in or out. ACTmap displays the following error message if a procedure has an inout parameter:

```
ERROR : (VHDL_1768). Line 88. Inout parameter not yet  
supported.
```

## Limitations

This section lists known limitations and unsupported features in ACTmap VHDL.

### **Bi-Directional Buffers**

When using bi-directional buffers, make sure the feedback signal connects to internal logic. If the feedback signal is not connected to internal logic, ACTmap connects the BIBUF macro incorrectly.

### **Preserving Character Case**

The “AMP\_EDIFUPPER” environment variable, which forces all characters to upper case, is set to “YES” in ACTmap. If you want ACTmap to preserve character case in your VHDL code, you must set the “AMP\_EDIFUPPER” environment variable to no.

### **Event Construct**

ACTmap does not support the event construct for a vector bit. The following example produces an error:

```
architecture behavioral of bug is
  signal vector : std_logic_vector( 7 downto 0);
begin
  process (vector)
  begin
    if (vector(0)'event )then
      k <= jj;
    else
      k(6 downto 0) <= jj and vector(6 downto 0);
      k(7) <= '1';
    end if
  end process;
end behavioral;
```

The above example should be written as follows:

```
architecture behavioral of bug is
  signal vector : std_logic_vector( 7 downto 0);
  signal e_vector: std_logic; -this line is added
begin
  e_vector <= vector(0); -this line is added
  process (e_vector, vector) -this line is changed
  begin
```

```

        if (e_vector'event )then -this line is changed
            k <= jj;
        else
            k(6 downto 0) <= jj and vector(6 downto 0);
            k(7) <= '1';
        end if
    end process;
end behavioral;

```

### **Multiple Clock Events**

Multiple clock events are not supported. The following examples do not work:

```

    if (rst'event and rst = '0') then
        ...
    elsif (clk'event and clk = '1') then
        ...
    end if;

    if ((rst'event and rst = '0') and (clk'event and clk = '1'))
    then
        ...
    end if;

```

### **VHDL 92 and 93**

The set of constructs added in the VHDL 92 and 93 specification were intended to be used for simulation purposes and are not supported in ACTmap.

### **Bus Width Errors**

ACTmap does not always correctly report bus width errors. Make sure that all of your bus widths match in your VHDL code or ACTmap may produce erroneous results.

### **Multi-Dimensional Buses**

ACTmap does not support multi-dimensional buses.

### **Unsupported Data Types**

The following data types are not supported: physical, floating point, signed arrays, access, and file. User defined arrays are only supported for a dimension not exceeding 2.

### **Wait For Time Construct**

The “wait for time” construct is not supported.

### **Loop Statements**

The “while...loop... end loop” and the “loop...end loop” statements are not supported.

### **Indexed and Sliced Signals in Sensitivity List**

ACTmap does not support the use of indexed or sliced signals in the sensitivity list of a process.

The following example is not supported:

```
process ( a(7), b(6 downto 4), s3)
```

The above example should be written as follows:

```
int_a <= a(7);
int_b <= b(6 downto 4);
...
process (int_a, int_b)
```

### **Object Specification Must Be a Constant**

The following construct is not supported by ACTmap VHDL:

```
process
begin
    wait until clk'event and clk = '1';
    b_r <= (others => '0');
    a_r <= (others => b_r);
end process;
```

The above example should be written as follows:

```
process
begin
    wait until clk'event and clk = '1';
    a_r <= (others => (others => '0'));
end process;
```

---

## ***Advanced Optimization Techniques***

This chapter describes optimization guidelines and features in ACTmap. This includes ACTmap VHDL and general optimization guidelines, information about optimizing state machines, and using design constraints during optimization. Also included is information about the ACTmap automatic I/O insertion and sequential remapping features, and information about using special cells in 3200DX and 42MX devices to improve performance. Finally, information about gated macro usage and about where to find radiation environment design techniques is given.

### *ACTmap VHDL Guidelines*

The following are ACTmap VHDL guidelines to assist you in obtaining the best synthesis results possible:

- For the ACT 3 FPGA family devices, Actel recommends that you avoid describing reset and clear flip-flops and latches in your VHDL descriptions. The ACT 3 preset and clear flip-flops cannot be connected to the hardwired global clock networks driven by HCLKBUF. For ACT 2 and ACT 3 family devices, use asynchronous clear latches and flip-flops. The active low asynchronous clear flip-flops and latches are ACTmap's basic building blocks. Using them may result in better optimization.
- Actel recommends that you avoid describing any flip-flops and latch configurations that do not have an asynchronous clear input. The JK or toggle flip-flops, without any asynchronous clear or preset (with sequential remapping) feature may not be simulated by your CAE simulator tools.

### *General Optimization Guidelines*

One of the most powerful features of the ACTmap program is its optimization capability. The optimization and mapping technique used in ACTmap is designed to improve the area or speed of most designs targeted for Actel devices. However, this does not mean that the algorithm can improve all designs. This section lists guidelines to keep in mind when optimizing your design with ACTmap.

### **Logic Design Type**

The type of logic used in the design affects how much of the design can be optimized. ACTmap's algorithm produces excellent results when optimizing random logic, but it does not work as well for structured logic blocks such as adders, subtractors, comparators, and accumulators. Many counters, adders, subtractors, decoders and multiplexers can be inferred through VHDL descriptions or generated using the ACTgen Macro Builder. Other logic blocks can also be created by the ACTgen Macro Builder and added to a design. Refer to "Inferring ACTgen Macros" on page 24" and "ACTgen Macros" on page 21 for information about integrating an ACTgen macro into your design.

