

Synopsys Synplify Pro for Microsemi Edition

Attribute Reference

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CHAPTER 1

Introduction

This document is part of a set that includes reference and procedural information for the Synopsys[®] Synplify Pro[®] FPGA synthesis tool.

This document describes the attributes and directives available in the synthesis tool. The attributes and directives let you direct the way a design is analyzed, optimized, and mapped during synthesis.

This chapter includes the following introductory information:

- [How Attributes and Directives are Specified, on page 8](#)
- [Summary of Attributes and Directives, on page 10](#)
- [Summary of Global Attributes, on page 10](#)

How Attributes and Directives are Specified

By definition, *attributes* control mapping optimizations and *directives* control compiler optimizations. Because of this difference, directives must be entered directly in the HDL source code. Attributes can be entered either in the source code, in the SCOPE Attributes tab, or manually in a constraint file. For detailed procedures on different ways to specify attributes and directives, see [Specifying Attributes and Directives, on page 87](#) in the *User Guide*.

Verilog files are case sensitive, so attributes and directives must be entered exactly as presented in the syntax descriptions. For more information about specifying attributes and directives using C-style and Verilog 2001 syntax, see [Verilog Attribute and Directive Syntax, on page 99](#).

The SCOPE Attributes Tab

This section describes how to enter attributes using the SCOPE Attributes tab. To use the SCOPE spreadsheet, use this procedure:

1. Start with a compiled design, then open the SCOPE window.
2. Scroll if needed and click the Attributes tab.

	Enabled	Object Type	Object	Attribute	Value	Val Type	Description
1	☒	<any>	<global>	syn_noclockbuf	1	boolean	Use normal input buffer
2	☒						
3	☒						
4	☒						
5	☒						
6							
7							
8							

3. Click in the Attribute cell and use the pull-down menus to enter the appropriate attributes and their values.

The Attributes panel includes the following columns.

Column	Description
Enabled	(Required) Turn this on to enable the constraint.
Object Type	Specifies the type of object to which the attribute is assigned. Choose from the pull-down list, to filter the available choices in the Object field.
Object	(Required) Specifies the object to which the attribute is attached. This field is synchronized with the Attribute field, so selecting an object here filters the available choices in the Attribute field. You can also drag and drop an object from the RTL or Technology view into this column.
Attribute	(Required) Specifies the attribute name. You can choose from a pull-down list that includes all available attributes for the specified technology. This field is synchronized with the Object field. If you select an object first, the attribute list is filtered. If you select an attribute first, the synthesis tool filters the available choices in the Object field. You must select an attribute before entering a value.
Value	(Required) Specifies the attribute value. You must specify the attribute first. Clicking in the column displays the default value; a drop-down arrow lists available values where appropriate.
Val Type	Specifies the kind of value for the attribute. For example, string or boolean.
Description	Contains a one-line description of the attribute.
Comment	Contains any comments you want to add about the attributes.

For more details on how to use the Attributes panel of the SCOPE spreadsheet, see [Specifying Attributes Using the SCOPE Editor, on page 90](#) in the *User Guide*.

When you use the SCOPE spreadsheet to create and modify a constraint file, the proper `define_attribute` or `define_global_attribute` statement is automatically generated for the constraint file. The following shows the syntax for these statements as they appear in the constraint file.

```
define_attribute {object} attributeName {value}
```

```
define_global_attribute attributeName {value}
```

<i>object</i>	The design object, such as module, signal, input, instance, port, or wire name. The object naming syntax varies, depending on whether your source code is in Verilog or VHDL format. See syn_black_box , on page 50 for details about the syntax conventions. If you have mixed input files, use the object naming syntax appropriate for the format in which the object is defined. Global attributes, since they apply to an entire design, do not use an <i>object</i> argument.
<i>attributeName</i>	The name of the synthesis attribute. This must be an attribute, not a directive, as directives are not supported in constraint files.
<i>value</i>	String, integer, or boolean value.

See [Summary of Global Attributes](#), on page 10 for more details on specifying global attributes in the synthesis environment.

Summary of Attributes and Directives

The [Attributes and Directives Summary](#), on page 13 summarize the synthesis attributes and directives. For detailed descriptions of individual attributes and directives, see the individual attributes and directives, which are listed in alphabetical order.

Summary of Global Attributes

Design attributes in the synthesis environment can be defined either globally, (values are applied to all objects of the specified type in the design), or locally, values are applied only to the specified design object (module, view, port, instance, clock, and so on). When an attribute is set both globally and locally on a design object, the local specification overrides the global specification for the object.

In general, the syntax for specifying a global attribute in a constraint file is:

```
define_global_attribute attribute_name {value}
```

The table below contains a list of attributes that can be specified globally in the synthesis environment. For complete descriptions of any of the attributes listed below, see [Attributes and Directives Summary](#), on page 13.

Global Attribute	Can Also Be Set On Design Objects
syn_allow_retiming	x
syn_hier	x
syn_multstyle	x
syn_netlist_hierarchy	
syn_noarrayports	
syn_noclockbuf	x
syn_ramstyle	x
syn_replicate	x

CHAPTER 2

Attributes and Directives

All attributes and directives supported for synthesis are listed in alphabetical order. Each command includes syntax, option and argument descriptions, and examples. You can apply attributes and directives globally or locally on a design object.

Attributes and Directives Summary

The following attributes and directives are listed in alphabetical order:

- [alsloc](#)
- [alspin](#)
- [alspreserve](#)
- [black_box_pad_pin](#)
- [black_box_tri_pins](#)
- [full_case](#)
- [loop_limit](#)
- [parallel_case](#)
- [pragma translate_off/pragma translate_on](#)
- [syn_allow_retiming](#)

- [syn_black_box](#)
- [syn_encoding](#)
- [syn_enum_encoding](#)
- [syn_global_buffers](#)
- [syn_hier](#)
- [syn_insert_buffer](#)
- [syn_insert_pad](#)
- [syn_isclock](#)
- [syn_keep](#)
- [syn_loc](#)
- [syn_looplevelimit](#)
- [syn_maxfan](#)
- [syn_multstyle](#)
- [syn_netlist_hierarchy](#)
- [syn_noarrayports](#)
- [syn_noclockbuf](#)
- [syn_noprune](#)
- [syn_pad_type](#)
- [syn_preserve](#)
- [syn_probe](#)
- [syn_radhardlevel](#)
- [syn_ramstyle](#)
- [syn_reference_clock](#)
- [syn_replicate](#)
- [syn_resources](#)
- [syn_safe_case](#)
- [syn_sharing](#)

- `syn_shift_resetphase`
- `syn_srstyle`
- `syn_state_machine`
- `syn_tco<n>`
- `syn_tpd<n>`
- `syn_tristate`
- `syn_tsu<n>`
- `translate_off/translate_on`

alsloc

Attribute

Preserves relative placements of macros and IP blocks in the Microsemi Designer place-and-route tool.

Vendor	Technology
Microsemi	All

Description

Preserves relative placements of macros and IP blocks in the Microsemi Designer place-and-route tool. The alsloc attribute has no effect on synthesis, but is passed directly to Microsemi Designer.

The alsloc constrain is passed directly to the post synthesis EDN netlist as the following:

```
(property alsloc (string "R15C6"))
```

```
(property alsloc (string "R35C6"))
```

alsloc Syntax Specification

Name	Global	Object
alsloc	No	Macro or IP block

alsloc Value

Value	Default	Description
location	None	Location of macro or IP block.

This table summarizes the syntax in different files:

FDC	define_attribute {object} alsloc {location}	SCOPE Example
Verilog	object /* synthesis alsloc = "location" */;	Verilog Example
VHDL	attribute alsloc of object : label is "location";	VHDL Example

SCOPE Example

Following is an example of setting `alsloc` on a macro (u1).

```
define_attribute {u1} alsloc {R15C6}
```

Verilog Example

```
module test(in1, in2, in3, clk, q);
  input in1, in2, in3, clk;
  output q;
  wire out1 /* synthesis syn_keep = 1 */, out2;
  and2a u1 (.A (in1), .B (in2), .Y (out1))
           /* synthesis alsloc="R15C6" */;
  assign out2 = out1 & in3;
  df1 u2 (.D (out2), .CLK (clk), .Q (q))
        /* synthesis alsloc="R35C6" */;
endmodule

module and2a(A, B, Y); // synthesis syn_black_box
  input A, B;
  output Y;
endmodule

module df1(D, CLK, Q); // synthesis syn_black_box
  input D, CLK;
  output Q;
endmodule
```

VHDL Example

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

entity test is
  port (in1, in2, in3, clk : in std_logic;
        q : out std_logic);
end test;

architecture rtl of test is
  signal out1, out2 : std_logic;

  component AND2A
  port (A, B : in std_logic;
        Y : out std_logic);
end component;
```

```
component df1
port (D, CLK : in std_logic;
      Q : out std_logic);
end component;

attribute syn_keep : boolean;
attribute syn_keep of out1 : signal is true;
attribute alsloc: string;
attribute alsloc of U1: label is "R15C6";
attribute alsloc of U2: label is "R35C6";
attribute syn_black_box : boolean;
attribute syn_black_box of AND2A, df1 : component is true;
begin
U1: AND2A port map (A => in1, B => in2, Y => out1);
out2 <= in3 and out1;
U2: df1 port map (D => out2, CLK => clk, Q => q);
end rtl;
```

alspin

Attribute

Assigns the scalar or bus ports of the design to Microsemi I/O pin numbers.

Vendor	Technology
Microsemi	All

Description

The `alspin` attribute assigns the scalar or bus ports of the design to Microsemi I/O pin numbers (pad locations). Refer to the Microsemi databook for valid pin numbers. If you use `alspin` for bus ports or for slices of bus ports, you must also use the `syn_noarrayports` attribute. See [Specifying Locations for Microsemi Bus Ports, on page 547](#) of the *User Guide* for information on assigning pin numbers to buses and slices.

The `alspin` pin location is passed as a property string to the output EDN netlist as the following:

```
(instance (rename dataoutZ0 "dataout") (viewRef netlist (cellRef df1 (libraryRef &54SXA)))  
(property alspin (string "48"))
```

alspin Syntax Specification

Name	Global	Object
<code>alspin</code>	No	

alspin Value

Value	Default	Description
<code>pin_number</code>	None	The Microsemi I/O pin

This table summarizes the syntax in different files:

FDC	define_attribute {port_name} alspin {pin_number}	Constraint File Example
Verilog	object /* synthesis alspin = "pin_number" */;	Verilog Example
VHDL	attribute alspin of object : objectType is "pin_number";	VHDL Example

Constraint File Example

In the attribute syntax, *port_name* is the name of the port and *pin_number* is the Microsemi I/O pin.

```
define_attribute {DATAOUT} alspin {48}
```

Verilog Example

Where *object* is the port and *pin_number* is the Microsemi I/O pin. For example:

```
module comparator (datain, clk, dataout);
  output reg dataout /* synthesis alspin="48" */;
  input [7:0] datain;
  input clk;

  always@(posedge clk)
    begin
      dataout <= datain;
    end
endmodule
```

VHDL Example

See [Verilog Attribute and Directive Syntax, on page 99](#) for different ways to specify VHDL attributes and directives.

Where *object* is the port, *objectType* is signal, and *pin_number* is the Microsemi I/O pin. For example:

```
library ieee;
use ieee.std_logic_1164.all;
entity comparator is
    port (datain : in std_logic_vector(7 downto 0);
          clk : in std_logic;
          dataout : out std_logic_vector(7 downto 0));
    attribute alspin : string;
    attribute alspin of dataout : signal is "48";
end;

architecture rtl of comparator is
begin

    process(clk)
    begin
        if clk'event and clk = '1' then
            dataout <= datain;
        end if;
    end process;

end rtl;
```

alspreserve

Attribute

Specifies a net that you do not want removed by the Microsemi Designer place-and-route tool.

Vendor	Technology
Microsemi	All

Description

The alspreserve attribute specifies a net that you do not want removed (optimized away) by the Microsemi Designer place-and-route tool. The alspreserve attribute has no effect on synthesis, but is passed directly to the Microsemi Designer place-and-route software. However, to prevent the net from being removed during the synthesis process, you must also use the [syn_keep](#) directive.

The alspreserve attribute is passed to the output EDN netlist file as the following:

```
(net (rename and_outZ0Z3 "and_out3") (joined
  (portRef b (instanceRef outZ0Z1))
  (portRef y (instanceRef and_out3_1))
)
(property alspreserve (integer 1)))
```

alspreserve Syntax Specification

Name	Global	Object
alspreserve	No	Net

alspreserve Value

Value	Default	Description
<i>object</i>	None	Name of the net to preserve

This table summarizes the syntax in different files:

FDC	define_attribute {n:net_name} alspreserve {1}	Constraint File Example
Verilog	<i>object</i> /* synthesis alspreserve = 1 */;	Verilog Example
VHDL	attribute alspreserve of <i>object</i> : signal is true;	VHDL Example

Constraint File Example

```
define_attribute {n:and_out3} alspreserve {1};
define_attribute {n:or_out1} alspreserve {1};
```

Verilog Example

```
module complex (in1, out1);
input [6:1] in1;
output out1;
wire out1;
wire or_out1 /* synthesis syn_keep=1 alspreserve=1 */;
wire and_out1;
wire and_out2;
wire and_out3 /* synthesis syn_keep=1 alspreserve=1 */;
assign and_out1 = in1[1] & in1[2];
assign and_out2 = in1[3] & in1[4];
assign and_out3 = in1[5] & in1[6];
assign or_out1 = and_out1 | and_out2;
assign out1 = or_out1 & and_out3;
endmodule
```

VHDL Example

See [Verilog Attribute and Directive Syntax, on page 99](#) for different ways to specify VHDL attributes and directives.

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

```
entity complex is
port (input : in std_logic_vector (6 downto 1);
      output : out std_logic);
end complex;

architecture RTL of complex is
signal and_out1 : std_logic;
signal and_out2 : std_logic;
signal and_out3 : std_logic;
signal or_out1 : std_logic;
attribute syn_keep of and_out3 : signal is true;
attribute syn_keep of or_out1 : signal is true;
attribute alspreserve of and_out3 : signal is true;
attribute alspreserve of or_out1 : signal is true;

begin
    and_out1 <= input(1) and input(2);
    and_out2 <= input(3) and input(4);
    and_out3 <= input(5) and input(6);
    or_out1 <= and_out1 or and_out2;
    output <= or_out1 and and_out3;
end;
```

black_box_pad_pin

Directive

Specifies that the pins on a black box are I/O pads visible to the outside environment.

black_box_pad_pin Values

Value	Description
<i>portName</i>	Specifies ports on the black box that are I/O pads.

Description

Used with the `syn_black_box` directive and specifies that pins on black boxes are I/O pads visible to the outside environment. To specify more than one port as an I/O pad, list the ports inside double-quotes ("*portName*"), separated by commas, and without enclosed spaces.

To instantiate an I/O from your programmable logic vendor, you usually do not need to define a black box or this directive. The synthesis tool provides predefined black boxes for vendor I/Os. For more information, refer to your vendor section under FPGA and CPLD Support.

The `black_box_pad_pin` directive is one of several directives that you can use with the `syn_black_box` directive to define timing for a black box. See [syn_black_box](#), on page 50 for a list of the associated directives.

black_box_pad_pin Values Syntax

The following support applies for the `black_box_pad_pin` attribute.

Global Support	Object
No	Verilog module or VHDL architecture declared for a black box

This table summarizes the syntax in different files:

Verilog	<code>object /* synthesis black_box_pad_pin = portList */;</code>	Verilog Example
VHDL	<code>attribute black_box_pad_pin of object: objectType is portList;</code>	VHDL Example

Where

- *object* is a module or architecture declaration of a black box.
- *portList* is a spaceless, comma-separated list of the names of the ports on black boxes that are I/O pads.
- *objectType* is a string in VHDL code.

Verilog Example

This example shows how to specify this attribute in the following Verilog code segment:

```
module BBDLHS(D,E,GIN,GOUT,PAD,Q)
  /* synthesis syn_black_box black_box_pad_pin="GIN[2:0],Q" */;
```

VHDL Example

This example shows how to specify this attribute in the following VHDL code:

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

Entity top is
generic (width : integer := 4);
  port (in1,in2 : in std_logic_vector(width downto 0);
        clk : in std_logic;
        q : out std_logic_vector (width downto 0)
        );
end top;

architecture top1_arch of top is
component test is
  generic (width1 : integer := 2);
  port (in1,in2 : in std_logic_vector(width1 downto 0);
        clk : in std_logic;
        q : out std_logic_vector (width1 downto 0)
        );
end component;

attribute syn_black_box : boolean;
attribute black_box_pad_pin : string;
attribute syn_black_box of test : component is true;
attribute black_box_pad_pin of test : component is
```

```
"in1(4:0), in2[4:0], q(4:0)";

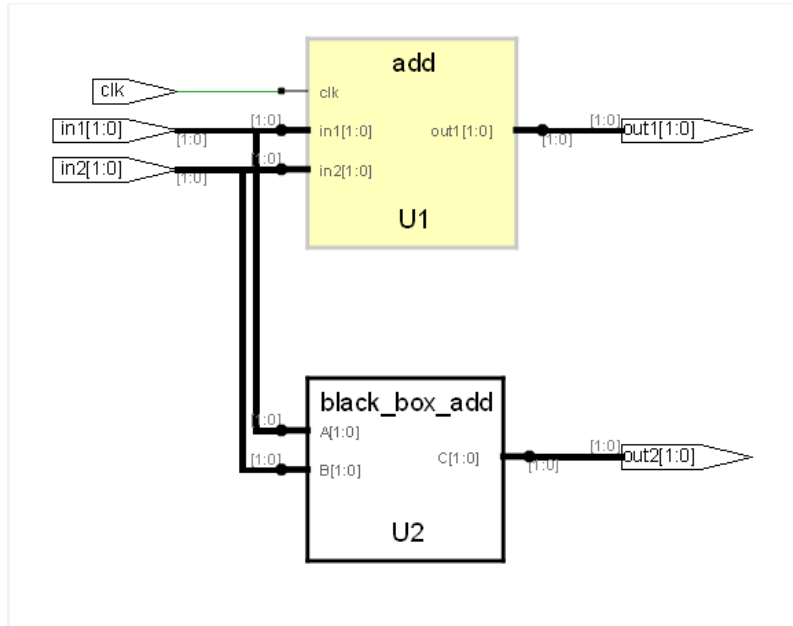
begin
  test123 : test generic map (width) port map (in1,in2,clk,q);
end topl_arch;
```

Effect of Using `black_box_pad_pin`

The following example shows the effect of applying the attribute.

Before using `black_box_pad_pin`

```
)
(cell black_box_add (cellType GENERIC)
  (view verilog (viewType NETLIST)
    (interface
      (port (array (rename A "A[1:0]") 2) (direction INPUT)
        (port (array (rename B "B[1:0]") 2) (direction INPUT)
          (port (array (rename C "C[1:0]") 2) (direction OUTPUT))
        )
      (property orig_inst_of (string "black_box_add"))
    )
  )
)
```

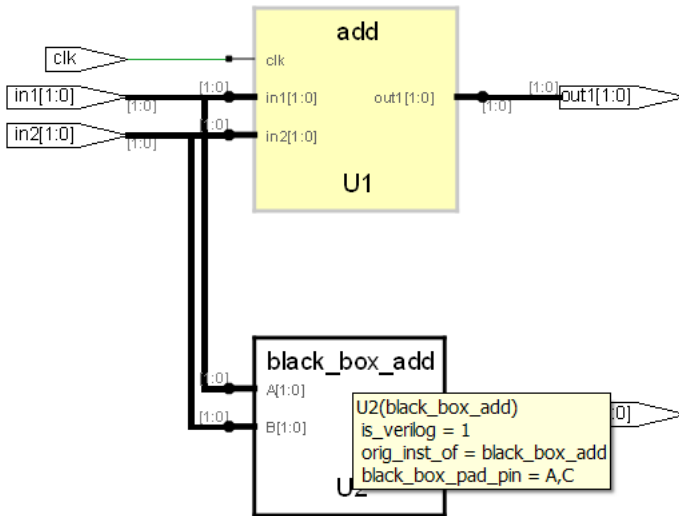


After using black_box_pad_pin

```

)
(cell black_box_add (cellType GENERIC)
  (view verilog (viewType NETLIST)
    (interface
      (port (array (rename A "A[1:0]") 2) (direction INPUT)
        (port (array (rename B "B[1:0]") 2) (direction INPUT)
          (port (array (rename C "C[1:0]") 2) (direction OUTPUT))
        )
      (property orig_inst_of (string "black_box_add"))
    )
  )
)

```



black_box_tri_pins

Directive

Specifies that an output port on a black box component is a tristate.

black_box_tri_pins Values

Value	Description
-------	-------------

<i>portName</i>	Specifies an output port on the black box that is a tristate.
-----------------	---

Description

Used with the `syn_black_box` directive and specifies that an output port on a black box component is a tristate. This directive eliminates multiple driver errors when the output of a black box has more than one driver. To specify more than one tristate port, list the ports inside double-quotes ("), separated by commas (,), and without enclosed spaces.

The `black_box_tri_pins` directive is one of several directives that you can use with the `syn_black_box` directive to define timing for a black box. See [syn_black_box](#), on page 50 for a list of the associated directives.

black_box_tri_pins Values Syntax

The following support applies for the `black_box_tri_pins` attribute.

Global Support	Object
----------------	--------

No	Verilog module or VHDL architecture declared for a black box
----	--

This table summarizes the syntax in different files:

Verilog	<code>object /* synthesis black_box_tri_pins = portList */;</code>	Verilog Example
VHDL	<code>attribute black_box_tri_pins of object: objectType is portList;</code>	VHDL Example

Where

- *object* is a module or architecture declaration of a black box.

- *portList* is a spaceless, comma-separated list of the tristate output port names.
- *objectType* is a string in VHDL code.

Verilog Example

Here is an example with a single port name:

```
module BBDLHS (D,E,GIN,GOUT,PAD,Q)
  /* synthesis syn_black_box black_box_tri_pins="PAD" */;
```

Here is an example with a list of multiple pins:

```
module bbl (D,E,tri1,tri2,tri3,Q)
  /* synthesis syn_black_box black_box_tri_pins="tri1,tri2,tri3" */;
```

For a bus, you specify the port name followed by all the bits on the bus:

```
module bbl (D,bus1,E,GIN,GOUT,Q)
  /* synthesis syn_black_box black_box_tri_pins="bus1[7:0]" */;
```

VHDL Example

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

package my_components is
  component BBDLHS
    port (D: in std_logic;
          E: in std_logic;
          GIN : in std_logic;
          GOUT : in std_logic;
          PAD : inout std_logic;
          Q: out std_logic);
  end component;

  attribute syn_black_box : boolean;
  attribute syn_black_box of BBDLHS : component is true;
  attribute black_box_tri_pins : string;
  attribute black_box_tri_pins of BBDLHS : component is "PAD";
end package my_components;
```

Multiple pins on the same component can be specified as a list:

```
attribute black_box_tri_pins of bb1 : component is  
    "tri,tri2,tri3";
```

To apply this directive to a port that is a bus, specify all the bits on the bus:

```
attribute black_box_tri_pins of bb1 : component is "bus1[7:0]";
```

full_case

Directive

For Verilog designs only. Indicates that all possible values have been given, and that no additional hardware is needed to preserve signal values.

full_case Values

Value	Description
1 (Default)	All possible values have been given and no additional hardware is needed to preserve signal values.

Description

For Verilog designs only. When used with a case, casex, or casez statement, this directive indicates that all possible values have been given, and that no additional hardware is needed to preserve signal values.

full_case Values Syntax

This table summarizes the syntax in the following file type:

Verilog	<code>object /* synthesis full_case */;</code>	Verilog Examples
---------	--	----------------------------------

Verilog Examples

The following casez statement creates a 4-input multiplexer with a pre-decoded select bus (a decoded select bus has exactly one bit enabled at a time):

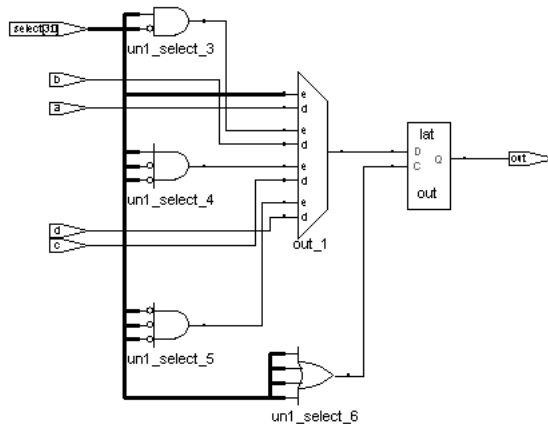
```

module muxnew1 (out, a,
b, c, d, select);
output out;
input a, b, c, d;
input [3:0] select;
reg out;

always @(select or a or b
or c or d)

begin
    casez (select)
        4'b???1: out = a;
        4'b??1?: out = b;
        4'b?1??: out = c;
        4'b1???: out = d;
    endcase
end
endmodule

```



This code does not specify what to do if the select bus has all zeros. If the select bus is being driven from outside the current module, the current module has no information about the legal values of select, and the synthesis tool must preserve the value of the output out when all bits of select are zero. Preserving the value of out requires the tool to add extraneous level-sensitive latches if out is not assigned elsewhere through every path of the always block. A warning message like the following is issued:

"Latch generated from always block for signal out, probably missing assignment in branch of if or case."

If you add the `full_case` directive, it instructs the synthesis tool not to preserve the value of out when all bits of select are zero.

```

module muxnew3 (out, a, b, c, d, select);
output out;
input a, b, c, d;
input [3:0] select;
reg out;

always @(select or a or b or c or d)

```

```
begin
    casez (select) /* synthesis full_case */
        4'b???1: out = a;
        4'b??1?: out = b;
        4'b?1??: out = c;
        4'b1???: out = d;
    endcase
end
endmodule
```

If the select bus is decoded in the same module as the case statement, the synthesis tool automatically determines that all possible values are specified, so the full_case directive is unnecessary.

Assigned Default and full_case

As an alternative to full_case, you can assign a default in the case statement. The default is assigned a value of 'bx (a 'bx in an assignment is treated as a “don't care”). The software assigns the default at each pass through the casez statement in which the select bus does not match one of the explicitly given values; this ensures that the value of out is not preserved and no extraneous level-sensitive latches are generated.

The following code shows a default assignment in Verilog:

```
module muxnew2 (out, a, b, c, d, select);
    output out;
    input a, b, c, d;
    input [3:0] select;
    reg out;

    always @(select or a or b or c or d)
    begin
        casez (select)
            4'b???1: out = a;
            4'b??1?: out = b;
            4'b?1??: out = c;
            4'b1???: out = d;
            default: out = 'bx;
        endcase
    end
endmodule
```

Both techniques help keep the code concise because you do not need to declare all the conditions of the statement. The following table compares them:

Default Assignment	full_case
Stays within Verilog to get the desired hardware	Must use a synthesis directive to get the desired hardware
Helps simulation debugging because you can easily find that the invalid select is assigned a 'bx	Can cause mismatches between pre- and post-synthesis simulation because the simulator does not use full_case

loop_limit

Directive

Verilog

Specifies a loop iteration limit for a for loop in a Verilog design when the loop index is a variable, not a constant.

loop_limit Values

Value	Description
-------	-------------

1 - 1999	Overrides the default loop limit of 2000 in the RTL.
----------	--

Description

Verilog designs only.

Specifies a loop iteration limit for a for loop on a per-loop basis when the loop index is a variable, not a constant. The compiler uses the default iteration limit of 1999 when the exit or terminating condition does not compute a constant value, or to avoid infinite loops. The default limit ensures the effective use of runtime and memory resources.

If your design requires a variable loop index or if the number of loops is greater than the default limit, use the `loop_limit` directive to specify a new limit for the compiler. If you do not, you get a compiler error. You must hard code the limit at the beginning of the loop statement. The limit cannot be an expression. The higher the value you set, the longer the runtime.

Alternatively, you can use the `set_option looplimit` command (Loop Limit GUI option) to set a global loop limit that overrides the default of 2000 loops in the RTL. To use the Loop Limit option on the Verilog tab of the Implementation Options panel, see [Verilog Panel, on page 224](#) in the *Command Reference*.

Note: VHDL applications use the `syn_looplimit` directive (see [syn_looplimit, on page 113](#)).

loop_limit Values Syntax

The following support applies for the `loop_limit` directive.

Global Support Object

Yes	Specifies the beginning of the loop statement.
-----	--

This table summarizes the syntax in the following file:

Verilog `/* synthesis loop_limit integer */ loopStatement`

[Verilog Example](#)

Verilog Example

The following is an example where the loop limit is set to 2000:

```
module test(din,dout,clk);
input[1999 : 0] din;
input clk;
output[1999 : 0] dout;
reg[1999 : 0] dout;
integer i;

always @(posedge clk)
begin
    /* synthesis loop_limit 2000 */
    for(i=0;i<=1999;i=i+1)
    begin
        dout[i] <= din[i];
    end
end
endmodule
```

Effect of Using loop_limit

Before using loop_limit

If the code has more than 2000 loops and the attribute is not set, the tool will produce an error.

```
@E:CS162 : loop_limit.v(10) | Loop iteration limit 2000 exceeded -
add '// synthesis loop_limit 4000' before the loop construct
```

After using `loop_limit`

Code with more than 2000 loops will not produce the `loop_limit` error.

parallel_case

Directive

For Verilog designs only. Forces a parallel-multiplexed structure rather than a priority-encoded structure.

Description

case statements are defined to work in priority order, executing (only) the first statement with a tag that matches the select value. The `parallel_case` directive forces a parallel-multiplexed structure rather than a priority-encoded structure.

If the select bus is driven from outside the current module, the current module has no information about the legal values of select, and the software must create a chain of disabling logic so that a match on a statement tag disables all following statements.

However, if you know the legal values of select, you can eliminate extra priority-encoding logic with the `parallel_case` directive. In the following example, the only legal values of select are 4'b1000, 4'b0100, 4'b0010, and 4'b0001, and only one of the tags can be matched at a time. Specify the `parallel_case` directive so that tag-matching logic can be parallel and independent, instead of chained.

parallel_case Syntax

The following support applies for the `parallel_case` directive.

Global Support Object

No	Object
	A case, casex, or casez statement declaration

This table summarizes the syntax in the following file type:

Verilog	object /* synthesis parallel_case */	Verilog Example
---------	--------------------------------------	---------------------------------

Verilog Example

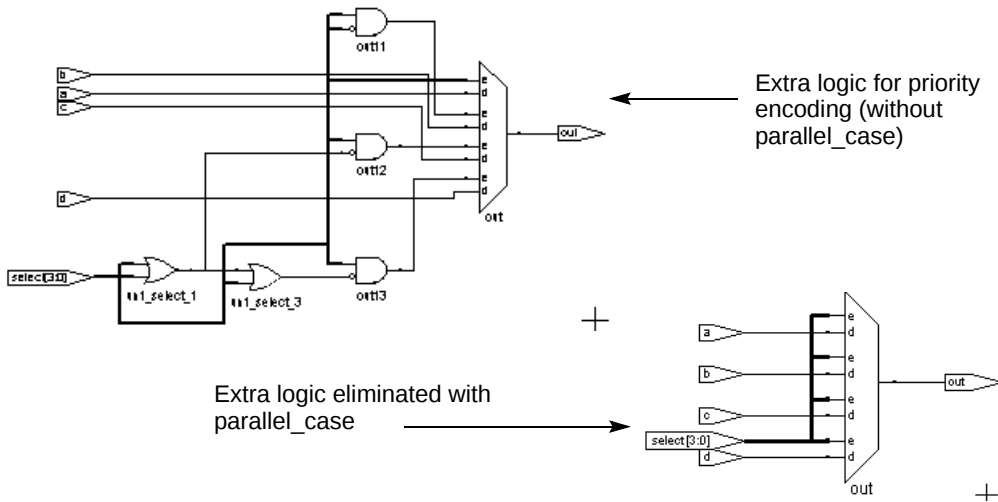
You specify the directive as a comment immediately following the select value of the case statement.

```
module muxnew4 (out, a, b, c, d, select);
  output out;
  input a, b, c, d;
  input [3:0] select;
  reg out;

  always @(select or a or b or c or d)
  begin
    casez (select) /* synthesis parallel_case */
      4'b???1: out = a;
      4'b??1?: out = b;
      4'b?1??: out = c;
      4'b1???: out = d;
      default: out = 'bx;
    endcase
  end
endmodule
```

If the select bus is decoded within the same module as the case statement, the parallelism of the tag matching is determined automatically, and the `parallel_case` directive is unnecessary.

Effect of Using `parallel_case`



pragma translate_off/pragma translate_on

Directive

Allows you to synthesize designs originally written for use with other synthesis tools without needing to modify source code. All source code that is between these two directives is ignored during synthesis.

Description

Another use of these directives is to prevent the synthesis of stimulus source code that only has meaning for logic simulation. You can use `pragma translate_off/translate_on` to skip over simulation-specific lines of code that are not synthesizable.

When you use `pragma translate_off` in a module, synthesis of all source code that follows is halted until `pragma translate_on` is encountered. Every `pragma translate_off` must have a corresponding `pragma translate_on`. These directives cannot be nested, therefore, the `pragma translate_off` directive can only be followed by a `pragma translate_on` directive.

Note: See also, [translate_off/translate_on](#), on page 229. These directives are implemented the same in the source code.

This table summarizes the syntax in the following file type:

Verilog	<pre>/* pragma translate_off */ /* pragma translate_on */ /*synthesis translate_off */ /*synthesis translate_on */</pre>	Verilog Example
VHDL	<pre>--pragma translate_off --pragma translate_on --synthesis translate_off --synthesis translate_on</pre>	VHDL Example

Verilog Example

```
module test(input a, b, output dout, Nout);
  assign dout = a + b;

  //Anything between pragma translate_off/translate_on is ignored by
  //the synthesis tool hence only
  //the adder circuit above is implemented, not the multiplier
  //circuit below:

  /* synthesis translate_off */ assign Nout = a * b;
  /* synthesis translate_on */
endmodule
```

VHDL Example

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

entity test is
  port (
    a : in std_logic_vector(1 downto 0);
    b : in std_logic_vector(1 downto 0);
    dout : out std_logic_vector(1 downto 0);
    Nout : out std_logic_vector(3 downto 0)
  );
end;

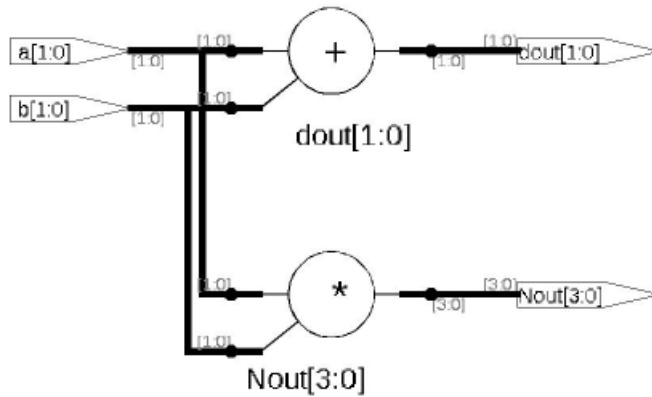
architecture rtl of test is
begin
  dout <= a + b;

  --Anything between pragma translate_off/translate_on is ignored by
  --the synthesis tool hence only
  --the adder circuit above is implemented not the multiplier circuit
  --below:

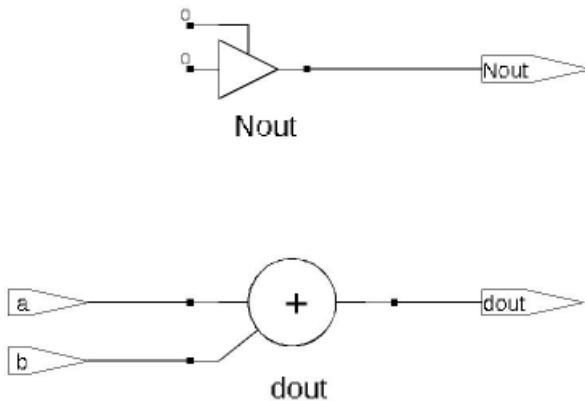
  --pragma translate_off
    Nout <= a * b;
  --pragma translate_on
end;
```

Effect of Using `pragma translate_off/pragma translate_on`

Before applying the attribute:



After applying the attribute:



syn_allow_retiming

Attribute

Determines if registers can be moved across combinational logic to improve performance.

Vendor	Technology	Synthesis Tool
Microsemi	Fusion IGLOO, IGLOOe, IGLOO+ ProASIC3/3E/3L	Synplify Pro

syn_allow_retiming values

1 | true Allows registers to be moved during retiming.

0 | false Does not allow retimed registers to be moved.

Description

The `syn_allow_retiming` attribute determines if registers can be moved across combinational logic to improve performance.

The attribute can be applied either globally or to specific registers. Typically, you enable the global Retiming option in the UI (or the `set_option -retiming 1` switch in Tcl) and use the `syn_allow_retiming` attribute to disable retiming for specific objects that you do not want moved.

syn_allow_retiming Syntax

Global	Object
Yes	Register

You can specify the attribute in the following files:

FDC	define_attribute {<i>register</i>} syn_allow_retiming {1 0} define_global_attribute syn_allow_retiming {1 0}	FDC Example
Verilog	<i>object</i> /* synthesis syn_allow_retiming = 0 1 */;	Verilog Example
VHDL	attribute syn_allow_retiming of <i>object</i> : <i>objectType</i> is true false;	VHDL Example

FDC Example

```
define_attribute {register} syn_allow_retiming {1|0}
define_global_attribute syn_allow_retiming {1|0}
```

Enable	Object Type	Object	Attribute	Value	Value Type	Description
☒	<any>	<Global>	syn_allow_retiming	1	boolean	Controls retiming of reg...

Verilog Example

```
object /* synthesis syn_allow_retiming = 0 | 1 */;
```

Here is an example of applying it to a register:

```
module parity_check (clk,data,count_one);
input clk;
input [20:0]data ;
output reg [3:0]count_one /* synthesis syn_allow_retiming=1*/;

integer i;
reg parity= 1'b1;

always @(posedge clk)
begin
    for (i=0; i<21; i=i+1)
        if (data[i] == parity)
            count_one<=count_one+1;

end
endmodule
```

VHDL Example

attribute syn_allow_retiming of object : objectType is true | false;

The data type is Boolean. Here is an example of applying it to a register:

```

LIBRARY IEEE;
USE      IEEE.STD_LOGIC_1164.ALL;
USE      IEEE.std_logic_unsigned.ALL;

ENTITY ones_cnt IS
    PORT (vin   : IN  STD_LOGIC_VECTOR (7 DOWNT0 0);
          vout  : OUT STD_LOGIC_VECTOR (3 DOWNT0 0);
          clk   : IN  STD_LOGIC);
END ones_cnt;

ARCHITECTURE lan OF ones_cnt IS
    signal vout_reg : STD_LOGIC_VECTOR (3 DOWNT0 0);
    attribute syn_allow_retiming : boolean;
    attribute syn_allow_retiming of vout_reg : signal is true;

BEGIN
    gen_vout: PROCESS(clk,vin)
        VARIABLE count : STD_LOGIC_VECTOR(vout'RANGE);
    BEGIN
        if rising_edge(clk) then
            count := (OTHERS => '0');
            FOR I IN vin'RANGE LOOP
                count := count + vin(i);
            END LOOP;
            vout_reg <= count;
        end if;
        vout <= vout_reg;
    END PROCESS gen_vout;
END lan;

```

See [Verilog Attribute and Directive Syntax, on page 99](#) for different ways to specify VHDL attributes and directives.