### **Design Optimization Level**

You must consider whether to optimize the complete design, or only a part of the design (generally, Actel recommends that you use smaller blocks for better optimization). At times it is beneficial to optimize the whole chip because chip optimization can break down the boundaries between the functional blocks. This allows ACTmap to globally consider the logic that is optimized, which often produces better results.

**Note:** ACTmap may not produce improved results when optimizing highly structured or optimized designs.

### **Limited Optimization**

If you are using an original design that has only structured or optimized sections, you can instruct ACTmap to ignore the optimal sections.

ACTmap ignores optimal sections when you add a donttouch attribute to an instance by editing the EDIF, ADL, or VHDL netlist files. The following example shows the "DONTTOUCH:TRUE" attribute used in an ADL design file:

```
USE FLIP; I1I386; DONTTOUCH:TRUE.  
USE ADLIB:OR3; DONTTOUCH:TRUE
```

This example shows an EDIF design file with the “donttouch:true” property added.

```
(instance (rename ili235")
(viewref Netlist (cellref or3 (libraryref act2)))
(property donttouch (string "true") )
)
instance (rename ili386 "ili386")
(viewref netlist (cellref flip (libraryref this_design)))
(property donttouch (string "true")
)
)
```

This example shows an ACTmap VHDL design description with the “donttouch:true” property added:

```
architecture structural of example is
  attribute donttouch : string;
  attribute donttouch of u0 : label is "true";

  component inva
  port (
    a: in bit;
    y: out bit);
  end component;

begin
  u0: inva port map (a, s1);
end structural;
```

## ***Structural VHDL***

ACTmap does not optimize structural VHDL netlists. Structural netlists are treated as though they have the “donttouch” attribute added to them. VHDL netlists created by ACTgen are not optimized when they are added as part of a project, they are merged into the project.

## ***Design Size***

Memory requirements and ACTmap run time vary with design type. If the ACTmap functions exceed hardware limitations, you may want to optimize by functional block, rather than the whole design. Actel recommends limiting VHDL blocks to less than 1500 logic modules and netlists to less than 800 logic modules.

## Memory Size

ACTmap's two primary goals are efficient memory usage and short run-times. However, optimizing certain designs, such as designs with adders, multipliers, and some counters, causes ACTmap to use large amounts of memory. These designs contain highly structured logic blocks. Use ACTgen to build these macros with donttouch attributes, and instantiate them directly into your ACTmap design. You can also use ACTmap to merge the top-level netlist with ACTgen macros after optimization.

## State Machine Optimization

ACTmap allows you to select between five state machine encoding algorithms. ACTmap uses the following methods to generate state machines from VHDL source files to netlists.

- **One-Hot.** The One-Hot algorithm reduces each bit in the state machine to a single register for maximum speed.
- **Compact.** The Compact algorithm produces decoded states for minimum area.
- **Gray.** The Gray Code algorithm identifies long paths without branching. It applies successive Gray codes on path nodes.
- **Johnson.** Like the Gray Code, the Johnson algorithm identifies long paths and applies successive Johnson codes on the path nodes.
- **Sequential.** Sequential encoding identifies the long paths and applies successive radix 2 codes on the nodes of the paths. The radix 2 code helps in minimizing area because it can efficiently minimize next-state equation complexity of paths.
- **User Defined.** The User Defined encoding is based on the states defined in the VHDL.

When optimizing smaller designs, optimizing the design for area frequently produces the greatest speed. Actel recommends that you first optimize small designs for area and save the results. You can then optimize the design for speed and compare the results.



## *Setting Design Constraints*

During netlist optimization, preferential treatment can be assigned to a given global design constraint (through the Set Constraint command in the Options menu). The ACTmap Netlist Optimizer will optimize the netlist so that the preferred global constraint receives the greatest amount of optimization. You can only set global constraints through the Netlist Optimizer window. It is not possible to set specific values for global constraints.

The following Global Constraints can be specified:

- **Clock Frequency.** Synthesis is targeted toward the optimization of the clock frequency.
- **Inpad to Outpad.** Synthesis is targeted toward the optimization of paths, starting at an input port and ending at an output port.
- **Inpad to Setup.** Synthesis is targeted toward the optimization of paths, starting at an input port and ending at the setup for latches and flip-flops.
- **Clock to Outpad.** Synthesis is targeted toward the optimization of paths, starting at the clock and ending at an output port.
- **All to Setup.** Synthesis is targeted toward the optimization of all paths, ending at the setup for latches and flip-flops.
- **All to Outpad.** Synthesis is targeted toward the optimization of paths, ending at an output port.
- **Maximum Delay.** Synthesis is targeted toward the minimization of the maximum path delay for the design.

## *Automatic I/O Insertion*

ACTmap automatically inserts global I/Os and buffers in all Actel family devices. ACTmap inserts CLKBUF macros to drive the CLKA global network in ACT 1 and 40MX devices, the CLKA and CLKB global networks in ACT 2, 1200XL, 3200DX, and 42MX devices, and the CLKA, CLKB, and HCLK global networks in ACT 3 and 54SX devices.

During insertion, ACTmap inserts CLKBUF macros in all dangling clock network input ports. It inserts INBUF macros in all other dangling input ports, and OUTBUF macros in all dangling output ports.

You can set your I/O insertion commands, and set the automatic I/O insertion commands at the command line or in your .ami file. Refer to “I/O Macros” on page 67 for a description of the commands.

## 3200DX and 42MX

The 3200DX and 42MX device families have specialized cells and clocks that can be used to improve performance. This section describes how to utilize those specialized cells and clocks.

### **Wide Decoders and RAM Cells**

You can use the wide decoder modules and the RAM cells in ACTmap, but they must be instantiated and their utilization must be monitored by the user. They cannot be inferred. Actel recommends that logic blocks using wide decoders and RAM cells are generated using ACTgen and instantiated into the design.

### **Quad Clocks**

The quad clock modules may be utilized using ACTmap, but they must be instantiated, and their utilization must be monitored by the user. They cannot be inferred.

## Sequential Remapping

For almost all ACT 3 flip-flops and some ACT 2 flip-flops, ACTmap performs pre-optimized, sequential remapping. The sequential remapping feature enhances the optimizer performance to take advantage of combinatorial and sequential combining features. It divides sequential library elements into smaller and more basic elements that may generate better results during optimization. Sequential remapping applies to both VHDL synthesis and optimization. This feature is available for the ACT2, 3200DX, 42MX, and ACT 3 families.



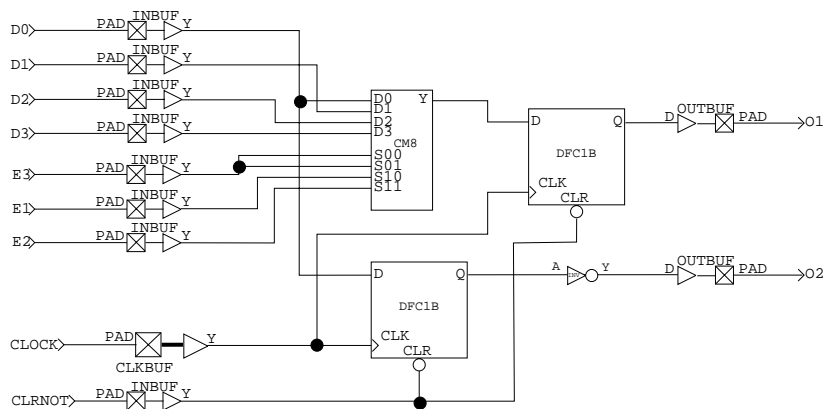


Figure 3-2. Library Cells DFC1E and DFM7A after Remapping

## Gated Macros

Gated macros must be instantiated to be utilized because ACTmap cannot synthesize to gated macros. Designs that must gate clocks on the dedicated clock network should utilize the gated macros “gand2,” “gm4,” “gnand2,” “gnor2,” and “gxor2.”

## Designing for Radiation Environments

ACTmap can compile and optimize Actel designs for radiation environments. Refer to *Enhanced Tools for Minimizing Single Event Upset Effects* on the Actel Web site (<http://www.actel.com>) and the ACTmap On-line Help for additional information.

---

## *Using ACTmap in Batch Mode*

This appendix contains information and procedures for using ACTmap in batch mode. This includes information about invoking ACTmap in batch mode and a description of command line format. Also included is batch file and configuration file creation information. Finally, available batch mode options are listed and usage examples for the options are given.

### *Invoking ACTmap in Batch Mode*

This sections describes the procedures for invoking ACTmap in batch mode.

#### **UNIX**

Both ACTmap functions and option settings can be specified on the command line or in the configuration file (ami file). Type the following command at the prompt to invoke ACTmap in batch mode:

```
actmap
```

#### **Microsoft Windows**

You can execute ACTmap functions and set options in the ACTmap windows or define options in the configuration file (ami file). Use the following procedure to invoke ACTmap in batch mode:

1. **Create a batch file using a text editor.** Refer to “Creating a Batch File” on page 58 for an example batch file.
2. **Choose the Run command from the Start menu.** The Run dialog box is displayed.
3. **Invoke ACTmap with the complete path of a batch file.** Type the following command in the Run box:

```
actmapw.exe bfile:<batch_file_location>\<batch_file>.bat
```

## Command Line Format

The command line format for using ACTmap in batch mode is:

```
actmap [function:{vhdl,netopt,translate}] [<option-  
name>:<option_value>] <design_name>
```

The function parameter invokes a specific ACTmap utility. When the function parameter is set to “vhdl,” the ACTmap VHDL Compiler is invoked. The default function parameter is “vhdl.” The <optionname> variable is the name of one of the ACTmap options and the <option\_value> variable is a legal value for that option.

All options can be specified in the configuration file. By default, ACTmap reads the <design\_name>.ami file located in the project directory, if it exists. To specify another configuration file name or location, use the initfile option.

## Creating a Batch File

You can use batch files with ACTmap in Windows. This allows you to run ACTmap for several designs or for one design with different options. The following is an example batch file:

```
actmap infile:\username\designs\decoder.v initfile:\user-  
name\designs\decoder1.ami
```

```
actmap infile:\username\designs\decoder.vhdl initfile:\user-  
name\designs\decoder2.ami
```

```
actmap infile:\username\designs\atm.vhdl
```

```
actmap infile:\username\designs\counter.vhdl informat:vhdl  
state:onehot effort:lo fam:act2 outformat:edif mode:chip  
cell:best mapstyle:speed maxfanout:10 counter
```

In the above example, “decoder.v,” “decoder.vhdl,” “atm.vhdl,” and “counter.vhdl” are design file names and formats and “decoder1.ami” and “decoder2.ami” are configuration files. Refer to “Specifying Input and Output Files” on page 63 for information about input and output files and “Creating a Configuration File” on page 59 for information about configuration files.