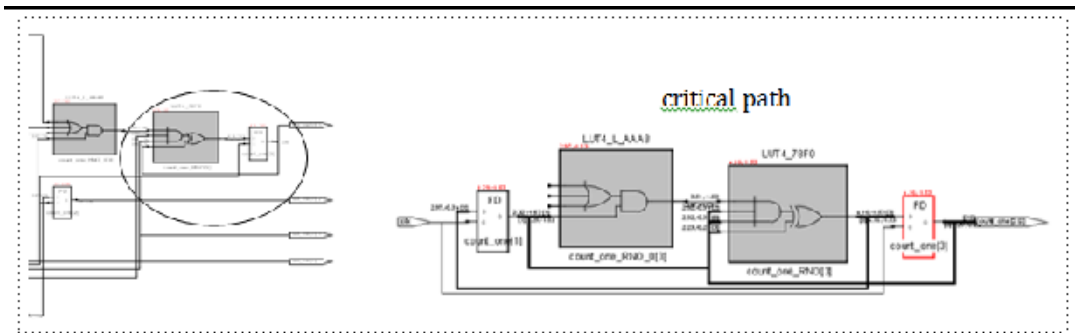
Effect of using syn_allow_retiming

Before applying syn_allow_retiming.

Verilog	output reg [3:0]count_one /* synthesis syn_allow_retiming=0*/;
---------	--

VHDL	attribute syn_allow_retiming of vout_reg : signal is false;
------	---

The critical path and the worst slack for this scenario are given below along with the original count_one [3] register (before being retimed) as found in the design.

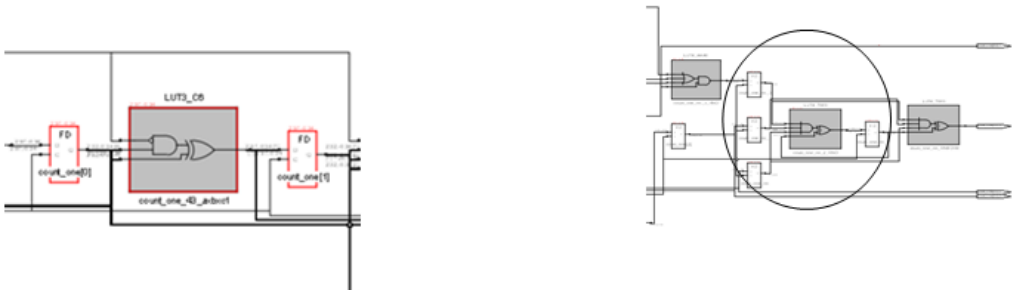


After applying syn_allow_retiming.

Verilog output reg [3:0]count_one /* synthesis syn_allow_retiming=1*/;

VHDL attribute syn_allow_retiming of vout_reg : signal is true;

The critical path and the worst slack for this scenario are shown along with the four '*_ret' retimed registers.



syn_black_box

Directive

Defines a module or component as a black box.

syn_black_box Value

Value	Default	Description
<i>moduleName</i>	N/A	Defines an object as a black box.

Description

Specifies that a module or component is a black box for synthesis. A black box module has only its interface defined for synthesis; its contents are not accessible and cannot be optimized during synthesis. A module can be a black box whether or not it is empty.

Typically, you set `syn_black_box` on objects like the ones listed below. You do not need to define a black box for such an object if the synthesis tool includes a predefined black box for it.

- Vendor primitives and macros (including I/Os).
- User-designed macros whose functionality is defined in a schematic editor, IP, or another input source where the place-and-route tool merges design netlists from different sources.

In certain cases, the tool does not honor a `syn_black_box` directive:

- In mixed language designs where a black box is defined in one language at the top level but where there is an existing description for it in another language, the tool can replace the declared black box with the description from the other language.
- If your project includes black box descriptions in `srs`, `ngc`, or `edf` formats, the tool uses these black box descriptions even if you have specified `syn_black_box` at the top level.

To override this and ensure that the attribute is honored, use these methods:

- Set a `syn_black_box` directive on the module or entity in the HDL file that contains the description, not at the top level. The contents will be black-boxed.

- If you want to define a black box when you have an `srs`, `ngc`, or `edf` description for it, remove the description from the project.

Once you define a black box with `syn_black_box`, you use other source code directives to define timing for the black box. You must add the directives to the source code because the timing models are specific to individual instances. There are no corresponding Tcl directives you can add to a constraint file.

Black-box Source Code Directives

Use the following directives with `syn_black_box` to characterize black-box timing:

<code>syn_isclock</code>	Specifies a clock port on a black box.
<code>syn_tpd<n></code>	Sets timing propagation for combinational delay through the black box.
<code>syn_tsu<n></code>	Defines timing setup delay required for input pins relative to the clock.
<code>syn_tco<n></code>	Defines the timing clock to output delay through the black box.

Black Box Pin Definitions

You define the pins on a black box with these directives in the source code:

<code>black_box_pad_pin</code>	Indicates that a black box is an I/O pad for the rest of the design.
<code>black_box_tri_pins</code>	Indicates tristates on black boxes.

For more information on black boxes, see [Instantiating Black Boxes in Verilog, on page 90](#), and [Instantiating Black Boxes in VHDL, on page 300](#).

`syn_black_box` Syntax Specification

Verilog	<code>object /* synthesis syn_black_box */;</code>	Verilog Example
VHDL	<code>attribute syn_black_box of object : objectType is true;</code>	VHDL Example

Verilog Example

```
module top(clk, in1, in2, out1, out2);

    input clk;
    input [1:0] in1;
    input [1:0] in2;

    output [1:0] out1;
    output [1:0] out2;

    add          U1 (clk, in1, in2, out1);
    black_box_add U2 (in1, in2, out2);

endmodule

module add (clk, in1, in2, out1);

    input clk;
    input [1:0] in1;
    input [1:0] in2;

    output [1:0] out1;
    reg [1:0] out1;

    always@(posedge clk)
        begin
            out1 <= in1 + in2;
        end
endmodule

module black_box_add(A, B, C)/* synthesis syn_black_box */;

    input [1:0] A;
    input [1:0] B;

    output [1:0] C;

    assign C = A + B;

endmodule
```

VHDL Example

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

entity add is
  port(
    in1 : in std_logic_vector(1 downto 0);
    in2 : in std_logic_vector(1 downto 0);
    clk : in std_logic;
    out1 : out std_logic_vector(1 downto 0));
end;

architecture rtl of add is
begin

  process(clk)
  begin
    if(clk'event and clk='1') then
      out1 <= (in1 + in2);
    end if;
  end process;
end;

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

entity black_box_add is
  port(
    A : in std_logic_vector(1 downto 0);
    B : in std_logic_vector(1 downto 0);
    C : out std_logic_vector(1 downto 0));
end;

architecture rtl of black_box_add is

  attribute syn_black_box : boolean;
  attribute syn_black_box of rtl: architecture is true;
begin

  C <= A + B;
end;

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

```
entity top is
  port(
    in1 : in std_logic_vector(1 downto 0);
    in2 : in std_logic_vector(1 downto 0);
    clk : in std_logic;
    out1 : out std_logic_vector(1 downto 0);
    out2 : out std_logic_vector(1 downto 0));
end;

architecture rtl of top is

  component add is
    port(
      in1 : in std_logic_vector(1 downto 0);
      in2 : in std_logic_vector(1 downto 0);
      clk : in std_logic;
      out1 : out std_logic_vector(1 downto 0));
  end component;

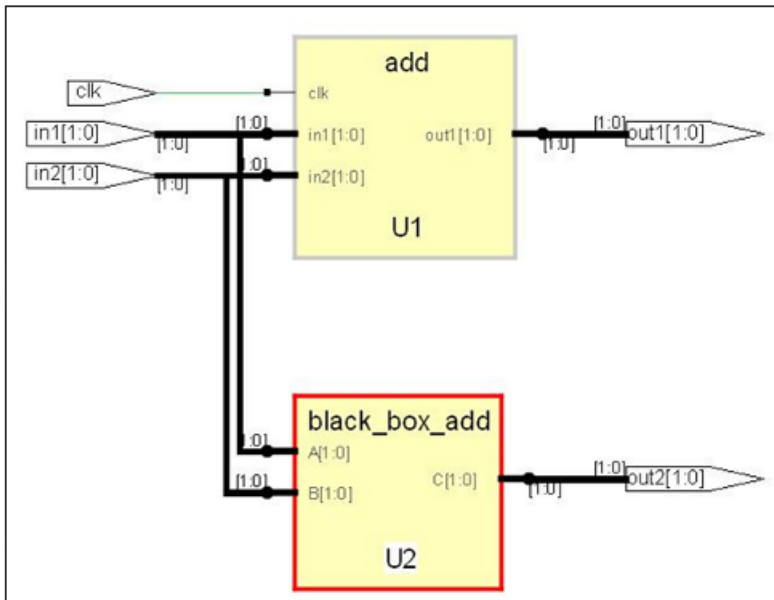
  component black_box_add
    port(
      A : in std_logic_vector(1 downto 0);
      B : in std_logic_vector(1 downto 0);
      C : out std_logic_vector(1 downto 0));
  end component;

begin
  U1: add port map(in1, in2, clk, out1);
  U2: black_box_add port map(in1, in2, out2);
end;
```

Effect of Using syn_black_box

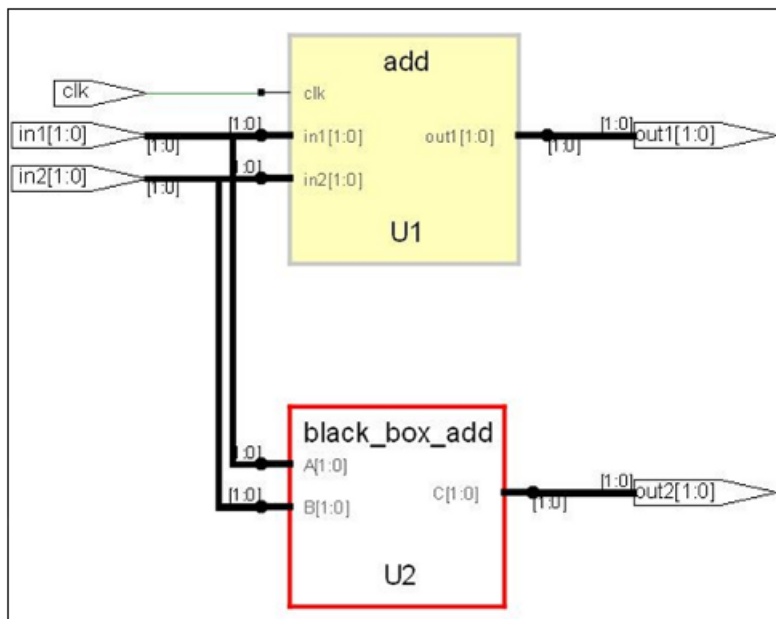
When the `syn_black_box` attribute is not set on the `black_box_add` module, its content are accessible, as shown in the example below:

```
module black_box_add(input [1:0]A, [1:0]B, output [1:0]C);
```



After applying `syn_black_box`, the contents of the black box are no longer visible:

```
module black_box_add(input [1:0]A, [1:0]B, output [1:0]C)/*
  synthesis syn_black_box */;
```



syn_encoding

Attribute

Overrides the default FSM Compiler encoding for a state machine and applies the specified encoding.

Vendor	Devices
Microsemi	ProASIC3, Fusion, SmartFusion2

syn_encoding Values

The default is that the tool automatically picks an encoding style that results in the best performance. To ensure that a particular encoding style is used, explicitly specify that style, using the values below:

Value	Description
onehot	Only two bits of the state register change (one goes to 0, one goes to 1) and only one of the state registers is hot (driven by 1) at a time. For example: 0001, 0010, 0100, 1000 Because onehot is not a simple encoding (more than one bit can be set), the value must be decoded to determine the state. This encoding style can be slower than a gray style if you have a large output decoder following a state machine.
gray	More than one of the state registers can be hot. The synthesis tool <i>attempts</i> to have only one bit of the state registers change at a time, but it can allow more than one bit to change, depending upon certain conditions for optimization. For example: 000, 001, 011, 010, 110 Because gray is not a simple encoding (more than one bit can be set), the value must be decoded to determine the state. This encoding style can be faster than a onehot style if you have a large output decoder following a state machine.

Value	Description
sequential	More than one bit of the state register can be hot. The synthesis tool makes no attempt at limiting the number of bits that can change at a time. For example: 000, 001, 010, 011, 100 This is one of the smallest encoding styles, so it is often used when area is a concern. Because more than one bit can be set (1), the value must be decoded to determine the state. This encoding style can be faster than a onehot style if you have a large output decoder following a state machine.
safe	This implements the state machine in the default encoding and adds reset logic to force the state machine to a known state if it reaches an invalid state. This value can be used in combination with any of the other encoding styles described above. You specify safe before the encoding style. The safe value is only valid for a state register, in conjunction with an encoding style specification. - For example, if the default encoding is onehot and the state machine reaches a state where all the bits are 0, which is an invalid state, the safe value ensures that the state machine is reset to a valid state. - If recovery from an invalid state is a concern, it may be appropriate to use this encoding style, in conjunction with onehot, sequential or gray, in order to force the state machine to reset. When you specify safe, the state machine can be reset from an unknown state to its reset state. - If an FSM with asynchronous reset is specified with the value safe and you do not want the additional recovery logic (flip-flop on the inactive clock edge) inserted for this FSM, then use the <code>syn_shift_resetphase</code> attribute to remove it. See syn_shift_resetphase, on page 197 for details.
original	This respects the encoding you set, but the software still does state machine and reachability analysis.

You can specify multiple values. This snippet uses `safe,gray`. The encoding style for register OUT is set to gray, but if the state machine reaches an invalid state the synthesis tool will reset the values to a valid state.

```
module prep3 (CLK, RST, IN, OUT);
  input CLK, RST;
  input [7:0] IN;
  output [7:0] OUT;
  reg [7:0] OUT;
  reg [7:0] current_state /* synthesis syn_encoding="safe,gray" */;

  // Other code
```

Description

This attribute takes effect only when FSM Compiler is enabled. It overrides the default FSM Compiler encoding for a state machine. For the specified encoding to take effect, the design must contain state machines that have been inferred by the FSM Compiler. Setting this attribute when `syn_state_machine` is set to 0 will not have any effect.

The default encoding style automatically assigns encoding based on the number of states in the state machine. Use the `syn_encoding` attribute when you want to override these defaults. You can also use `syn_encoding` when you want to disable the FSM Compiler globally but there are a select number of state registers in your design that you want extracted. In this case, use this attribute with the `syn_state_machine` directive on for just those specific registers.

The encoding specified by this attribute applies to the final mapped netlist. For other kinds of enumerated encoding, use `syn_enum_encoding`. See [syn_enum_encoding, on page 66](#) and [syn_encoding Compared to syn_enum_encoding, on page 68](#) for more information.

Encoding Style Implementation

The encoding style is implemented during the mapping phase. A message appears when the synthesis tool extracts a state machine, for example:

```
@N: CL201 : "c:\design\..."|Trying to extract state machine for  
register current_state
```

The log file reports the encoding styles used for the state machines in your design. This information is also available in the FSM Viewer.

See also the following:

- For information on enabling state machine optimization for individual modules, see [syn_state_machine, on page 205](#).
- For VHDL designs, see [syn_encoding Compared to syn_enum_encoding, on page 68](#) for comparative usage information.

Syntax Specification

Global Object

No	Instance, register
----	--------------------

This table shows how to specify the attribute in different files:

FDC	<code>define_attribute {object} syn_encoding {value}</code>	SCOPE Example
-----	---	-------------------------------

Verilog	<code>Object /* synthesis syn_encoding = "value" */;</code>	Verilog Example
---------	---	---------------------------------

VHDL	<code>attribute syn_encoding of object: objectType is "value";</code>	VHDL Example
------	---	------------------------------

If you specify the `syn_encoding` attribute in Verilog or VHDL, all instances of that FSM use the same `syn_encoding` value. To have unique `syn_encoding` values for each FSM instance, use different entities or modules, or specify the `syn_encoding` attribute in a constraint file.

SCOPE Example

	Enabled	Object Type	Object	Attribute	Value	Val Type	Description
1	☒	fsm	i:state[3:0]	syn_encoding	gray	string	FSM encoding (onehot, sequential, gray, original, safe)

The *object* must be an instance prefixed with **i:**, as in **i:instance**. The instance must be a sequential instance with a view name of `statemachine`.

Although you cannot set this attribute globally, you can define a SCOPE collection and then apply the attribute to the collection. For example:

```
define_scope_collection sm {find -hier -inst * -filter
    @inst_of==statemachine}
define_attribute {$sm} {syn_encoding} {safe}
```

Verilog Example

The object can be a register definition signals that hold the state values of state machines.

```
module fsm (clk, reset, x1, outp);
input      clk, reset, x1;
output     outp;
reg        outp;
reg        [1:0] state /* synthesis syn_encoding = "onehot" */;
parameter s1 = 2'b00; parameter s2 = 2'b01;
parameter s3 = 2'b10; parameter s4 = 2'b11;

always @(posedge clk or posedge reset)
begin
    if (reset)
        state <= s1;
    else begin
        case (state)
            s1: if (x1 == 1'b1)
                state <= s2;
            else
                state <= s3; s2: state <= s4;
            s3: state <= s4;
            s4: state <= s1;
        endcase
    end
end

always @(state) begin
    case (state)
        s1: outp = 1'b1;
        s2: outp = 1'b1;
        s3: outp = 1'b0;
        s4: outp = 1'b0;
    endcase
end
endmodule
```

VHDL Example

```
library ieee;
use ieee.std_logic_1164.all;
use ieee.numeric_std.all;
entity fsm is
    port (x1 : in std_logic;
          reset : in std_logic;
          clk : in std_logic;
          outp : out std_logic);
end fsm;
```

```
architecture rtl of fsm is
  signal state : std_logic_vector(1 downto 0);
  constant s1 : std_logic_vector := "00";
  constant s2 : std_logic_vector := "01";
  constant s3 : std_logic_vector := "10";
  constant s4 : std_logic_vector := "11";
  attribute syn_encoding : string;
  attribute syn_encoding of state : signal is "onehot";

begin
  process (clk,reset)
  begin
    if (clk'event and clk = '1') then
      if (reset = '1') then
        state <= s1 ;
      else
        case state is
          when s1 =>
            if x1 = '1' then
              state <= s2;
            else
              state <= s3;
            end if;
          when s2 =>
            state <= s4;
          when s3 =>
            state <= s4;
          when s4 =>
            state <= s1;
          end case;
        end if;
      end if;
    end process;

  process (state)
  begin
    case state is
      when s1 =>
        outp <= '1';
      when s2 =>
        outp <= '1';
      when s3 =>
        outp <= '0';
    end case;
  end process;
```

```

        when s4 =>
            outp <= '0';
        end case;
    end process;
end rtl;

```

See [VHDL Attribute and Directive Syntax, on page 302](#) for different ways to specify VHDL attributes and directives.

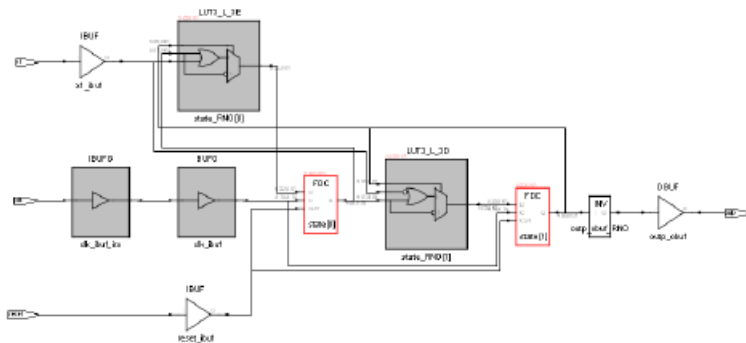
Effect of Using `syn_encoding`

The following figure shows the default implementation of a state machine, with these encoding details reported:

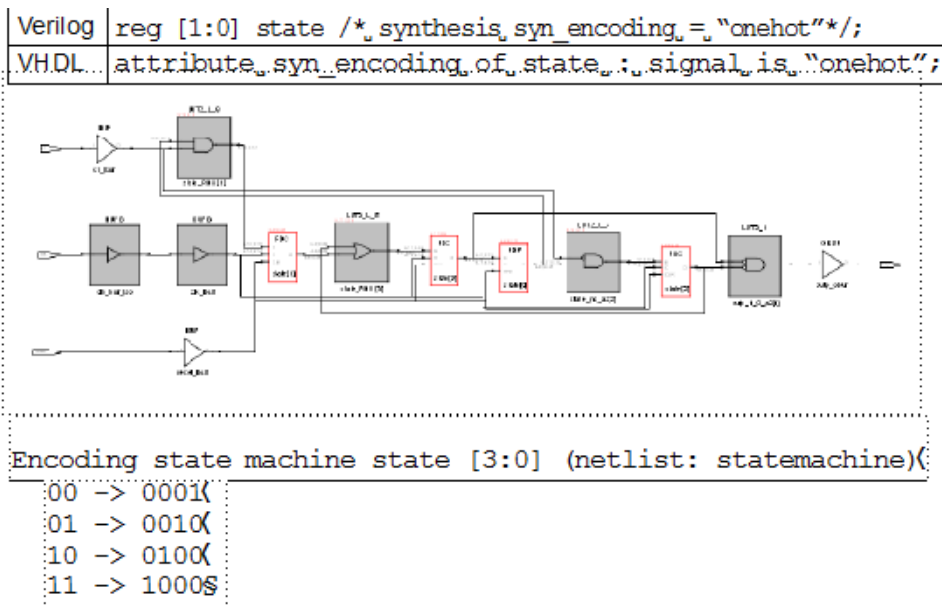
```

Encoding state machine state [3:0] (netlist: statemachine)
original code -> new code
00 -> 00
01 -> 01
10 -> 10
11 -> 11

```



The next figure shows the state machine when the `syn_encoding` attribute is set to `onehot`, and the accompanying changes in the code:



syn_enum_encoding

Directive

For VHDL designs. Defines how enumerated data types are implemented. The type of implementation affects the performance and device utilization.

syn_enum_encoding Values

Value	Description
default	Automatically assigns an encoding style that results in the best performance.
sequential	More than one bit of the state register can change at a time, but because more than one bit can be hot, the value must be decoded to determine the state. For example: 000, 001, 010, 011, 100.
onehot	Only two bits of the state register change (one goes to 0; one goes to 1) and only one of the state registers is hot (driven by a 1) at a time. For example: 0000, 0001, 0010, 0100, 1000.
gray	Only one bit of the state register changes at a time, but because more than one bit can be hot, the value must be decoded to determine the state. For example: 000, 001, 011, 010, 110.
string	This can be any value you define. For example: 001, 010, 101. See Example of syn_enum_encoding for User-Defined Encoding, on page 68 .

Description

If FSM Compiler is enabled, this directive has no effect on the encoding styles of extracted state machines; the tool uses the values specified in the syn_encoding attribute instead.

However, if you have enumerated data types and you turn off the FSM Compiler so that no state machines are extracted, the syn_enum_encoding style is implemented in the final circuit. See [syn_encoding Compared to syn_enum_encoding, on page 68](#) for more information. For step-by-step details about setting coding styles with this attribute see [Defining State Machines in VHDL, on page 358](#) of the *User Guide*.

A message appears in the log file when you use the `syn_enum_encoding` directive; for example:

```
CD231: Using onehot encoding for type mytype (red="10000000")
```

When using an application such as an equivalence checker, the encoding value automatically reverts to the sequential standard interpretation for the enumerations. Using a value other than sequential cannot guarantee that the application will use the same value. A message (CD233) is written to the log file as notification of the value change.

`syn_enum_encoding`, `enum_encoding`, and `syn_encoding`

Custom attributes are attributes that are not defined in the IEEE specifications, but which you or a tool vendor define for your own use. They provide a convenient back door in VHDL, and are used to better control the synthesis and simulation process. `enum_encoding` is one of these custom attributes that is widely used to allow specific binary encodings to be attached to objects of enumerated types.

The `enum_encoding` attribute is declared as follows:

```
attribute enum_encoding: string;
```

This can be either written directly in your VHDL design description, or provided to you by the tool vendor in a package. Once the attribute has been declared and given a name, it can be referenced as needed in the design description:

```
type statevalue is (INIT, IDLE, READ, WRITE, ERROR);
attribute enum_encoding of statevalue: type is
    "000 001 011 010 110";
```

When this is processed by a tool that supports the `enum_encoding` attribute, it uses the information about the `statevalue` encoding. Tools that do not recognize the `enum_encoding` attribute ignore the encoding.

Although it is recommended that you use `syn_enum_encoding`, the Synopsys FPGA tools recognize `enum_encoding` and treat it just like `syn_enum_encoding`. The tool uses the specified encoding when the FSM compiler is disabled, and ignores the value when the FSM Compiler is enabled.

If `enum_encoding` and `syn_encoding` are both defined and the FSM compiler is enabled, the tool uses the value of `syn_encoding`. If you have both `syn_enum_encoding` and `enum_encoding` defined, the value of `syn_enum_encoding` prevails.

syn_encoding Compared to syn_enum_encoding

To implement a state machine with a particular encoding style when the FSM Compiler is enabled, use the `syn_encoding` attribute. The `syn_encoding` attribute affects how the technology mapper implements state machines in the final netlist. The `syn_enum_encoding` directive only affects how the compiler interprets the associated enumerated data types. Therefore, the encoding defined by `syn_enum_encoding` is *not propagated* to the implementation of the state machine. However, when FSM Compiler is disabled, the value of `syn_enum_encoding` is implemented in the final circuit.

Example of syn_enum_encoding for User-Defined Encoding

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

entity shift_enum is
  port (clk, rst : bit;
        O : out std_logic_vector(2 downto 0));
end shift_enum;

architecture behave of shift_enum is
  type state_type is (S0, S1, S2);
  attribute syn_enum_encoding: string;
  attribute syn_enum_encoding of state_type : type is "001 010 101";
  signal machine : state_type;
begin
  process (clk, rst)
  begin
    if rst = '1' then
      machine <= S0;
    elsif clk = '1' and clk'event then
      case machine is
        when S0 => machine <= S1;
        when S1 => machine <= S2;
        when S2 => machine <= S0;
      end case;
    end if;
  end process;
  with machine select
    O <= "001" when S0,
        "010" when S1,
        "101" when S2;
end behave;
```

syn_enum_encoding Values Syntax

The following support applies for the syn_enum_encoding directive.

Global Support	Object
----------------	--------

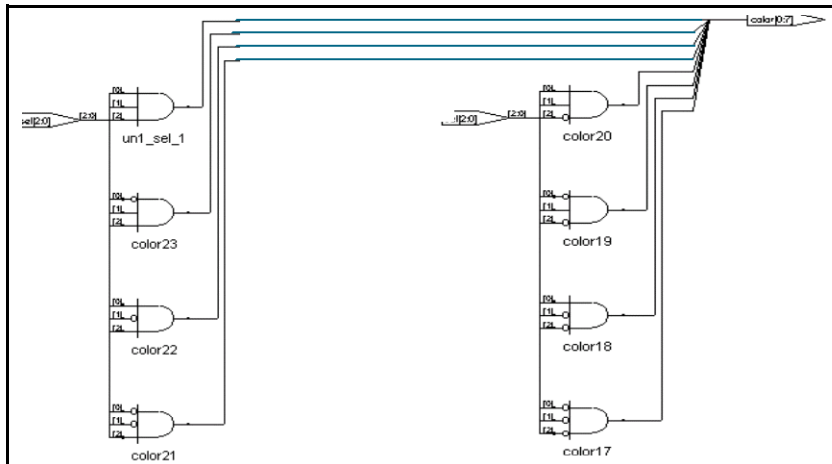
No/Yes	Enumerated data type.
--------	-----------------------

This table summarizes the syntax in the following file type:

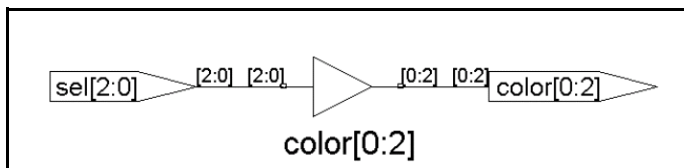
VHDL	attribute syn_enum_encoding of object : objectType is "value";	VHDL Example
------	---	------------------------------

Effect of Encoding Styles

The following figure provides an example of two versions of a design: one with the default encoding style, the other with the syn_enum_encoding directive overriding the default enumerated data types that define a set of eight colors.



syn_enum_encoding = "default" Based on 8 states, onehot assigned



syn_enum_encoding = "sequential"

In this example, using the default value for syn_enum_encoding, onehot is assigned because there are eight states in this design. The onehot style implements the output color as 8 bits wide and creates decode logic to convert the input sel to the output. Using sequential for syn_enum_encoding, the logic is reduced to a buffer. The size of output color is 3 bits.

See the following section for the source code used to generate the schematics above.

VHDL Example

See [VHDL Attribute and Directive Syntax, on page 302](#) for different ways to specify VHDL attributes and directives.

Here is the code used to generate the second schematic in the previous figure. (The first schematic will be generated instead, if "sequential" is replaced by "onehot" as the syn_enum_encoding value.)

```
package testpkg is
  type mytype is (red, yellow, blue, green, white,
    violet, indigo, orange);
  attribute syn_enum_encoding : string;
  attribute syn_enum_encoding of mytype : type is "sequential";
end package testpkg;

library IEEE;
use IEEE.std_logic_1164.all;
use work.testpkg.all;

entity decoder is
  port (sel : in std_logic_vector(2 downto 0);
    color : out mytype);
end decoder;
architecture rtl of decoder is
begin
  process(sel)
  begin
    case sel is
      when "000" => color <= red;
      when "001" => color <= yellow;
      when "010" => color <= blue;
      when "011" => color <= green;
      when "100" => color <= white;
      when "101" => color <= violet;
      when "110" => color <= indigo;
      when others => color <= orange;
    end case;
  end process;
end rtl;
```


syn_global_buffers

Attribute

Specifies the number of global buffers to be used in a design.

Vendor	Devices
Microsemi	IGLOO/IGLOOe, ProASIC3/3E

syn_global_buffers Values

Default	Global	Object
Maximum buffers available for a technology	Yes	Top-level module

Value	Description
An integer	For Microsemi designs, it can be any integer between 6 and 18.

Description

The synthesis tool automatically adds global buffers for clock nets with high fanout; use this attribute to specify a maximum number of buffers and restrict the amount of global buffer resources used. Also, if there is a black box in the design that has global buffers, you can use `syn_global_buffers` to prevent the synthesis tool from inferring clock buffers or exceeding the number of global resources.

You specify the attribute globally on the top-level module/entity or view. For Microsemi designs, it can be any integer between 6 and 18. If you specify an integer less than 6, the software infers six global buffers.

Syntax Specification

FDC file	<code>define_attribute {view} syn_global_buffers {maximum}</code> <code>define_global_attribute syn_global_buffers {maximum}</code>
Verilog	<code>object /* synthesis syn_global_buffers = maximum */;</code>
VHDL	<code>attribute syn_global_buffers : integer;</code> <code>attribute syn_global_buffers of object : objectType is maximum;</code>

SCOPE Example

	Enabled	Object Type	Object	Attribute	Value	Val Type	Description
1	☒	global	<global>	syn_global_buffers	10	integer	Number of global buffers

```
define_global_attribute syn_global_buffers {10}
```

Verilog Example

```
object /* synthesis syn_global_buffers = maximum */;
```

Here is a Verilog example:

```
module top (clk1, clk2, clk3, clk4, clk5, clk6, clk7, clk8, clk9,
  clk10, clk11, clk12, clk13, clk14, clk15, clk16, clk17, clk18,
  clk19, clk20, d1, d2, d3, d4, d5, d6, d7, d8, d9, d10, d11,
  d12, d13, d14, d15, d16, d17, d18, d19, d20, q1, q2, q3, q4, q5,
  q6, q7, q8, q9, q10, q11, q12, q13, q14, q15, q16, q17, q18,
  q19, q20, reset) /* synthesis syn_global_buffers = 10 */;

input clk1, clk2, clk3, clk4, clk5, clk6, clk7, clk8, clk9, clk10,
  clk11, clk12, clk13, clk14, clk15, clk16, clk17, clk18,
  clk19, clk20;
input d1, d2, d3, d4, d5, d6, d7, d8, d9, d10, d11, d12, d13, d14,
  d15, d16, d17, d18, d19, d20;
output q1, q2, q3, q4, q5, q6, q7, q8, q9, q10, q11, q12, q13, q14,
  q15, q16, q17, q18, q19, q20;
input reset;
reg q1, q2, q3, q4, q5, q6, q7, q8, q9, q10,
  q11, q12, q13, q14, q15, q16, q17, q18, q19, q20;
```

```
always @(posedge clk1 or posedge reset)
  if (reset)
    q1 <= 1'b0;
  else
    q1 <= d1;

always @(posedge clk2 or posedge reset)
  if (reset)
    q2 <= 1'b0;
  else
    q2 <= d2;

always @(posedge clk3 or posedge reset)
  if (reset)
    q3 <= 1'b0;
  else
    q3 <= d3;

always @(posedge clk4 or posedge reset)
  if (reset)
    q4 <= 1'b0;
  else
    q4 <= d4;

always @(posedge clk5 or posedge reset)
  if (reset)
    q5 <= 1'b0;
  else
    q5 <= d5;

always @(posedge clk6 or posedge reset)
  if (reset)
    q6 <= 1'b0;
  else
    q6 <= d6;

always @(posedge clk7 or posedge reset)
  if (reset)
    q7 <= 1'b0;
  else
    q7 <= d7;

always @(posedge clk8 or posedge reset)
  if (reset)
    q8 <= 1'b0;
  else
    q8 <= d8;
```

:

```
always @(posedge clk9 or posedge reset)
    if (reset)
        q9 <= 1'b0;
    else
        q9 <= d9;

always @(posedge clk10 or posedge reset)
    if (reset)
        q10 <= 1'b0;
    else
        q10 <= d10;

always @(posedge clk11 or posedge reset)
    if (reset)
        q11 <= 1'b0;
    else
        q11 <= d11;

always @(posedge clk12 or posedge reset)
    if (reset)
        q12 <= 1'b0;
    else
        q12 <= d12;

always @(posedge clk13 or posedge reset)
    if (reset)
        q13 <= 1'b0;
    else
        q13 <= d13;

always @(posedge clk14 or posedge reset)
    if (reset)
        q14 <= 1'b0;
    else
        q14 <= d14;

always @(posedge clk15 or posedge reset)
    if (reset)
        q15 <= 1'b0;
    else
        q15 <= d15;

always @(posedge clk16 or posedge reset)
    if (reset)
        q16 <= 1'b0;
    else
        q16 <= d16;
```

```

always @(posedge clk17 or posedge reset)
    if (reset)
        q17 <= 1'b0;
    else
        q17 <= d17;

always @(posedge clk18 or posedge reset)
    if (reset)
        q18 <= 1'b0;
    else
        q18 <= d18;

always @(posedge clk19 or posedge reset)
    if (reset)
        q19 <= 1'b0;
    else
        q19 <= d19;

always @(posedge clk20 or posedge reset)
    if (reset)
        q20 <= 1'b0;
    else
        q20 <= d20;

endmodule

```

VHDL Example

Here is a VHDL example:

```

library ieee;
use ieee.std_logic_1164.all;

entity top is
    port (clk : in std_logic_vector(19 downto 0);
          d : in std_logic_vector(19 downto 0);
          q : out std_logic_vector(19 downto 0);
          reset : in std_logic);
end top;

architecture behave of top is
    attribute syn_global_buffers : integer;
    attribute syn_global_buffers of behave : architecture is 10;
begin
    process (clk, reset)
    begin
        for i in 0 to 19 loop
            if (reset = '1') then

```

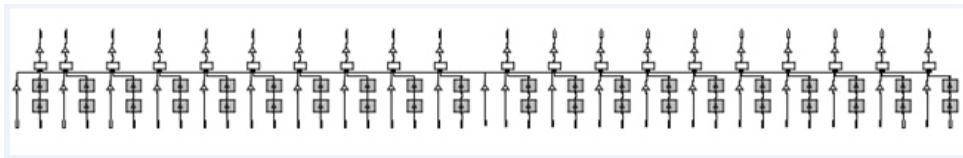
:

```
        q(i) <= '0';
    elsif clk(i) = '1' and clk(i)' event then
        q(i) <= d(i);
    end if;
end loop;
end process;
end behave;
```

Effect of Using syn_global_buffers

Before applying attribute:

Verilog	Not applied
VHDL	Not applied

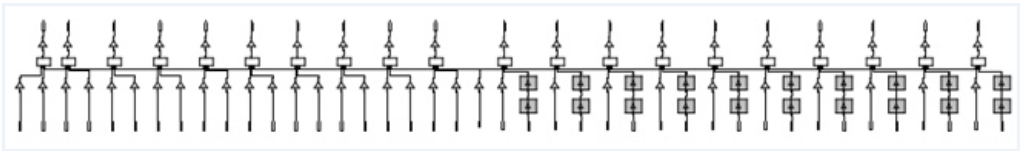


A message like the one below is generated:

```
@W:FX726: | Ignoring out-of-range global buffer count of 33 for
chip view:work.top(behave)
```

After applying attribute:

Verilog	<pre>module top (clk1, clk2, clk3, clk4, clk5, clk6, clk7, clk8, clk9, clk10, clk11, clk12, clk13, clk14, clk15, clk16, clk17, clk18, clk19, clk20, d1, d2, d3, d4, d5, d6, d7, d8, d9, d10, d11, d12, d13, d14, d15, d16, d17, d18, d19, d20, q1, q2, q3, q4, q5, q6, q7, q8, q9, q10, q11, q12, q13, q14, q15, q16, q17, q18, q19, q20, reset) /* synthesis syn_global_buffers = 10 */;</pre>
VHDL	<pre>attribute syn_global_buffers : integer; attribute syn_global_buffers of behave : architecture is 10;</pre>



Verify results in the log file.