## *Creating a Configuration File*

All options for each ACTmap function can be specified in the configuration file (ami file). The format for specifying options in the ami file is:

```
fam:act3  
mapstyle:area
```

The options in the configuration files are applied to given ACTmap functions as follows:

1. All options specified after the function declaration statement and before another function declaration statement are applied to the given ACTmap function at runtime.

```
function:vhdl  
infile:design.vhd  
fam:act3  
mapstyle:area  
state:onehot
```

```
function:netopt  
infile:design.edn  
fam:act3  
mapstyle:area  
maxfanout:12
```

```
function:translate  
infile:design.edo  
fam:act3  
outformat:verilog  
merge:on
```

The options specified between the “function:vhdl” and the “function:netopt” statements are read by the ACTmap VHDL Compiler. The options specified between the “function:netopt” and the “function:translate” statements are read by the ACTmap Netlist Optimizer. The options specified after the “function:translate” statement are read by the ACTmap Translator utility.

2. When the “informat” option is set in the configuration file, all other options are applied to that ACTmap utility only. When the “informat” option is set to “vhdl,” “edif,” or “adl” the other options are applied to the VHDL Compiler, and the Netlist Optimizer respectively.

3. When neither the “informat” option nor a function declaration statement has been specified in the configuration file, all options are applied to the ACTmap VHDL Compiler only.

## ACTmap Options

Table A-1 describes the available ACTmap batch mode options. The default value for the option is shown in bold.

*Table A-1. ACTmap Options*

Option Name	Option Values	Applicable Functions	Reference Page
actgenmacro	<b>on</b> , blackbox, off	vhdl	page 66
arch	<name of architecture to be compiled>	vhdl	page 64
cell	<b>best</b> , lm, lib	vhdl, netopt	page 65
clka	<port name of first clkbuf>	vhdl, netopt	page 67
clkb	<port name of second clkbuf>	vhdl, netopt	page 68
edninflavor	<b>generic</b> , wv, mentor	netopt, translate	page 63
effort	lo, <b>med</b> , hi	vhdl, netopt	page 65
ent	<name of entity to be compiled>	vhdl	page 64
fam	act1, act2, act3, 3200dx, 1200xl, 40mx, <b>42mx</b> , 54sx	vhdl, netopt, translate	page 64
flatten	on, <b>off</b>	vhdl	page 66



Table A-1. ACTmap Options (Continued)

Option Name	Option Values	Applicable Functions	Reference Page
globalconstraint	<b>clock_freq</b> , inpad_to_outpad, inpad_to_gated, clock_to_outpad, all_to_gated, all_to_outpad, max_delay	netopt	page 67
hclk	<port name of hclkbuf>	vhdl, netopt	page 68
infile	<name of design file to read>	vhdl, netopt, translate	page 63
initfile	<name of configu- ration file>	vhdl, netopt, translate	page 62
logfile	<log file name>	vhdl, netopt, translate	page 62
mapstyle	<b>area</b> , speed	vhdl, netopt	page 65
maxcpu	< up to a 20 digit number>	vhdl, netopt	page 68
maxfanout	2 to 24	vhdl, netopt	page 65
merge	<b>on</b> , off	translate	page 69
mode	<b>block</b> , chip	vhdl, netopt	page 65
outfile	<name of output file>	vhdl, netopt, translate	page 63
outformat	<b>designer</b> , vhdl, edif, adl, verilog, vl	translate	page 63
portinstname	match, <b>unique</b>	vhdl, netopt	page 68

Table A-1. ACTmap Options (Continued)

Option Name	Option Values	Applicable Functions	Reference Page
seqremap	<b>off</b> , on	vhdl, netopt	page 66
state	<b>compact</b> , onehot, gray, johnson, sequential, user	vhdl	page 66
ff_type	<b>default</b> , cc (ACT 2, ACT 3, 3200DX, 42MX only), tnr (ACT 1 and 40MX are not supported)	vhdl, netopt	page 69

## Batch Mode Options Usage Examples

This section describes the batch mode options, and gives an example usage of each.

### Specifying the Configuration File

Use the “initfile” option to specify the name of the configuration file to be read into ACTmap. Actel recommends using the “.ami” extension. The default value is <design\_name>.ami. For example:

```
initfile:config1.ami
```

### Specifying the Log File

Use the “logfile” option to specify the name of your log file to store ACTmap output messages. Actel recommends using the “.aml” extension. The default value is <design\_name>.aml. For example:

```
logfile:run1.aml
```

## ***Specifying Input and Output Files***

The following options are used to specify input and output file names and formats.

### ***Specifying Input File Name***

Use the “infile” option to specify the name of your input file. Actel recommends using the following extensions:

- ACTmap VHDL - use “.vhd”
- ADL input file - use “.aal” or “.adl”
- EDIF input file - use “.edn”

For example:

```
infile:<filename>.vhd
infile:<filename>.aal or .adl
infile:<filename>.edn
```

### ***Specifying Output File Format***

Use the “outformat” option to specify which output files to generate during netlist translation. The default value is “designer.” For example:

```
outformat:vhdl
```

### ***Specifying the EDIF Output Filename***

Use the “outfile” option to specify the name of the EDIF file to be written by the VHDL Compiler. Actel recommends using an “.edo” extension for the optimized EDIF netlists written by the VHDL Compiler. For example:

```
outfile:<filename>.edo
```

## ***Specifying EDIF Netlist Flavor***

Use the “edninflavor” option to specify the flavor of the EDIF netlist to be read. Use “viewlogic” for Viewlogic, “mgc” for Mentor Graphics and “generic” for all other EDIF netlists. The default value is “generic.” For example:

```
edninflavor:viewlogic
```

## ***Specifying VHDL Entity and Architecture***

The following options are used to specify which entity and architecture in the VHDL file to compile.

### ***Specifying the Entity***

Use the “ent” option to specify which entity in the VHDL file to compile. By default, the top-level entity is used. For example:

```
ent:<entity_name>
```

### ***Specifying the Architecture***

Use the “arch” option to specify the architecture in the VHDL file to compile. By default, the VHDL Compiler compiles the first architecture for a given entity that is found. For example:

```
arch:<architecture_name>
```

## ***Specifying the Target Family***

This section describes how to specify the target device family.

### ***Specifying the Target Family***

Use the “fam” option to specify the target family of the netlist to be retargeted. The default value is “42mx.” For example:

```
fam:act3
```

In this example, the retargeted netlist is created using the ACT 3 Family architecture.

## **Technology Mapping**

This section describes how to specify technology mapping options.

### ***Specifying Mapping Approach***

Use the “cell” option to specify the mapping. Use “lm” to map to the Actel internal module. All logic is mapped to CM8 or CM8A. Use “lib” to map to predefined Actel library cells. Since not all possible combinations have predefined cells in the library, mapping to the CM8 or CM8A module can produce better results. To allow the Compiler to choose the mapping, specify “best” for the “cell” option. The default value is “best.” For example:

```
cell:lib
```

### ***Specifying Mapping Effort***

Use the “effort” option to specify the amount of effort that ACTmap should use to find satisfactory results. Use “lo,” “med,” and “high” to specify increasing amounts of effort. The default value is “med.” For example:

```
effort:lo
```

In this example, ACTmap runs an optimization with low effort.

### ***Specifying Optimization Type***

Use the “mapstyle” option to specify the type of optimization. Use “area” for area optimization and “speed” for speed optimization. The default value is “area.” For example:

```
mapstyle:area
```

### ***Specifying the Maximum Fanout***

Use the “maxfanout” option to specify the maximum fanout limit during netlist optimization. You can set a fanout range from 2 to 24. The default value is “16” for the ACT 2, ACT 3, 3200DX, and 42MX families. The default value is “10” for the ACT 1 and 40 MX families. For example:

```
maxfanout:8
```

### ***Specifying the Remapping of Sequential Elements***

Use the “seqremap” option to specify which sequential elements should be remapped to basic Actel sequential elements before optimization. Use “on” to remap the basic sequential elements or “off” to remap no sequential elements. The default value is “off.” Refer to “Sequential Remapping” on page 54 for more information. For example:

```
seqremap:on
```

### ***Specifying the Encoding Algorithm for State Machines***

Use the “state” option to specify the encoding algorithm used to map state machines by the VHDL Compiler. The following option values may be specified: “onehot,” “compact,” “gray,” “johnson,” “sequential,” and “user.” The default option is “compact.” For a description of these options, refer to “State Machine Optimization” on page 52. For example:

```
state:user
```

In this example, the user-defined encoding specified in the VHDL file is used during optimization.

### ***Specifying ACTgen Macro Usage***

Use the “actgenmacro” option to specify when ACTgen macros are to be generated for identified templates. Use “on” to let ACTgen generate any macros it can identify, use “off” to force ACTmap to generate the logic. Use “blackbox” to force ACTmap to create black boxes for ACTgen macros. The default value is “on.” For example:

```
actgenmacro:off
```

### ***Specifying Hierarchical Conservation During Compilation***

Use the “flatten” option to specify when the design hierarchy will be preserved during VHDL compilation. Use “on” to preserve the hierarchy during VHDL compilation. Use “off” to let ACTmap flatten the design. The default value is “off.” For example:

```
flatten:on
```

### ***Specifying Global Optimization Constraints***

Use the “globalconstraint” option to specify the optimization constraint. For a description of these options, refer to “Setting Design Constraints” on page 53. The default value is “clock\_freq.” For example:

```
globalconstraint:clock_freq
```

In this example, synthesis is targeted toward the optimization of the clock frequency.

## ***I/O Macros***

The following describes how to specify the options related to inserting I/O macros. Refer to “Automatic I/O Insertion” on page 53 for more information.

### ***I/O Buffer Insertion***

Use the “mode” option to specify when I/O macros are to be inserted. Use “chip” to add I/O macros to top-level ports that do not have I/O macros already added. Use “block” when no I/O insertion is desired. The default value is “block.” For example:

```
mode:chip
```

### ***Specifying the First Clock***

Use the “clka” option to specify the first global routed clock port name. A CLKBUF macro is added to the specified port when the “mode” option is set to “chip.” For example:

```
clka:clock1
```

In this example, a CLKBUF macro is added to the clock1 port during optimization.

### ***Specifying the Second Clock***

Use the “clkb” option to specify the second global routed clock port name. A CLKBUF macro is added to the specified port when the “mode” option is set to “chip.” For example:

```
clkb:clock2
```

In this example, a CLKBUF macro is added to the clock2 port during optimization.

### ***Specifying the Hardwired Clock***

Use the “hclk” option to specify the global hardwired clock port name. An HCLKBUF macro is added to the specified port when the “mode” option is set to “chip.” This option is only available for ACT 3 devices. For example:

```
hclk:hclock
```

In this example, an HCLKBUF macro will be added to the hclock port during optimization.

## ***Port and Instance Name Matching***

Use the “portinstname” option to specify a unique port name and I/O macro instance name. A number of CAE systems do not allow identical names to be used for the port and the I/O macro instance names. Use “unique” to specify that different names be used for the port name and the I/O macro instance name. Use “match” to specify that identical names be used. The default value is “unique.” For example:

```
portinstname:match
```

## ***Optimization Time***

Use the “maxcpu” option to set a maximum allowable cpu time. Optimization continues until the “maxcpu” time is reached. Any positive integer value less than 20 digits is allowed. The value represents minutes. For example:

```
maxcpu:60
```



## ***Block Merging***

Use the “merge” option to set specify when external netlists are to be merged. The default value is “on.” For example:

```
merge: on
```

In this example, all referenced ADL and EDIF netlists are merged into the top-level design.