```
@N:FX112 : | Setting available global buffers in chip view:work.top(behav) to 10
Clock Buffers:
Inserting Clock buffer for port clk[0],
Inserting Clock buffer for port clk[1],
Inserting Clock buffer for port clk[2],
Inserting Clock buffer for port clk[3],
Inserting Clock buffer for port clk[4],
Inserting Clock buffer for port clk[5],
Inserting Clock buffer for port clk[6],
Inserting Clock buffer for port clk[7],
Inserting Clock buffer for port clk[8],
Inserting Clock buffer for port clk[9],
@W:FX434 : global.vhd(4) | Because of resource limitations, clock buffer insertion could not be done on n
et clk_c[10] in view view:work.top(behav) (fanout 1)
@W:FX434 : global.vhd(4) | Because of resource limitations, clock buffer insertion could not be done on n
et clk_c[11] in view view:work.top(behav) (fanout 1)
@W:FX434 : global.vhd(4) | Because of resource limitations, clock buffer insertion could not be done on n
et clk_c[12] in view view:work.top(behav) (fanout 1)
@W:FX434 : global.vhd(4) | Because of resource limitations, clock buffer insertion could not be done on n
et clk_c[13] in view view:work.top(behav) (fanout 1)
@W:FX434 : global.vhd(4) | Because of resource limitations, clock buffer insertion could not be done on n
et clk_c[14] in view view:work.top(behav) (fanout 1)
@W:FX434 : global.vhd(4) | Because of resource limitations, clock buffer insertion could not be done on n
et clk_c[15] in view view:work.top(behav) (fanout 1)
@W:FX434 : global.vhd(4) | Because of resource limitations, clock buffer insertion could not be done on n
et clk_c[16] in view view:work.top(behav) (fanout 1)
@W:FX434 : global.vhd(4) | Because of resource limitations, clock buffer insertion could not be done on n
et clk_c[17] in view view:work.top(behav) (fanout 1)
@W:FX434 : global.vhd(4) | Because of resource limitations, clock buffer insertion could not be done on n
et clk_c[18] in view view:work.top(behav) (fanout 1)
@W:FX434 : global.vhd(4) | Because of resource limitations, clock buffer insertion could not be done on n
et clk_c[19] in view view:work.top(behav) (fanout 1)
@N:FX112 : | Setting available global buffers in chip view:work.top(behav) to 10
```

syn_hier

Attribute/Directive

Controls the amount of hierarchical transformation across boundaries on module or component instances during optimization.

Vendor	Devices
Microsemi	SmartFusion, ProASIC3

syn_hier Values

Default	Global	Object
Soft	No	View

Value	Description
soft (default)	The synthesis tool determines the best optimization across hierarchical boundaries. This attribute affects only the design unit in which it is specified.
firm	Preserves the interface of the design unit. However, when there is cell packing across the boundary, it changes the interface and does not guarantee the exact RTL interface. This attribute affects only the design unit in which it is specified.
hard	Preserves the interface of the design unit and prevents most optimizations across the hierarchy. However, the boundary optimization for constant propagation is performed.
fixed	Preserves the interface of the design unit with no exceptions. Fixed prevents all optimizations performed across hierarchical boundaries and retains the port interfaces as well. For more information, see Using syn_hier fixed, on page 82 .

remove	Removes the level of hierarchy for the design unit in which it is specified. The hierarchy at lower levels is unaffected. This only affects synthesis optimization. The hierarchy is reconstructed in the netlist and Technology view schematics.
macro	Preserves the interface and contents of the design with no exceptions. This value can only be set on structural netlists. (In the constraint file, or using the SCOPE editor, set <code>syn_hier</code> to <code>macro</code> on the view (the V: object type).
flatten	Flattens the hierarchy of all levels below, but not the one where it is specified. This only affects synthesis optimization. The hierarchy is reconstructed in the netlist and Technology view schematics. To create a completely flattened netlist, use the <code>syn_netlist_hierarchy</code> attribute (syn_netlist_hierarchy, on page 126), set to <code>false</code>. You can use <code>flatten</code> in combination with other <code>syn_hier</code> values; the effects are described in Using syn_hier flatten with Other Values, on page 89. If you apply <code>syn_hier</code> to a compile point, <code>flatten</code> is the only valid attribute value. All other values only apply to the current level of hierarchy. The compile point hierarchy is determined by the type of compile point specified, so a <code>syn_hier</code> value other than <code>flatten</code> is redundant and is ignored.

Description

During synthesis, the tool dissolves as much hierarchy as possible to allow efficient logic optimization across hierarchical boundaries while maintaining optimal run times. The tool then rebuilds the hierarchy as close as possible to the original source to preserve the topology of the design.

Use the `syn_hier` attribute to address specific needs to maintain the original design hierarchy during optimization. This attribute gives you manual control over flattening/preserving instances, modules, or architectures in the design.

It is advised that you avoid using `syn_hier="fixed"` with tri-states.

Syntax Specification

FDC file	<code>define_attribute {object} syn_hier {value}</code>
Verilog	<code>object /* synthesis syn_hier = "value" */;</code>
VHDL	<code>attribute syn_hier of object : architecture is "value";</code>

SCOPE Example

	Enable	Object Type	Object	Attribute	Value	Value Type	Description	Comment
1	☒	view	v:work.alu	syn_hier	hard	string	Control hierarchy flattening	

```
define_attribute {v:work.alu} {syn_hier} {hard}
```

Example of Applying syn_hier Attribute Globally

The `syn_hier` attribute is not supported globally. However, you can apply this attribute globally on design hierarchies using Tcl collection commands.

To do this, create a global collection of the design views in the FDC constraint file. Then, apply the attribute to the collection as shown below:

```
define_scope_collection all_views {find {v:*}}
define_attribute {$all_views} {syn_hier} {hard}
```

syn_hier in the SCOPE Window

If you use the SCOPE window to specify the `syn_hier` attribute, do not drag and drop the object into the SCOPE spreadsheet. Instead, first select `syn_hier` in the Attribute column, and then use the pull-down menu in the Object column to select the object. This is because you must set the attribute on a view (v:). If you drag and drop an object, you might not get a view object. Selecting the attribute first ensures that only the appropriate objects are listed in the Object column.

Using syn_hier fixed

When you use the fixed value with `syn_hier`, hierarchical boundaries are preserved with no exceptions. For example, optimizations such as constant propagation and generated clock conversions are not performed across these boundaries.

Note: It is recommended that you do not use `syn_hier` with the fixed value on modules that have ports driven by tri-state gates. For details, see [When Using Tri-states, on page 83](#).

When Using Tri-states

It is advised that you avoid using `syn_hier="fixed"` with tri-states. However, if you do, here is how the software handles the following conditions:

- Tri-states driving output ports

If a module with `syn_hier="fixed"` includes tri-state gates that drive a primary output port, then the synthesis software retains a tri-state buffer so that the P&R tool can pack the tri-state into an output port.

- Tri-states driving internal logic

If a module with `syn_hier="fixed"` includes tri-state gates that drive internal logic, then the synthesis software converts the tri-state gate to a MUX and optimizes within the module accordingly.

In the following code example, `myreg` has `syn_hier` set to `fixed`.

```
module top(
    clk1,en1, data1,
    q1, q2
);
input clk1, en1;
input data1;
output q1, q2;
wire cwire, rwire;
wire clk_gt;
assign clk_gt = en1 & clk1;

// Register module
myreg U_reg (
    .datain(data1),
    .rst(1'b1),
    .clk(clk_gt),
    .en(1'b0),
    .dout(rwire),
    .cout(cwire)
);
assign q1 = rwire;
assign q2 = cwire;
endmodule

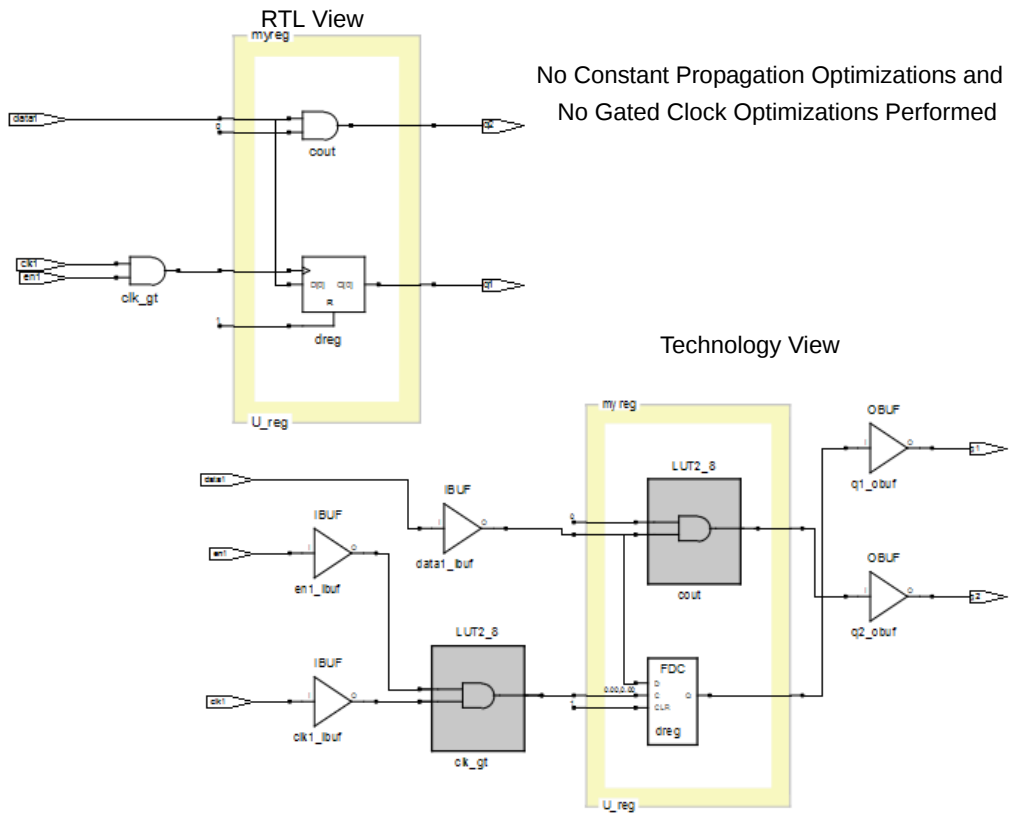
module myreg (
    datain,
    rst,
    clk,
    en,
```

:

```
    dout,
    cout
  ) /* synthesis syn_hier = "fixed" */;
input clk, rst, datain, en;
output dout;
output cout;
reg dreg;
assign cout = en & datain;

always @(posedge clk or posedge rst)
  begin
    if (rst)
      dreg <= 'b0;
    else
      dreg <= datain;
    end
  assign dout = dreg;
endmodule
```

The HDL Analyst views show that myreg preserves its hierarchical boundaries without exceptions and prevents constant propagation optimizations.



Effect of Using syn_hier

The following VHDL and Verilog examples show the effects of using the fixed and macro values with the syn_hier attribute.

VHDL Example 1

```
library ieee;
use ieee.std_logic_1164.all;
entity top is
port (data1: in std_logic;
      clk1: in std_logic;
      en1: in std_logic;
      q1: out std_logic;
      q2: out std_logic);
end;

architecture rtl of top is
signal cwire, rwire: std_logic;
signal clk_gt: std_logic;
component dff is
  port (datain: in std_logic;
        rst: in std_logic;
        clk: in std_logic;
        en: in std_logic;
        dout: out std_logic;
        cout: out std_logic);
end component;
begin
U1 : dff port map(datain => data1, rst => '1', clk =>
  clk_gt, en => '0', dout => rwire, cout => cwire);
q1 <= rwire;
q2 <= cwire;
clk_gt <= en1 and clk1;
end;

library ieee;
use ieee.std_logic_1164.all;
entity dff is
  port (datain: in std_logic;
        rst: in std_logic;
        clk: in std_logic;
        en: in std_logic;
        dout: out std_logic;
        cout: out std_logic);
end;

architecture rtl of dff is
signal dreg: std_logic;
attribute syn_hier : string;
attribute syn_hier of rtl: architecture is "fixed";
begin
```

```

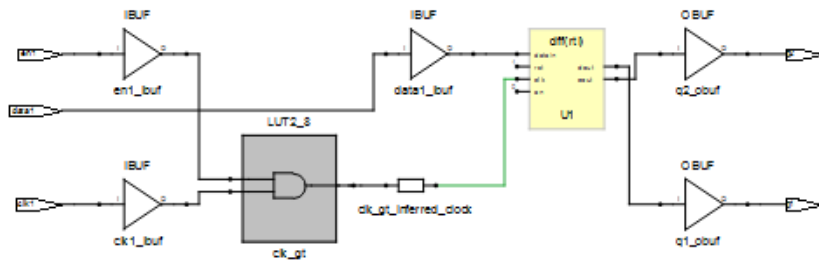
        process (clk, rst)
        begin
            if (rst = '1') then
                dreg<= '0';
            elsif (clk'event and clk ='1') then
                dreg<= datain;
            end if;
            dout <= dreg;
        end process;
    end;

```

After applying attribute with the value *fixed*:

Verilog Module myreg(datain,rst,clk,en,dout,cout)/**synthesis syn_hier="fixed"*/*;

VHDL attribute syn_hier : string;
 attribute syn_hier of rtl: architecture is "fixed";



Verilog Example 2

```

module inc(a_in, a_out) /* synthesis syn_hier = "macro" */;
input [3:0] a_in;
output [3:0] a_out;
endmodule

module reg4(clk, rst, d, q);
input [3:0] d;
input clk, rst;
output [3:0] q;
reg [3:0] q;
always @(posedge clk or posedge rst)

```

:

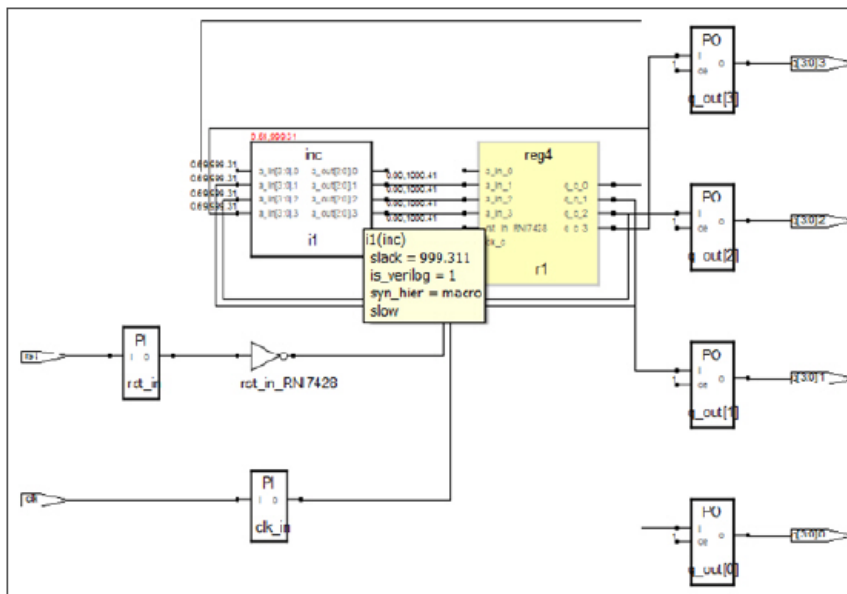
```
if(rst)
q <= 0;
else
q <= d;
endmodule

module top(clk, rst, q);
input clk, rst;
output [3:0] q;
wire [3:0] a_in;
inc il(q, a_in);
reg4 r1(clk, rst, a_in, q);
endmodule
```

After applying attribute with value *macro*:

Verilog module inc(a_in, a_out) /* synthesis syn_hier = "macro" */;

VHDL attribute syn_hier : string;
 attribute syn_hier of rtl: architecture is "macro";



Using syn_hier flatten with Other Values

You can combine flatten with other syn_hier values as shown below:

flatten,soft	Same as flatten.
flatten,firm	Flattens all lower levels of the design but preserves the interface of the design unit in which it is specified. This option also allows optimization of cell packing across the boundary.
flatten,remove	Flattens all lower levels of the design, including the one on which it is specified.

If you use flatten in combination with another option, the tool flattens as directed until encountering another syn_hier attribute at a lower level. The lower level syn_hier attribute then takes precedence over the higher level one.

These example demonstrate the use of the flatten and remove values to flatten the current level of the hierarchy and all levels below it (unless you have defined another syn_hier attribute at a lower level).

```
Verilog module top1 (Q, CLK, RST, LD, CE, D)
  /* synthesis syn_hier = "flatten,remove" */;

  // Other code
```

```
VHDL architecture struct of cpu is

  attribute syn_hier : string;
  attribute syn_hier of struct: architecture is "flatten,remove";

  -- Other code
```

syn_insert_buffer

Attribute

Inserts a technology-specific clock buffer.

Vendor	Technologies
Microsemi	IGLOO/IGLOOe/IGLOO+/IGLOO2 ProASIC3/3E/3L SmartFusion2

syn_insert_buffer Values

Vendor	Value	Description	Technology
Microsemi	CLKBUF	Pads: CLKBUF	SmartFusion2, IGLOO2, IGLOO+, IGLOOe, IGLOO
	HCLKBUF	Pads: HCLKBUF (for nets that drive the clock pins of sequential primitives)	IGLOO+, IGLOOe, IGLOO
	CLKBIBUF	Pads: CLKBIBUF	SmartFusion2, IGLOO2 only
	CLKINT	Nets: CLKINT	SmartFusion2, IGLOO2 only
	GCLKINT	Nets: HCLKINT (for nets that drive the clock pins of sequential primitives)	IGLOO+, IGLOOe, IGLOO
	RCLKINT	Nets: RCLKINT	SmartFusion2, IGLOO2 only

Description

Use this attribute to insert a clock buffer. You can also use it on a non-clock high fanout net, such as reset or common enable that needs global routing, to insert a global buffer for that port. The synthesis tool inserts a technology-specific clock buffer. The object you attach the attribute to also varies with the vendor.

Vendor	Object	Description
Microsemi	Instance	Inserts the specified clock buffer.

syn_insert_buffer Syntax Specification

You cannot specify this attribute as a global value.

FDC	define_attribute object syn_insert_buffer <i>value</i>	FDC Example
Verilog	<i>object</i> /* synthesis syn_insert_buffer = " <i>value</i> " */;	Verilog Examples
VHDL	attribute syn_insert_buffer of <i>object</i> : <i>objectType</i> is " <i>value</i> ";	VHDL Examples

FDC Example

	Enabled	Object Type	Object	Attribute	Value	Val Type	Description
1	☒		clk_mux	syn_insert_buffer	BUFGMUX		

Verilog Examples

In the following example, the attribute is attached to LDPRE, SEL, RST, LDCOMP, and CLK.