## ***Sequential Type***

Use the “ff\_type” to specify what implementation of sequential macros to use if you are designing for radiation environments. The “cc” option implements combinatorial macros only (54SX devices to not support combinatorial macros). The “tmr” option implements triple voting macros only. The default value is “default,” which uses standard macros. For example:

```
ff_type: tmr
```

In this example, ACTmap will use triple voting macros only in the design that is being compiled/optimized.



---

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# Glossary

**ACTgen Macro Builder Software** A program developed by Actel to generate custom macros for a specific Actel Family architecture.

**architecture** VHDL name used for the section of code that defines the behavior or composition of a block.

**attribute** A VHDL property that can be attached to signals or instances.

**behavioral VHDL** VHDL code written to describe the functionality of a design without regard for a specific architecture.

**binding statement** VHDL declaration of entity/architecture pair.

**bit** Signal type having logic states 0 and 1.

**case** A VHDL statement used to synthesize a selected signal assignment within a process.

**clocked process** A VHDL statement used to synthesize circuits with flip flops, registers, latches, or any other type of clocked logic.

**compact encoding** When states are decoded for minimum area.

**component declaration** A VHDL statement that references the name and I/O ports of an entity that will be used in a block.

**component instantiation** The occurrence of an entity in a VHDL block, similar to the placement of a part on a schematic.

**configuration file** A text file used to assign values to ACTmap options.

**constant declaration** A VHDL statement defining the type and value of a constant.

**dataflow method** A style of VHDL code that represents a lower level of abstraction than behavioral VHDL while still not resorting to a true gate- level structure.

**design file** A text file used to describe the behavior of a design block.

**entity** A VHDL statement used to identify a functional piece of a system and its I/O connections.

**enumerated types** VHDL data types that are defined to have a fixed number of unique states.

**explicit mapping** A VHDL port mapping style that maps the port name to a signal, regardless of the port order. This is also referred to as Named Port Mapping.

**function** A VHDL subprogram that has only one output. This is used to simplify the coding of repetitive or commonly used circuit operations.

**Gray encoding** States are defined so that only one bit changes at a time.

**implicit mapping** A VHDL port-mapping style that maps the a given signal to a given port, based on the port order.

**initialization file** A text file used to assign values to ACTmap options. This is also referred to as a configuration file.

**I/O insertion** The automatic addition of I/O buffers to ports not having I/O buffers.

**Johnson encoding** Like the Gray Code, the Johnson algorithm identifies long paths and applies successive Johnson codes on the path nodes.

**keywords** Words reserved by the VHDL language.

**libraries** A convenient mechanism for storing commonly used VHDL functions and for defining data types.

**one-hot encoding** each bit in the state machine is mapped to a single register for maximum speed.

**operators** A VHDL keyword or symbol that causes an operation to occur between signals.

**overloading** A VHDL technique used to define operations between the same and different types of data, thus making it possible to mix integer, bit, and other data types.

**package** VHDL code that is generally used to define the names and the inputs and outputs of the functions in the library.



**port map** A list of the specific signals connected to the I/O ports of a instance of an entity.

**procedures** A VHDL subprogram having multiple outputs used to simplify the coding of repetitive or commonly used circuit operations.

**processes** A VHDL block of code that waits for some condition to occur and, in response, causes some other action.

**reserved words** Words reserved by the VHDL language.

**resource sharing** A style of writing VHDL that takes advantage of commonly shared functions such as adders, thus reducing the number of gates needed to implement a function.

**Register Transfer Level (RTL) VHDL** VHDL code written to describe the detail behavior of a design, but without regard for the gate-level details.

**sensitivity list** A list of the signals that a process waits for.

**sequential encoding** Sequential encoding identifies the long paths and applies successive radix 2 codes on the nodes of the paths. The radix 2 code helps in minimizing area because it can efficiently minimize next-state equation complexity of paths.

**sequential remapping** A pre-optimization technique that divides sequential library elements into smaller and more basic elements.

**slices** A portion of a bus or register.

**std\_ulogic** A nine state logic value system. Also referred to as MVL9, for Multi-Valued Logic, 9 states. Actel does not recommend using this state system in VHDL designs.

**test bench** A VHDL entity used to generate the input signals for the design being tested and to monitor the results at the output ports or at points internal to the entity.

**VHDL** VHSIC Hardware Description Language developed by the United States Government during the 1980s to support the electronic design communities.



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# Index

<act\_fam> variable viii

## A

Actel

- Component Package 44

- Device Families viii

Actel FTP Site 73

Actel Web Site 73

- Technical Support 72

ACTgen

- Adder Template 29

- Case Statement Multiplexer Template 28

- Counter Template 24

- Decrementer Template 31

- If Statement Multiplexer Template 26

- Incrementer Template 31

- Inferring Adders 29

- Inferring Counters 24

- Inferring DecrementersDecrementers 31

- Inferring Incrementers 31

- Inferring Macros 24–30

- Inferring Multiplexers 25–29

- Inferring Multipliers 30

- Inferring Subtractors 29

- Instantiating Macros 21

- Multiplier Template 30

- Subtractor Template 29

- With Statement Multiplexer Template 27

actgenmacro 66

Action Facts 72

ACTmap

- Batch Mode 57–69

- Batch Mode Options 60

- Blocks 3

- Design Flow 2–4

- Invoking in Batch Mode 57

- Limitations 46–48

- VHDL Guidelines 49

ACTmap Limitations

- Bi-directional Buffers 46

- Bus Width 47

- Character Case 46

- Constructs 48

- Event Constructs 46

- Indexed Signals 48

- Loop Statements 48

- Multi-dimensional Busses 47

- Multiple Clock Events 47

- Sliced Signals 48

- Unsupported Data Types 48

- VHDL 92 47

- VHDL 93 47

- Wait For Time Construct 48

Adders 29

Adding Blocks to a schematic 3

All to Outpad Constraint 53

All to Setup Constraint 53

ami file 59

arch 64

Architecture Description 7

Assumptions viii

Attributes 19

- donttouch 19, 50, 51

Automatic I/O Insertion 53

## B

Batch Mode 57–69

- actgenmacro 66

- arch 64

- cell 65

- clka 67

- clkb 68

- Command Line Format 58
- Configuration (ami) File 59
- edninflavor 63
- effort 65
- ent 64
- fam 64
- flatten 66
- globalconstraint 67
- hclk 68
- infile 63
- initfile 62
- logfile 62
- mapstyle 65
- maxcpu 68
- maxfanout 65
- merge 69
- mode 67
- Options 60
- outfile 63
- outformat 63
- portinstname 68
- seqremap 66
- state 66
- Bi-directional Buffers 46
- Bit Type 9
- Block Statement 18
- Blocks 3
  - Functional 51
- Boolean Type 9
- Bus
  - Multi-dimensional 47
- Bus Width 47
- C**
- Capturing a Design 2
- Case Statement 17
- cell 65
- Cells
  - ACTgen Macros 21
  - Instantiating 20–21
  - Library Macros 20
  - RAM 54
  - Wide Decoder 54
- Character Case 46
- Circuit 6–8
  - Architecture Description 7
  - Entity Description 7
- clka 67
- clkb 68
- Clock Frequency Constraint 53
- Clock to Output Constraint 53
- Compact Encoding 52
- Configuration (ami) File 59
- Constant Type 13
- Constraint 53
  - All to Output 53
  - All to Setup 53
  - Clock Frequency 53
  - Clock to Output 53
  - Global 53
  - Inpad to Output 53
  - Inpad to Setup 53
  - Maximum Delay 53
- Construct 46
  - Wait For Time 48
- Contacting Actel
  - Customer Service 71
  - Electronic Mail 73
  - Technical Support 72
  - Toll-Free 71
  - Web Based Technical Support 72
- Conventions viii

- <act\_fam> variable viii
- Naming, VHDL 5
- Counters 24
- Creating a Configuration (ami) File 59
- Customer Service 71

## **D**

- Data Type 9–13
  - Unsupported 48
- Declaring a Circuit 6–8
  - Architecture Description 7
  - Entity Description 7
- Declaring a Signal 9
- Design Constraint 53
  - All to Outpad 53
  - All to Setup 53
  - Clock Frequency 53
  - Clock to Outpad 53
  - Global 53
  - Inpad to Outpad 53
  - Inpad to Setup 53
  - Maximum Delay 53
  - Setting Design Constraints 53
- Design Creation/Verification 2
  - Behavioral Simulation 2
  - EDIF Netlist Generation 3
  - Structural Netlist Generation 3
  - Structural Simulation 3
  - Synthesis 2
  - VHDL Source Entry 2
- Design Flow 2–4
  - Design Creation/Verification 2
  - Design Implementation 3
  - Programming 4
  - System Verification 4
- Design Implementation 3

- Place and Route 3
- Timing Analysis 4
- Timing Simulation 4
- Design Layout 3
- Design Optimization 49–56
  - Automatic I/O Insertion 53
  - Design Constraints 53
  - Design Size 51
  - Gated Macros 56
  - General Guidelines 49
  - Limiting Optimization 50
  - Logic Design Type 50
  - Memory Requirements 52
  - Optimization Level 50
  - Optimizing Functional Blocks 51
  - Quad Clocks 54
  - RAM Cells 54
  - Sequential Remapping 54
  - State Machine 52
  - State Machine Algorithms 52
  - Structural VHDL 51
  - VHDL Guidelines 49
  - Wide Decoder Cells 54
- Design Synthesis 2
- Designer
  - DT Analyze Tool 4
  - Manuals ix
  - Place and Route 3
  - Timing Analysis 4
- Device
  - Debugging 4
  - Families viii
  - Programming 4
- Document Assumptions viii
- Document Conventions viii
- Document Organization vii

donttouch 19, 50, 51  
Double Process Finite State Machine (FSM) 38  
DT Analyze  
    Static Timing Analysis 4

## E

EDIF Netlist Generation 3  
edninflavor 63  
effort 65  
Electronic Mail 73  
ent 64  
Entity Description 7  
Enumerated Type 9  
Event Constructs 46

## F

fam 64  
Finite State Machine (FSM) 37–44  
    Algorithms 52  
    Double Process 38  
    Mealy State Machine Code 40  
    Single Process 37  
    User Defined 42  
flatten 66  
Flip-Flops 34  
For-Generate  
    Loop 18  
    Statement 18