```

module prep2_2 (DATA0, DATA1, DATA2, LDPRE, SEL, RST, CLK, LDCOMP);
output [7:0] DATA0;
input [7:0] DATA1, DATA2;
input LDPRE, SEL, RST, CLK
    /* synthesis syn_insert_buffer = "GL25" */ , LDCOMP;
wire [7:0] DATA0_internal;
prep2_1 inst1 (CLK, RST, SEL, LDCOMP, LDPRE, DATA1, DATA2,
    DATA0_internal);
prep2_1 inst2 (CLK, RST, SEL, LDCOMP, LDPRE, DATA0_internal,
    DATA2, DATA0);
endmodule

```

:

```
module prep2_1 (CLK, RST, SEL, LDCOMP, LDPRE, DATA1, DATA2, DATA0);
input CLK, RST, SEL, LDCOMP, LDPRE;
input [7:0] DATA1, DATA2;
output [7:0] DATA0;
reg [7:0] DATA0;
reg [7:0] highreg_output, lowreg_output; // internal registers
wire compare_output = (DATA0 == lowreg_output); // comparator
wire [7:0] mux_output = SEL ? DATA1 : highreg_output;

// mux registers
always @ (posedge CLK or posedge RST)
begin
    if (RST) begin
        highreg_output = 0;
        lowreg_output = 0;
    end else begin
        if (LDPRE)
            highreg_output = DATA2;
        if (LDCOMP)
            lowreg_output = DATA2;
    end
end

// counter
always @(posedge CLK or posedge RST)
begin
    if (RST)
        DATA0 = 0;
    else if (compare_output) // load
        DATA0 = mux_output;
    else
        DATA0 = DATA0 + 1;
end

endmodule
```

VHDL Examples

This section provides technology-specific examples.

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

```

entity prep2_1 is
  port (clk : in bit;
        rst : in bit;
        sel : in bit;
        ldcomp : in bit;
        ldpre : in bit;
        data1,data2 : in std_logic_vector(7 downto 0);
        data0 : out std_logic_vector(7 downto 0));
end prep2_1;

architecture behave of prep2_1 is
  signal equal: bit;
  signal mux_output: std_logic_vector(7 downto 0);
  signal lowreg_output: std_logic_vector(7 downto 0);
  signal highreg_output: std_logic_vector(7 downto 0);
  signal data0_i: std_logic_vector(7 downto 0);
begin
  compare: process(data0_i, lowreg_output)
  begin
    if data0_i = lowreg_output then
      equal <= '1';
    else
      equal <= '0';
    end if;
  end process compare;

  mux: process(sel, data1, highreg_output)
  begin
    case sel is
      when '0' =>
        mux_output <= highreg_output;
      when '1' =>
        mux_output <= data1;
    end case;
  end process mux;

  registers: process (rst,clk)
  begin
    if (rst = '1') then
      highreg_output <= "00000000";
      lowreg_output <= "00000000";
    elsif clk = '1' and clk'event then
      if ldpre = '1' then
        highreg_output <= data2;
      end if;
    end if;
  end process registers;
end architecture behave of prep2_1;

```

:

```
        if ldcomp = '1' then
            lowreg_output <= data2;
        end if;
    end if;
end process registers;

counter: process (rst,clk)
begin
    if rst = '1' then
        data0_i <= "00000000";
    elsif clk = '1' and clk'event then
        if equal = '1' then
            data0_i <= mux_output;
        elsif equal = '0' then
            data0_i <= data0_i + "00000001";
        end if;
    end if;
end process counter;
data0 <= data0_i;
end behave;

library ieee;
use ieee.std_logic_1164.all;

entity prep2_2 is
    port (CLK : in bit;
          RST : in bit;
          SEL : in bit;
          LDCOMP : in bit;
          LDPRE : in bit;
          DATA1,DATA2 : in std_logic_vector(7 downto 0);
          DATA0 : out std_logic_vector(7 downto 0));
    attribute syn_insert_buffer : string;
    attribute syn_insert_buffer of clk : signal is "GL25";
end prep2_2;

architecture behave of prep2_2 is
    component prep2_1
        port (clk : in bit;
              rst : in bit;
              sel : in bit;
              ldcomp : in bit;
              ldpre : in bit;
              data1,data2 : in std_logic_vector(7 downto 0);
              data0 : out std_logic_vector(7 downto 0));
    end component;

    signal data0_internal : std_logic_vector (7 downto 0);
```

```
begin
inst1: prep2_1 port map(clk => CLK, rst => RST, sel => SEL,
    ldcomp => LDCOMP, ldpre => LDPRE, data1 => DATA1,
    data2 => DATA2, data0 => data0_internal);
inst2: prep2_1 port map(clk => CLK, rst => RST, sel => SEL,
    ldcomp => LDCOMP, ldpre => LDPRE, data1 => data0_internal,
    data2 => DATA2, data0 => DATA0);
end behave;
```

syn_insert_pad

Attribute

Removes an existing I/O buffer from a port or net when I/O buffer insertion is enabled.

Vendor	Technology
--------	------------

Microsemi	SmartFusion2 and IGLOO2
-----------	-------------------------

syn_insert_pad Values

Value	Description	Default	Global	Object
0	Removes an IBUF/OBUF from a port or net	None	No	Port, net
1	Replaces a previously removed IBUF/OBUF on a port or net.	None	No	Port, net

Description

The syn_insert_pad attribute is used when the Disable I/O Insertion option is not enabled (when buffers are automatically inserted) to allow users to selectively remove an individual buffer from a port or net or to replace a previously removed buffer.

- Setting the attribute to 0 on a port or net removes the I/O buffer (or prevents an I/O buffer from being automatically inserted).
- Setting the attribute to 1 on a port or net replaces a previously removed I/O buffer.

The syn_insert_pad attribute can only be applied through a constraint file.

syn_insert_pad Syntax

FDC **define_attribute** {*object*} **syn_insert_pad** {1|0}

[SCOPE](#)
[Example](#)

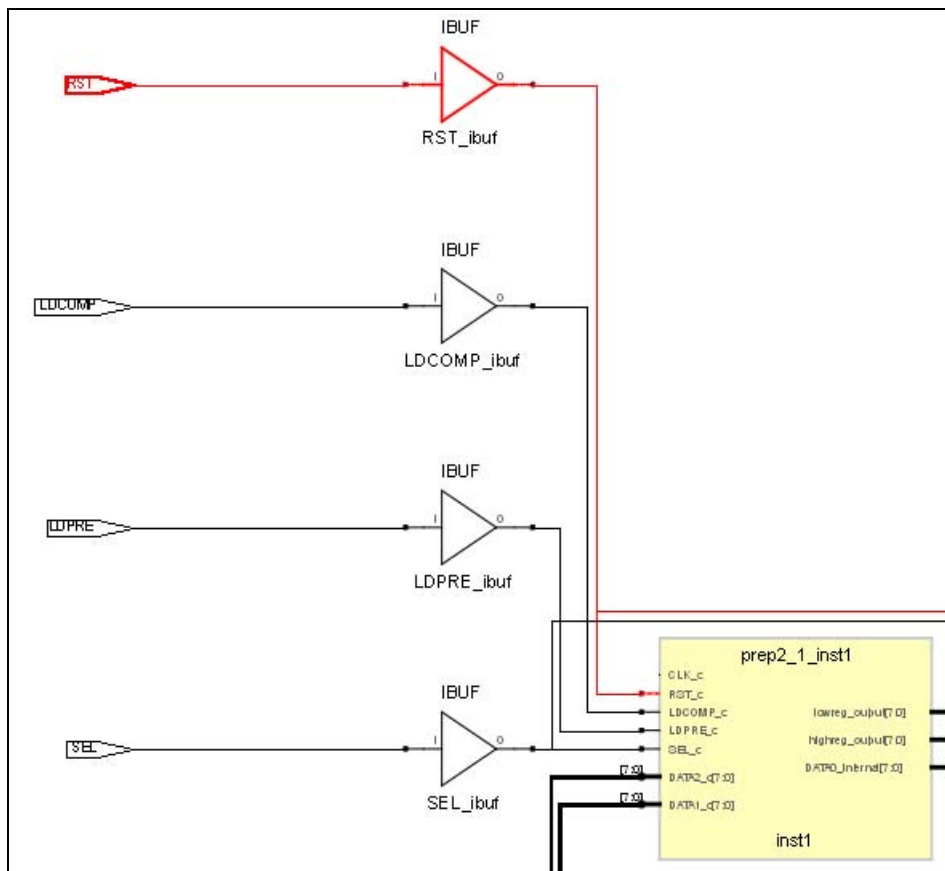
SCOPE Example

The following figure shows the attribute applied to the RST port using the SCOPE window:

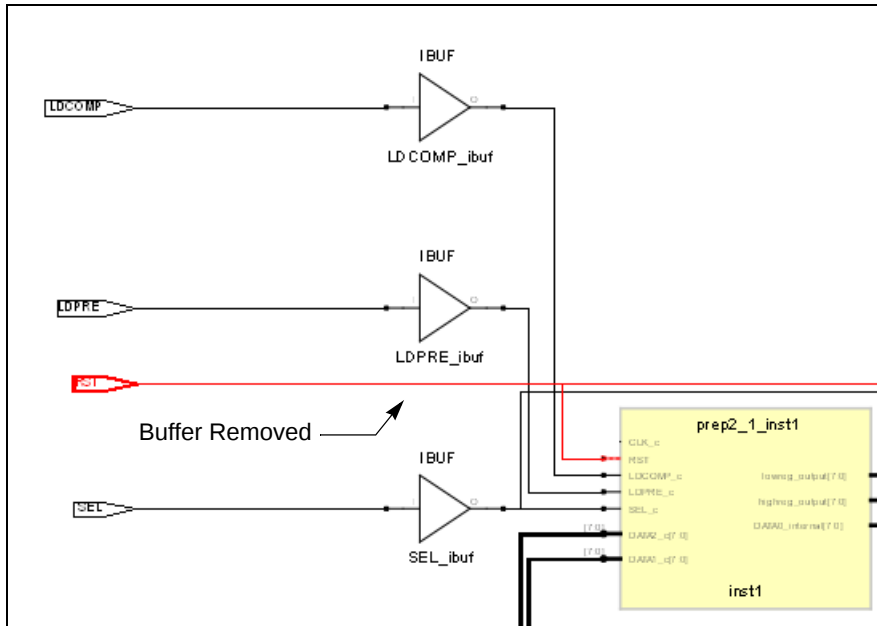
Enable	Object Type	Object	Attribute	Value	Value Type
☒	<any>	p:RST	syn_insert_pad	0	

Effect of Using syn_insert_pad

Original design before applying syn_insert_pad (or after applying syn_insert_pad with a value of 1 to replace a previously removed buffer).



Technology view after applying `syn_insert_pad` with a value of 0 to remove the original buffer from the RST input.



syn_isclock

Directive

Specifies an input port on a black box as a clock.

syn_isclock Values

Value	Description	Object
1 true	Specifies input port is a clock.	Input port on a black box
0 false	Specifies input port is not a clock.	Input port on a black box

Description

Used with the `syn_black_box` directive and specifies an input port on a black box as a clock. Use the `syn_isclock` directive to specify that an input port on a black box is a clock, even though its name does not correspond to one of the recognized names. Using this directive connects it to a clock buffer if appropriate. The data type is Boolean.

The `syn_isclock` directive is one of several directives that you can use with the `syn_black_box` directive to define timing for a black box. See [syn_black_box, on page 50](#) for a list of the associated directives.

syn_isclock Values Syntax

Verilog	<code>object /* synthesis syn_isclock = 1 */;</code>
VHDL	<code>attribute syn_isclock of object: objectType is true;</code>

Verilog Example

```
module test (myclk, a, b, tout,) /* synthesis syn_black_box */;
input myclk /* synthesis syn_isclock = 1 */;
input a, b;
output tout;
endmodule

//Top Level
module top (input clk, input a, b, output fout);
test U1 (clk, a, b, fout);
endmodule
```

VHDL Example

See [VHDL Attribute and Directive Syntax, on page 302](#) for different ways to specify VHDL attributes and directives.

```

library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;
entity test is
generic (size: integer := 8);
port (tout : out std_logic_vector (size- 1 downto 0);
      a : in std_logic_vector (size- 1 downto 0);
      b : in std_logic_vector (size- 1 downto 0);
      myclk : in std_logic);
attribute syn_isclock : boolean;
attribute syn_isclock of myclk: signal is true;
end;

architecture rtl of test is
attribute syn_black_box : boolean;
attribute syn_black_box of rtl: architecture is true;
begin
end;

-- TOP Level--
library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;
entity top is
generic (size: integer := 8);
port (fout : out std_logic_vector (size- 1 downto 0);
      a : in std_logic_vector (size- 1 downto 0);
      b : in std_logic_vector (size- 1 downto 0);
      clk : in std_logic
      );
end;

architecture rtl of top is
component test
generic (size: integer := 8);
port (tout : out std_logic_vector (size- 1 downto 0);
      a : in std_logic_vector (size- 1 downto 0);
      b : in std_logic_vector (size- 1 downto 0);
      myclk : in std_logic
      );

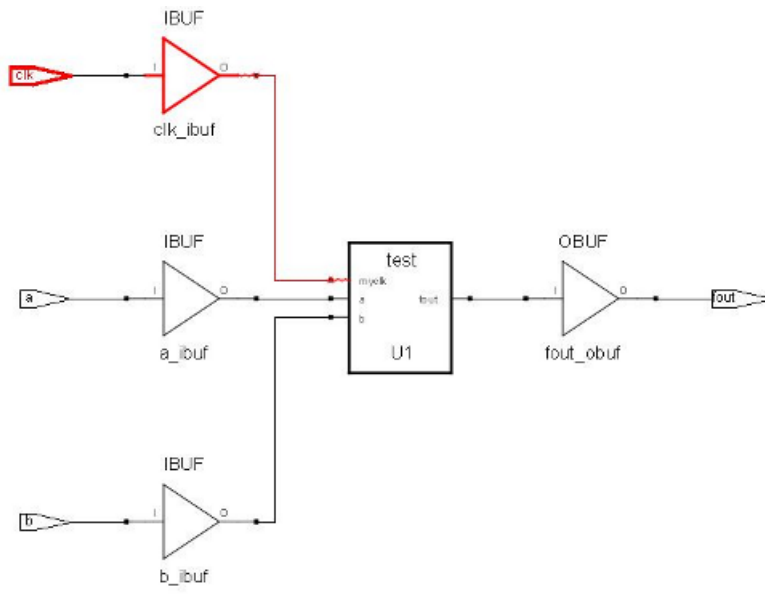
```

:

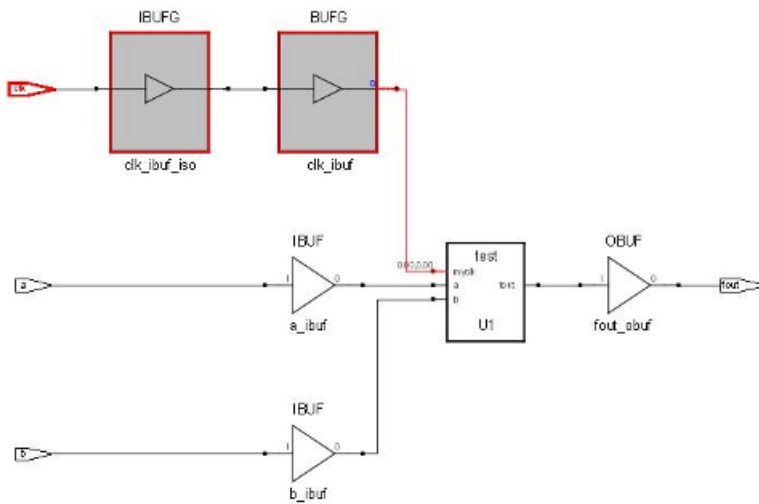
```
end component;  
  
begin  
  U1 : test port map (fout, a, b, clk);  
end;
```

Effect of Using syn_isclock

This figure shows the HDL Analyst Technology view before using syn_isclock:



This figure shows the HDL Analyst Technology view after using `syn_isclock`:



syn_keep

Directive

Preserves the specified net and keeps it intact during optimization and synthesis.

Vendor	Technology	Global	Object
--------	------------	--------	--------

All	All	No	Net
-----	-----	----	-----

syn_keep Values

Value	Description
-------	-------------

0 false (Default)	Allows nets to be optimized away.
------------------------	-----------------------------------

1 true	Preserves the specified net and keeps it intact during optimization and synthesis.
----------	--

Description

With this directive, the tool preserves the net without optimizing it away by placing a temporary keep buffer primitive on the net as a placeholder. You can view this buffer in the schematic views (see [Effect of Using syn_keep, on page 108](#) for an example). The buffer is not part of the final netlist, so no extra logic is generated. There are various situations where this directive is useful:

- To preserve a net that would otherwise be removed as a result of optimization. You might want to preserve the net for simulation results or to obtain a different synthesis implementation.
- To prevent duplicate cells from being merged during optimization. You apply the directive to the nets connected to the input of the cells you want to preserve.
- As a placeholder to apply the -through option of the set_multicycle_path or set_false_path timing constraint. This allows you to specify a unique path as a multiple-cycle or false path. Apply the constraint to the keep buffer.

- To prevent the absorption of a register into a macro. If you apply `syn_keep` to a reg or signal that will become a sequential object, the tool keeps the register and does not absorb it into a macro.

syn_keep with Multiple Nets in Verilog

In the following statement, `syn_keep` only applies to the last variable in the wire declaration, which is net `c`:

```
wire a,b,c /* synthesis syn_keep=1 */;
```

To apply `syn_keep` to all the nets, use one of the following methods:

- Declare each individual net separately as shown below.

```
wire a /* synthesis syn_keep=1 */;  
wire b /* synthesis syn_keep=1 */;  
wire c /* synthesis syn_keep=1 */;
```

- Use Verilog 2001 parenthetical comments, to declare the `syn_keep` directive as a single line statement.

```
(* syn_keep=1 *) wire a,b,c;
```

For more information, see [Attribute Examples Using Verilog 2001 Parenthetical Comments](#), on page 101.

syn_keep and SystemVerilog Data Types

The SystemVerilog data types behave like logic or reg, and SystemVerilog allows them to be assigned either inside or outside an always block. If you want to use `syn_keep` to preserve a net with a SystemVerilog data type, like bit, byte, longint or shortint for example, you must make sure that continuous assigns are made inside an always block, not outside.

The following table shows examples of SystemVerilog data type assignments:

Assignment in always block,
syn_keep works

```
assign keep1_wireand_out;
assign keep2_wireand_out;
always @(*) begin
    keep1_bitand_out;
    keep2_bitand_out;
    keep1_byteand_out;
    keep2_byteand_out;
    keep1_longintand_out;
    keep2_longintand_out;
    keep1_shortintand_out;
    keep2_shortintand_out;
```

Assignment outside always block,
syn_keep does not work

```
assign keep1_wireand_out;
assign keep2_wireand_out;
assign keep1_bitand_out;
assign keep2_bitand_out;
assign keep1_byteand_out;
assign keep2_byteand_out;
assign keep1_longintand_out;
assign keep2_longintand_out;
assign keep1_shortintand_out;
assign keep2_shortintand_out;
```

For information about supported SystemVerilog data types, see [Data Types](#), on page 110.

Comparison of syn_keep, syn_preserve, and syn_noprune

Although these directives all work to preserve logic from optimization, syn_keep, syn_preserve, and syn_noprune work on different objects:

syn_keep	Only works on nets and combinational logic. It ensures that the wire is kept during synthesis, and that no optimizations cross the wire. This directive is usually used to prevent unwanted optimizations and to ensure that manually created replications are preserved. When applied to a register, the register is preserved and not absorbed into a macro.
syn_preserve	Ensures that registers are not optimized away.
syn_noprune	Ensures that a black box is not optimized away when its outputs are unused (i.e., when its outputs do not drive any logic).

See [Preserving Objects from Being Optimized Away](#), on page 393 in the *User Guide* for more information.

syn_keep Syntax

Verilog	<code>object /* synthesis syn_keep = 1 */;</code>	Verilog Example
VHDL	<code>attribute syn_keep : boolean attribute syn_keep of object : objectType is true;</code>	VHDL Example

Verilog Example

`object /* synthesis syn_keep = 1 */;`

object is a wire or reg declaration. Make sure that there is a space between the object name and the beginning of the comment slash (/).

Here is the source code used to produce the results shown in [Effect of Using syn_keep](#), on page 108.

```
module example2(out1, out2, clk, in1, in2);
  output out1, out2;
  input clk;
  input in1, in2;
  wire and_out;
  wire keep1 /* synthesis syn_keep=1 */;
  wire keep2 /* synthesis syn_keep=1 */;
  reg out1, out2;
  assign and_out=in1&in2;
  assign keep1=and_out;
  assign keep2=and_out;

  always @(posedge clk)begin;
    out1<=keep1;
    out2<=keep2;
  end
endmodule
```

VHDL Example

`attribute syn_keep of object : objectType is true;`

object is a single or multiple-bit signal.

Here is the source code used to produce the schematics shown in [Effect of Using syn_keep, on page 108](#).

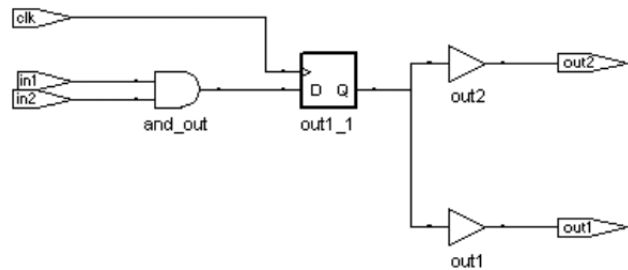
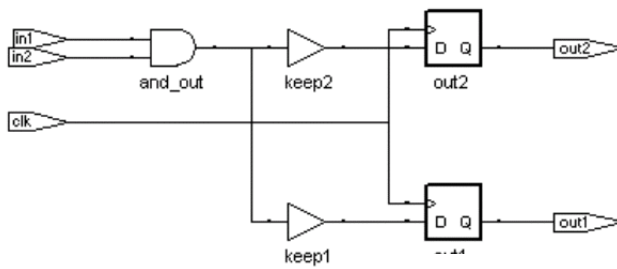
```
entity example2 is
    port (in1, in2 : in bit;
          clk : in bit;
          out1, out2 : out bit);
end example2;

architecture rtl of example2 is
    attribute syn_keep : boolean;
    signal and_out, keep1, keep2: bit;
    attribute syn_keep of keep1, keep2 : signal is true;
begin
    and_out <= in1 and in2;
    keep1 <= and_out;
    keep2 <= and_out;
    process(clk)
    begin
        if (clk'event and clk = '1') then
            out1 <= keep1;
            out2 <= keep2;
        end if;
    end process;
end rtl;
```

Effect of Using syn_keep

When you use `syn_keep` on duplicate logic, the tool retains it instead of optimizing it away. The following figure shows the Technology view for two versions of a design.

In the first, `syn_keep` is set on the nets connected to the inputs of the registers `out1` and `out2`, to prevent sharing. The second figure shows the same design without `syn_keep`. Setting `syn_keep` on the input wires for the registers ensures that the design has duplicate registered outputs for `out1` and `out2`. If you do not apply `syn_keep` to `keep1` and `keep2`, the software optimizes `out1` and `out2`, and only has one register.



syn_loc

Attribute

The `syn_loc` attribute specifies the location (placement) of ports.

Vendor	Technology
Microsemi	SmartFusion

syn_loc Values

Value	Description
Pin numbers	Assigns pin numbers to ports.

Description

Specifies pin locations for I/O pins and cores, and forward-annotates this information to the place-and-route tool. This attribute can only be specified in a top-level source file or a constraint file.

syn_loc Syntax

Default	Global Attribute	Object
Not Applicable	No	Port

pinNumbers is a comma-separated list of pin or placement numbers. Refer to the vendor data book for valid values.

FDC	define_attribute <i>portDesignName</i> { syn_loc } { <i>pinNumbers</i> }	FDC Example
Verilog	<i>object</i> !* synthesis syn_loc = " <i>pinNumbers</i> " *!	Verilog Example
VHDL	attribute syn_loc of <i>object</i> : <i>objectType</i> is " <i>pinNumbers</i> ";	VHDL Example

FDC Example

	Enable	Object Type	Object	Attribute	Value	Value Type	Description
1	☒	port	n:CR_DIN[3:0]	syn_loc	M7,Y6,B6,D10	string	Assign the object location
2							

The following are examples of using this attribute:

```
Microsemi    define_attribute {CR_DIN[3:0]} syn_loc
              {M7, Y6, B6, D10}
```

You can also specify locations for individual bus bits with this attribute:

Microsemi

define_attribute {CR_DIN[3]} syn_loc {M7}	Specify the b: prefix and the bit slice:
define_attribute {CR_DIN[2]} syn_loc {Y6}	define_attribute {b:CR_DIN[0]} syn_loc {D10}
define_attribute {CR_DIN[1]} syn_loc {B6}	define_attribute {b:CR_DIN[1]} syn_loc {B6}
define_attribute {CR_DIN[0]} syn_loc {D10}	define_attribute {b:CR_DIN[2]} syn_loc {Y6}
	define_attribute {b:CR_DIN[3]} syn_loc {M7}

Verilog Example

```
Microsemi    input [3:0] CR_DIN /* synthesis syn_loc = "M7,Y6, B6, D10"
```

```

module test(a, b, clk, out1);
    input clk;
    input [2:0]a;
    input [2:0]b;
    output reg [2:0] out1/* synthesis syn_loc = "D10,B6,Y6,M7*/;

    always@(posedge clk)
    begin
        out1 <= a + b;
    end
endmodule
```

VHDL Example

```
Microsemi attribute syn_loc : string;  
attribute syn_loc of CR_DIN : signal is "M7, Y6, B6, D10";
```

```
library ieee;  
use ieee.std_logic_1164.all;  
  
entity test is  
    generic (s : integer := 2);  
  
    port (  
        clk: in std_logic;  
        in1: in std_logic_vector(s downto 0);  
        in2: in std_logic_vector(s downto 0);  
        d_out: out std_logic_vector(5 downto 0));  
        attribute syn_loc : string;  
        attribute syn_loc of d_out:signal is "M7,Y6,B6,D10";  
    end test;  
  
    architecture beh of test is  
    begin  
        process (clk)  
        begin  
            if rising_edge(clk) then  
                d_out <= in1 & in2;  
            end if;  
        end process;  
    end beh;
```

syn_looplimit

Directive

VHDL

Specifies a loop iteration limit for while loops in the design.

Description

VHDL only. For Verilog applications use the loop_limit directive (see [loop_limit](#), on page 37).

The syn_looplimit directive specifies a loop iteration limit for a while loop on a per-loop basis, when the loop index is a variable, not a constant. If your design requires a variable loop index, use the syn_looplimit directive to specify a limit for the compiler. If you do not, you can get a “while loop not terminating” compiler error.

The limit cannot be an expression.

Alternatively, you can use the set_option looplimit command (Loop Limit GUI option) to set a global loop limit that overrides the default of 2000 loops. To use the Loop Limit option on the VHDL tab of the Implementation Options panel, see [VHDL Panel](#), on page 228 in the *Command Reference*.

syn_looplimit Summary

Technology	Global	Object
All	Yes	Architecture

syn_looplimit Syntax

VHDL	attribute syn_looplimit : integer; attribute syn_looplimit of labelName : label is value;	VHDL Example
------	--	------------------------------

VHDL Example

```
library ieee;
use ieee.std_logic_1164.all;
use IEEE.numeric_std.all;
entity test is
```

:

```
port (  
    clk : in  std_logic;  
    d_in : in  std_logic_vector(2999 downto 0);  
    d_out: out std_logic_vector(2999 downto 0)  
);  
end test;  
  
architecture beh of test is  
  
    attribute syn_looplimit : integer;  
    attribute syn_looplimit of loopabc: label is 3000;  
  
begin  
    process (clk)  
        variable i, k: integer := 0;  
        begin  
            if (clk'event and clk = '1') then  
                k:=0;  
                loopabc: while (k<2999) loop  
                    k:= k+ 1;  
                    d_out(k) <= d_in(k);  
                end loop loopabc;  
                d_out(0) <= d_in(0);  
            end if;  
        end process;  
    end beh;
```

syn_maxfan

Attribute

Overrides the default (global) fanout guide for an individual input port, net, or register output.

Vendor	Technology	Default
Microsemi	All	None

syn_maxfan Value

<i>value</i>	Integer for the maximum fanout
--------------	--------------------------------

Description

syn_maxfan overrides the global fanout for an individual input port, net, or register output. You set the default Fanout Guide for a design through the Device panel on the Implementation Options dialog box or with the -fanout_limit command. Use the syn_maxfan attribute to specify a different (local) value for individual I/Os.

Generally, syn_maxfan and the default fanout guide are suggested guidelines only, but in certain cases they function as hard limits.

- When they are guidelines, the synthesis tool takes them into account, but does not always respect them absolutely. The synthesis tool does not respect the syn_maxfan limit if the limit imposes constraints that interfere with optimization.

You can apply the syn_maxfan attribute to the following objects:

- Registers or instances.
- Ports or nets. If you apply the attribute to a net, the synthesis tool creates a KEEPBUF component and attaches the attribute to it to prevent the net itself from being optimized away during synthesis.

The `syn_maxfan` attribute is often used along with the `syn_noclockbuf` attribute on an input port that you do not want buffered. There are a limited number of clock buffers in a design, so if you want to save these special clock buffer resources for other clock inputs, put the `syn_noclockbuf` attribute on the clock signal. If timing for that clock signal is not critical, you can turn off buffering completely to save area. To turn off buffering, set the maximum fanout to a very high number; for example, 1000.

Similarly, you use `syn_maxfan` with the `syn_replicate` attribute in certain technologies to control replication.

syn_maxfan Syntax

Global Object Type

No	Registers, instances, ports, nets	
FDC	define_attribute {object} syn_maxfan {integer}	FDC Example
Verilog	object /* synthesis syn_maxfan = "value" */;	Verilog Example
VHDL	attribute syn_maxfan of object : objectType is "value";	VHDL Example

FDC Example

```
define_attribute {object} syn_maxfan {integer}
```

Enable	Object Type	Object	Attribute	Value	Value Type	Description
☒	<any>	<Global>	syn_maxfan	1	integer	Overrides the default...

Verilog Example

```
object /* synthesis syn_maxfan = "value" */;
```

For example:

```
module syn_maxfan (clk,rst,a,b,c);
input clk,rst;
input [7:0] a,b;
output reg [7:0] c;
```

```

reg d/* synthesis syn_maxfan=3 */;

always @ (posedge clk)
begin
    if(rst)
        d <= 0;
    else
        d <= ~d;
    end

always @ (posedge d)
begin
    c <= a^b;
end

endmodule

```

VHDL Example

attribute syn_maxfan of object : objectType is "value";

See [VHDL Attribute and Directive Syntax, on page 302](#) for different ways to specify VHDL attributes and directives.

```

library ieee;
use ieee.std_logic_1164.all;
use ieee.numeric_std.all;
entity maxfan is
    port (a : in std_logic_vector(7 downto 0);
          b : in std_logic_vector(7 downto 0);
          rst : in std_logic;
          clk : in std_logic;
          c : out std_logic_vector(7 downto 0));
end maxfan;

architecture rtl of maxfan is
    signal d : std_logic;

    attribute syn_maxfan : integer;
    attribute syn_maxfan of d : signal is 3;

begin

    process (clk)
    begin
        if (clk'event and clk = '1') then
            if (rst = '1') then
                d <= '0';
            end if;
        end if;
    end process;
end rtl;

```

:

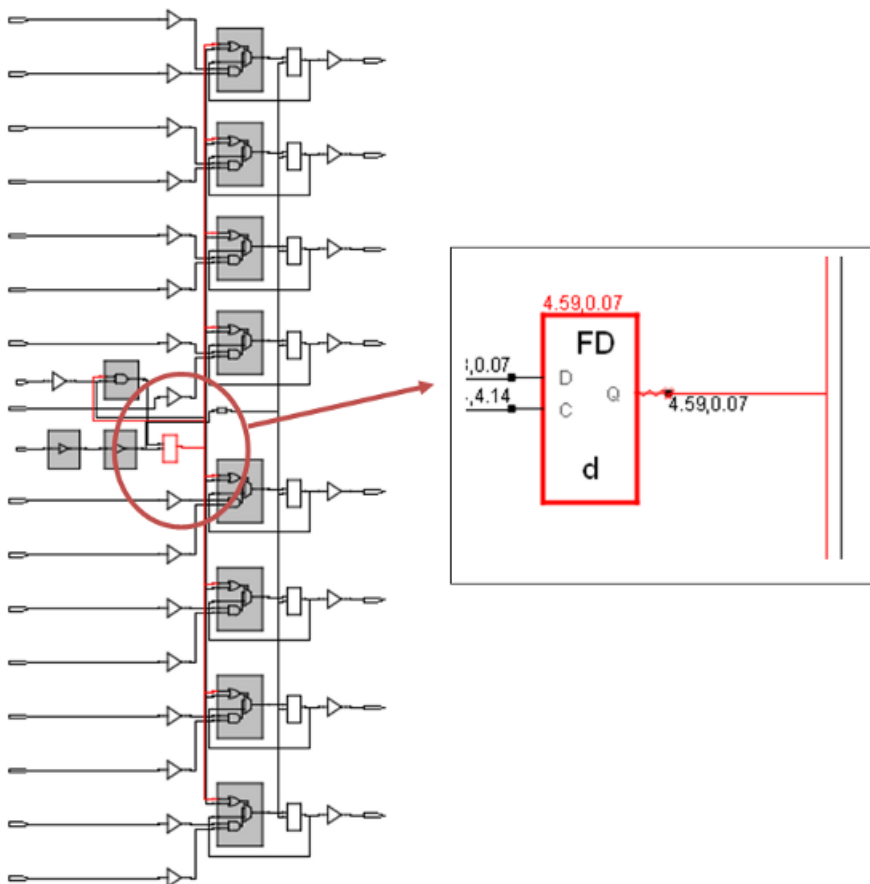
```
        else
            d <= not d;
        end if;
    end if;
end process;

process (d)
begin
    if (d'event and d = '1') then
        c <= a and b;
    end if;
end process;

end rtl;
```

Effect of Using syn_maxfan

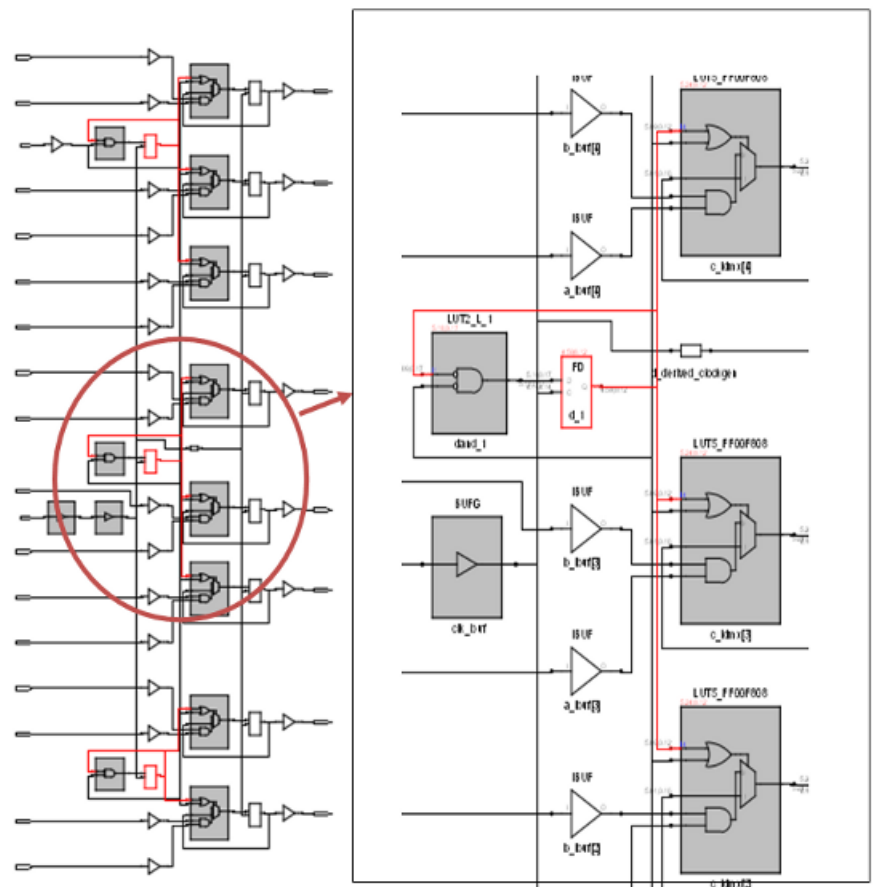
Before applying syn_maxfan:



After applying the attribute `syn_maxfan`, the register `d` is replicated three times (shown in red) because its actual fanout is 8, but we have restricted it to 3.

Verilog	<code>reg d/* synthesis syn_maxfan=3 */;</code>
---------	---

VHDL	<code>attribute syn_maxfan of d : signal is 3;</code>
------	---



syn_multstyle

Attribute

Determines how multipliers are implemented.

Vendor	Device	Values
Microsemi	SmartFusion2 IGLOO2	dsp logic

syn_multstyle Values

Value	Description	Default
logic	Implements the multipliers as logic.	-
dsp	Implements the multipliers as DSP blocks.	X

This table lists the valid values for each vendor:

Microsemi	- dsp Uses dedicated hardware DSP blocks. This is the default. - logic Uses logic instead of dedicated resources.
-----------	--

Description

This attribute specifies whether the multipliers are implemented as dedicated hardware blocks or as logic. The implementation varies with the technology, as shown in the preceding table.

syn_multstyle Syntax

Global Attribute	Object
Yes	Module or instance

:

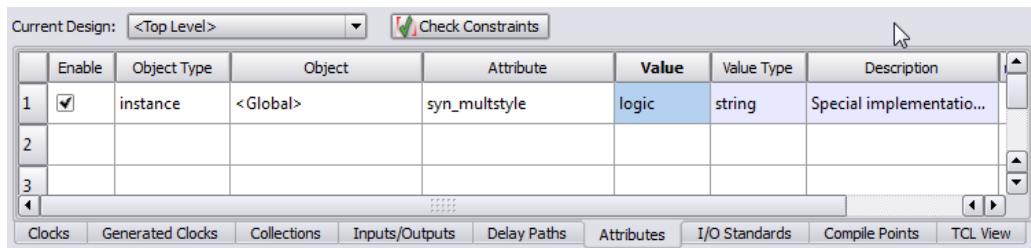
The following shows the attribute syntax when specified in different files:

FDC	<pre>define_attribute {instance} syn_multstyle {logic dsp} Global attribute: define_global_attribute syn_multstyle {logic dsp}</pre>	SCOPE Example
Verilog	<pre>input net /* synthesis syn_multstyle = "logic dsp" */;</pre>	Verilog Example
VHDL	<pre>attribute syn_multstyle of instance : signal is "logic dsp";</pre>	VHDL Example

See [VHDL Attribute and Directive Syntax](#), on page 302 for different ways to specify VHDL attributes and directives.

SCOPE Example

This SCOPE example specifies that the multipliers be globally implemented as logic:



This example specifies that multipliers be implemented as logic.