## G

Gated Macros 56  
Gate-Level Netlist 2  
Generating  
    EDIF Netlist 3  
    Gate-Level Netlist 2  
    Structural Netlist 3

globalconstraint 67  
Gray Encoding 52

## H

Half Adder 8  
hclk 68  
Hierarchy in VHDL 22

## I

I/O Insertion 53  
IEEE Packages 45  
If Statement 15  
If-Generate Statement 18  
Incomplete Construct Value Specification 36  
Incomplete Sensitivity Lists 35  
Incrementers 31  
Indexed Signals 48  
Inferring ACTgen Macros 24–30  
    Adders 29  
    Counters 24  
    Decrementers 31  
    Incrementers 31  
    Multiplexers 25–29  
    Multipliers 30  
    Subtractors 29  
Inferring Flip-Flops 34  
Inferring Latches 34  
Inferring Multiplexers 33  
infile 63  
initfile 62  
Inout Parameters 45  
Inpad to Outpad Constraint 53  
Inpad to Setup Constraint 53  
Instantiating Cells 20–21  
    ACTgen Macros 21  
    Library Macros 20

Integer Type 13  
Intermediate Signals 45

## J

Johnson Encoding 52

## K

Keywords, VHDL 5

## L

Latches 34  
Library Macros 20  
Limitations 46–48  
    Bi-directional Buffers 46  
    Bus Width 47  
    Character Case 46  
    Constructs 48  
    Event Constructs 46  
    Indexed Signals 48  
    Loop Statements 48  
    Multi-dimensional Buses 47  
    Multiple Clock Events 47  
    Sliced Signals 48  
    Unsupported Data Types 48  
    VHDL 92 47  
    VHDL 93 47  
    Wait For Time Construct 48  
Limiting Optimization 50  
logfile 62  
Logic Condition 15–18  
    Case Statement 17  
    If Statement 15  
    Select Statement 17  
    When Statement 16  
Loop Statements 48

## M

Macro  
    Gated 56  
Mapping 21  
mapstyle 65  
maxcpu 68  
maxfanout 65  
Maximum Delay Constraint 53  
Mealy State Machine Code 40  
Memory Requirements for Optimization 52  
merge 69  
mode 67  
Multi-dimensional Busses 47  
Multiple Clock Events 47  
Multiplexers 25–29, 33  
Multipliers 30

## N

Naming Conventions, VHDL 5  
Netlist Generation  
    EDIF 3  
    Gate-Level 2  
    Structural 3

## O

Object Specification 48  
One-Hot Encoding 52  
On-Line Documentation ix  
On-Line Help xi  
Operators 14–15  
Optimization 49–56  
    Decreasing Time For 52  
    Functional Blocks 51  
    Level 50  
    Limiting 50  
    State Machine 52

outfile 63  
outformat 63

## P

Packages 44  
    Actel Component 44  
    IEEE 45  
Place and Route 3  
Port Mapping 21  
portinstname 68  
Positional Mapping 21  
Preserving Character Case 46  
Procedures 45  
    Inout Parameters 45  
    Intermediate Signals 45  
Processes 32–36  
    Incomplete Construct Value Specification 36  
    Incomplete Sensitivity Lists 35  
    Inferring Flip-Flops 34  
    Inferring Latches 34  
    Inferring Multiplexers 33  
Product Support 71–73  
    Action Facts 72  
    Customer Applications Center 72  
    Customer Service 71  
    Electronic Mail 73  
    FTP Site 73  
    Technical Support 72  
    Toll-Free Line 71  
    Web Site 73  
Programming 4

## Q

Quad Clocks 54

## R

Radiation 56  
RAM Cells 54  
Related Manuals ix  
Repetitive Operations 18–19  
    For-Generate Loop 18  
    For-Generate Statement 18  
    If-Generate Statement 18

## S

Select Statement 17  
seqremap 66  
Sequential Encoding 52  
Sequential Remapping 54  
Signal Declaration 9  
Simulation 2, 3, 4  
    Behavioral 2  
    Structural 3  
    Timing 4  
Single Process Finite State Machine (FSM) 37  
Slice 12  
Slice Signals 48  
state 66  
State Machine  
    Algorithms 52  
    Compact Encoding 52  
    Design 37–44  
    Double Process 38  
    Encoding Options 52  
    Gray Encoding 52  
    Johnson Encoding 52  
    Mealy State Machine Code 40  
    One-Hot Encoding 52  
    Optimization 52  
    Sequential Encoding 52  
    Single Process 37



- User Defined 42
- User Defined Encoding 52
- Static Timing Analysis 4
- Std\_Logic Type 11
- Structural Netlist Generation 3
- Structural Simulation 3
- Structural VHDL 22, 51
- Subtractors 29
- Supported Operators 14–15
- Supported Packages 44
  - Actel Component 44
  - IEEE 45
- Synthesis 2
- System Verification 4
  - Silicon Explorer 4

## T

- Technical Support 72
- Timing Analysis 4
- Timing Simulation 4
- Toll-Free Line 71
- Type 9–13, 48, 50
  - Bit 9
  - Boolean 9
  - Choosing 50
  - Constant 13
  - Enumerated 9
  - Integer 13
  - Std\_Logic 11
  - Unsupported 48
  - User Defined 10
  - Vector 11

## U

- Unit Delays 2
- User Defined

- Encoding 52
- Finite State Machine (FSM) 42
- Type 10
- Using Procedures 45
  - Inout Parameters 45
  - Intermediate Signals 45

## V

- variable, <act\_fam> viii
- Vector
  - Slice 12
  - Type 11
- VHDL
  - 92 47
  - 93 47
  - Character Case 46
  - Design Flow 2–4
  - Guidelines 49
  - Naming Conventions 5
  - Reserved Words 5
  - Source Entry 2
  - Structural 22, 51

## W

- Wait For Time Construct 48
- Web Based Technical Support 72
- When Statement 16
- Wide Decoders Cells 54