```
define_attribute {temp[15:0]} syn_multstyle {logic}
```

Verilog Example

```
module mult(a,b,c,r,en);
input  [7:0] a,b;
output [15:0] r;
input  [15:0] c;
input  en;
wire [15:0] temp /* synthesis syn_multstyle="logic" */;
assign temp = a*b;
assign r = en ? temp: c;
endmodule
```

VHDL Example

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

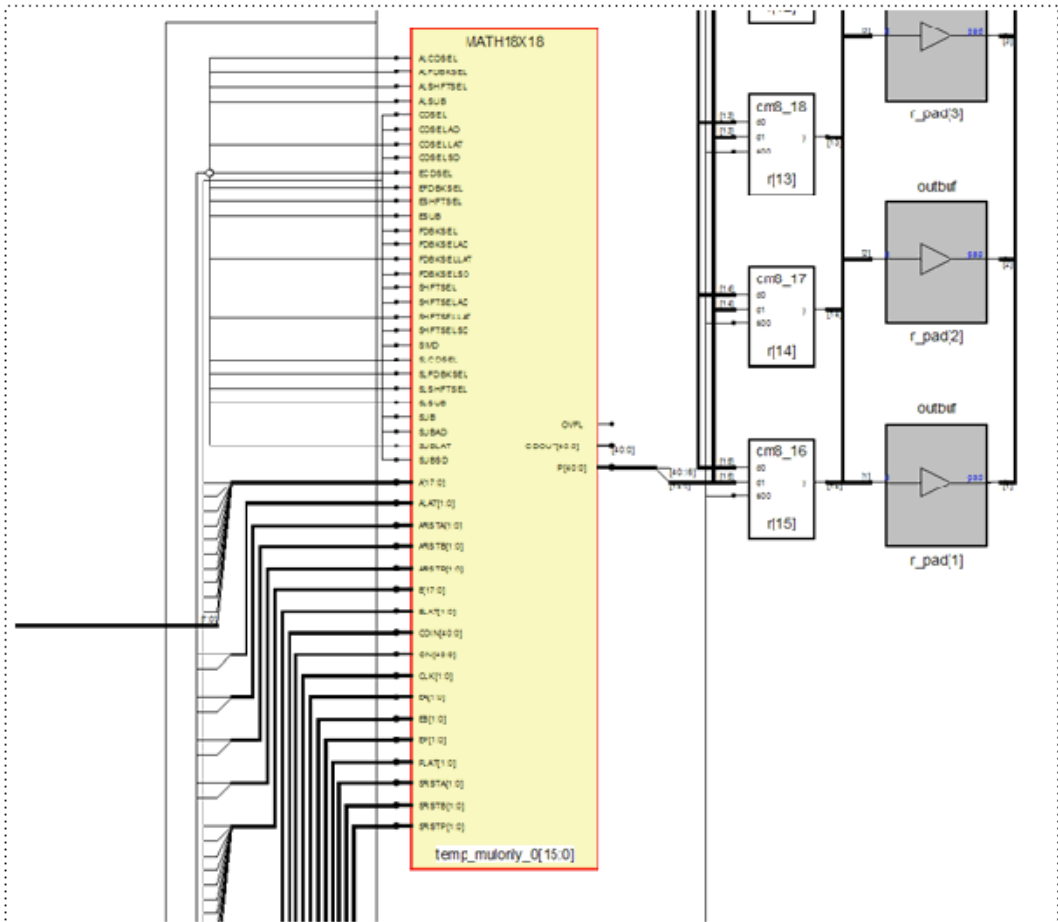
entity mult is
    port (clk : in std_logic;
          a : in std_logic_vector(7 downto 0);
          b : in std_logic_vector(7 downto 0);
          c : out std_logic_vector(15 downto 0))
end mults;

architecture rtl of mult is
    signal mult_i : std_logic_vector(15 downto 0);
    attribute syn_multstyle : string;
    attribute syn_multstyle of mult_i : signal is "logic";
begin
    mult_i <= std_logic_vector(unsigned(a)*unsigned(b));
    process(clk)
    begin
        if (clk'event and clk = '1') then
            c <= mult_i;
        end if;
    end process;
end rtl;
```

Effect of Using syn_multstyle in a Microsemi Design

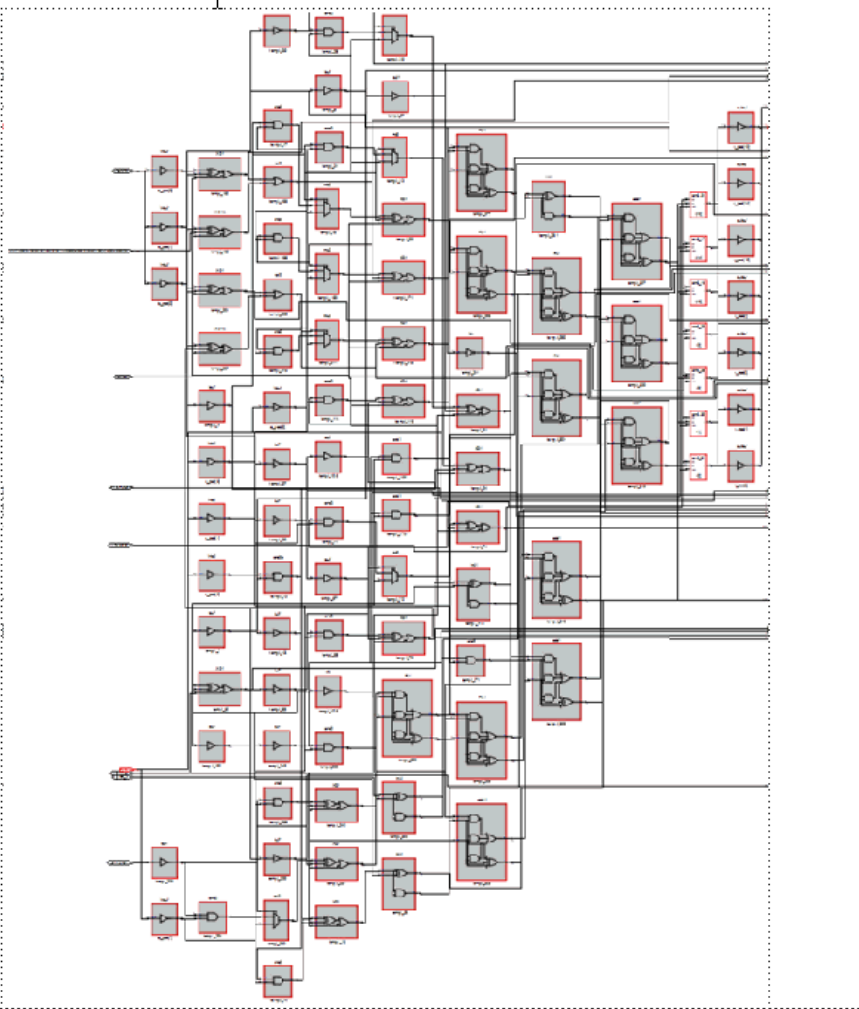
In a Microsemi design, you can specify that the multipliers be implemented as logic or as dedicated DSP blocks. The following figure shows a multiplier implemented as DSP:

Verilog	wire [15:0] temp; /*_synthesis_syn_multstyle_="dsp"*/;
VHDL	attribute _syn_multstyle_of_mult_i_ : signal is "dsp";



The following figure shows the same Microsemi design with the multiplier implemented as logic when the attribute is set to logic:

Verilog	wire [15:0] temp; /*_synthesis_syn_multstyle_="logic"*/;
VHDL	attribute _syn_multstyle_of_mult_i : _signal_is "logic";



syn_netlist_hierarchy

Attribute

Determines if the generated netlist is to be hierarchical or flat.

Vendor	Technology
Microsemi	IGLOO families

syn_netlist_hierarchy Values

Value	Description	Default
1/true	Allows hierarchy generation	Default
0/false	Flattens hierarchy in the netlist	

Description

A global attribute that controls the generation of hierarchy in the output netlist when assigned to the top-level module in your design. The default (1/true) allows hierarchy generation, and setting the attribute to 0/false flattens the hierarchy and produces a completely flattened output netlist.

Syntax Specification

Global	Object
Yes	Module/Architecture

FDC	define_global_attribute syn_netlist_hierarchy {0 1}	SCOPE Example
Verilog	object !* synthesis syn_netlist_hierarchy = 0 1 */;	Verilog Example
VHDL	attribute syn_netlist_hierarchy of object : objectType is true false;	VHDL Example

SCOPE Example

Enable	Object Type	Object	Attribute	Value	Value Type	Description
☒	global	<Global>	syn_netlist_hierarchy	1	boolean	Enable hierarchy reconstruction

Verilog Example

```

module fu_add(input a,b,cin,output su,cy);
  assign su = a ^ b ^ cin;
  assign cy = (a & b) | ((a^b) & cin);
endmodule

module rca_adder#(parameter width =4)
  (input [width-1:0]A,B,input CIN,
   output [width-1:0]SU,output COUT);
  wire [width-2:0]CY;
  fu_add FA0 (.su(SU[0]),.cy(CY[0]),.cin(CIN),.a(A[0]),.b(B[0]));
  fu_add FA1 (.su(SU[1]),.cy(CY[1]),.cin(CY[0]),.a(A[1]),.b(B[1]));
  fu_add FA2 (.su(SU[2]),.cy(CY[2]),.cin(CY[1]),.a(A[2]),.b(B[2]));
  fu_add FA3 (.su(SU[3]),.cy(COUT),.cin(CY[2]),.a(A[3]),.b(B[3]));
endmodule

module rp_top#(parameter width =16)
  (input [width-1:0]A1,B1,input CIN1,
   output [width- 1:0]SUM,output COUT1) /*synthesis
   syn_netlist_hierarchy=0*/;
  wire [2:0]CY1;
  rca_adder RA0 (.SU(SUM[3:0]),.COUT(CY1[0]),.CIN(CIN1),
    .A(A1[3:0]),.B(B1[3:0]));
  rca_adder RA1 (.SU(SUM[7:4]),.COUT(CY1[1]),.CIN(CY1[0]),
    .A(A1[7:4]),.B(B1[7]));
  rca_adder RA2 (.SU(SUM[11:8]),.COUT(CY1[2]),.CIN(CY1[1]),
    .A(A1[11:8]),.B(B1[11:8]));
  rca_adder RA3 (.SU(SUM[15:12]),.COUT(COUT1),.CIN(CY1[2]),
    .A(A1[15:12]),.B(B1[15:12]));
endmodule

```

VHDL Example

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

entity FULLADDER is
    port (a, b, c : in std_logic;
          sum, carry: out std_logic);
end FULLADDER;

architecture fulladder_behav of FULLADDER is
begin
    sum <= (a xor b) xor c ;
    carry <= (a and b) or (c and (a xor b));
end fulladder_behav;

library ieee;
use ieee.std_logic_1164.all;

entity FOURBITADD is
    port (a, b : in std_logic_vector(3 downto 0);
          Cin : in std_logic;
          sum : out std_logic_vector (3 downto 0);
          Cout, V : out std_logic);
end FOURBITADD;

architecture fouradder_structure of FOURBITADD is
    signal c: std_logic_vector (4 downto 1);
    component FULLADDER
        port (a, b, c: in std_logic;
              sum, carry: out std_logic);
    end component;
begin
    FA0: FULLADDER
        port map (a(0), b(0), Cin, sum(0), c(1));
    FA1: FULLADDER
        port map (a(1), b(1), C(1), sum(1), c(2));
    FA2: FULLADDER
        port map (a(2), b(2), C(2), sum(2), c(3));
    FA3: FULLADDER
        port map (a(3), b(3), C(3), sum(3), c(4));
    V <= c(3) xor c(4);
    Cout <= c(4);
end fouradder_structure;
```

```

library ieee;
use ieee.std_logic_1164.all;

entity BITADD is
    port (A, B: in std_logic_vector(15 downto 0);
          Cin : in std_logic;
          SUM : out std_logic_vector (15 downto 0);
          COUT: out std_logic);
end BITADD;

architecture adder_structure of BITADD is
    attribute syn_netlist_hierarchy : boolean;
    attribute syn_netlist_hierarchy of adder_structure:
        architecture is false;
    signal C: std_logic_vector (4 downto 1);

    component FOURBITADD
        port (a, b: in std_logic_vector(3 downto 0);
              Cin : in std_logic;
              sum : out std_logic_vector (3 downto 0);
              Cout, V: out std_logic);
    end component;

begin
    F1: FOURBITADD
        port map (A(3 downto 0),B(3 downto 0),
                  Cin, SUM(3 downto 0),C(1));
    F2: FOURBITADD
        port map (A(7 downto 4),B(7 downto 4),
                  C(1), SUM(7 downto 4),C(2));
    F3: FOURBITADD
        port map (A(11 downto 8),B(11 downto 8),
                  C(2), SUM(11 downto 8),C(3));
    F4: FOURBITADD
        port map (A(15 downto 12),B(15 downto 12),
                  C(3), SUM(15 downto 12),C(4));
    COUT <= c(4);
end adder_structure;

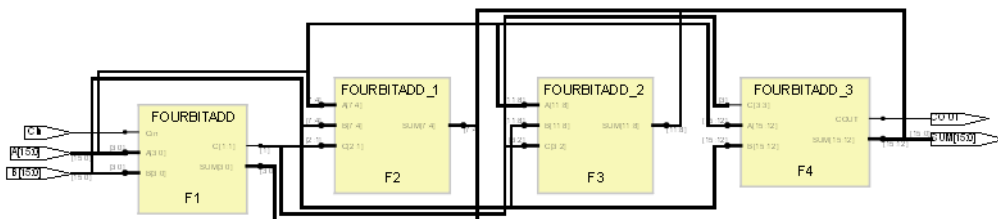
```

Effect of Using syn_netlist_hierarchy

Without applying the attribute (default is to allow hierarchy generation) or setting the attribute to 1/true creates a hierarchical netlist.

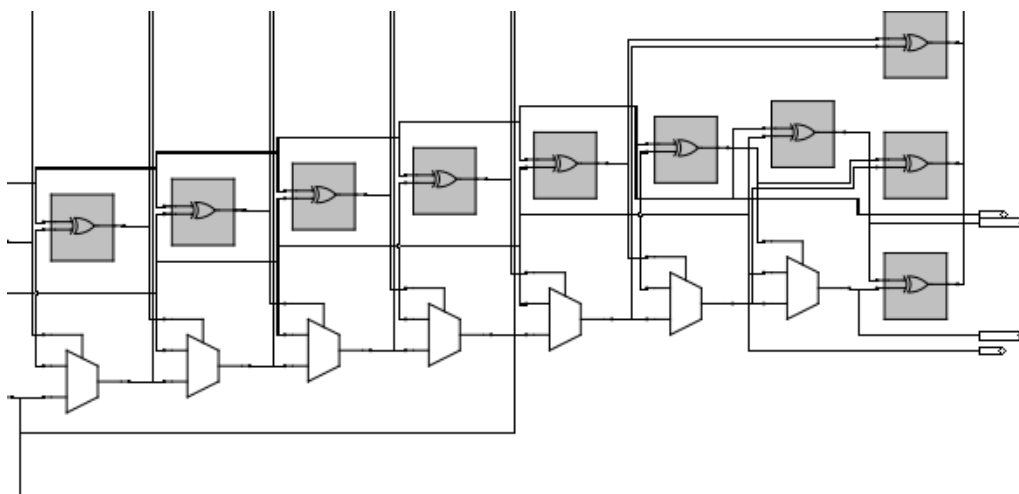
Verilog output [width-1:0] SUM, output COUT1)
 /*synthesis syn_netlist_hierarchy=1*/;

VHDL attribute syn_netlist_hierarchy of adder_structure :
 architecture is true;



Applying the attribute with a value of 0/false creates a flattened netlist.

Verilog	<code>output [width-1:0] SUM, output COUT1) /*synthesis syn_netlist_hierarchy=0*/;</code>
VHDL	<code>attribute syn_netlist_hierarchy of adder_structure : architecture is false;</code>



syn_hier flatten and syn_netlist_hierarchy

The `syn_hier=flatten` attribute and the `syn_netlist_hierarchy=false` attributes both flatten hierarchy, but work slightly differently. Use the `syn_netlist_hierarchy` attribute if you want a completely flattened netlist (this attribute flattens all levels of hierarchy). When you set `syn_hier=flatten`, you flatten the hierarchical levels below the component on which it is set, but you do not flatten the current hierarchical level where it is set. Refer to [syn_hier, on page 80](#) for information about this attribute.

syn_noarrayports

Attribute

Specifies signals as scalar in the output file.

Vendor Devices

Microsemi	SmartFusion, ProASIC3E
-----------	------------------------

syn_noarrayports Values

Default	Global	Object
0	Yes	Module/Architecture

Description

Use this attribute to specify that the ports of a design unit be treated as individual signals (scalars), not as buses (arrays) in the output file.

Syntax Specification

SCOPE	define_global_attribute syn_noarrayports {0 1}
Verilog	object /* synthesis syn_noarrayports = 0 1;
VHDL	attribute syn_noarrayports of <i>object</i> : <i>objectType</i> is true false;

SCOPE Example

	Enabled	Object Type	Object	Attribute	Value	Val Type	Description	Comment
1	☒	global	<global>	syn_noarrayports	1	boolean	Disable array ports	

Verilog Example

```

module adder8(cout,sum,a,b,cin)
    /* synthesis syn_noarrayports = "1" */;
    input[7:0] a,b;
    input cin;
    output reg[7:0] sum;
    output reg cout;
    always@(*)
    begin
        {cout,sum}=a+b+cin;
    end
endmodule

```

VHDL Example

```

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

entity ADDER is
    generic(n: natural :=8);
    port( A:      in std_logic_vector(n-1 downto 0);
          B:      in std_logic_vector(n-1 downto 0);
          carry:   out std_logic;
          sum:     out std_logic_vector(n-1 downto 0)
    );
end ADDER;

architecture adder_struct of ADDER is
    attribute syn_noarrayports : boolean;
    attribute syn_noarrayports of adder_struct : architecture is true;
    signal result: std_logic_vector(n downto 0);
    begin
        result <= ('0' & A)+('0' & B);
        sum <= result(n-1 downto 0);
        carry <= result(n);
    end adder_struct;

```

Effect of Using syn_noarrayports

This example shows the netlist before applying the attribute:

Verilog module adder8(cout,sum,a,b,cin)/* synthesis syn_noarrayport="0" */

VHDL attribute syn_noarrayports : boolean;
 attribute syn_noarrayports of adder_struct : architecture is false;

```
(library work
  (edifLevel 0)
  (technology (numberDefinition))
  (cell ADDER (cellType GENERIC)
    (view behv (viewType NETLIST)
      (interface
        (port (array (rename A "A(7:0)") 8) (direction INPUT))
        (port (array (rename B "B(7:0)") 8) (direction INPUT))
        (port (array (rename sum "sum(7:0)") 8) (direction OUTPUT))
        (port carry (direction OUTPUT))
      )
    )
  )
```

This example shows the netlist after applying the attribute:

Verilog module adder8(cout,sum,a,b,cin)/* synthesis syn_noarrayport="1" */

VHDL attribute syn_noarrayports : boolean;
attribute syn_noarrayports of adder_struct : architecture is true;

```
(library work
(edifLevel 0)
(technology (numberDefinition))
(cell ADDER (cellType GENERIC)
(view behv (viewType NETLIST)
(interface
(port (rename A_0 "A(0)") (direction INPUT))
(port (rename A_1 "A(1)") (direction INPUT))
(port (rename A_2 "A(2)") (direction INPUT))
(port (rename A_3 "A(3)") (direction INPUT))
(port (rename A_4 "A(4)") (direction INPUT))
(port (rename A_5 "A(5)") (direction INPUT))
(port (rename A_6 "A(6)") (direction INPUT))
(port (rename A_7 "A(7)") (direction INPUT))
(port (rename B_0 "B(0)") (direction INPUT))
(port (rename B_1 "B(1)") (direction INPUT))
(port (rename B_2 "B(2)") (direction INPUT))
(port (rename B_3 "B(3)") (direction INPUT))
(port (rename B_4 "B(4)") (direction INPUT))
(port (rename B_5 "B(5)") (direction INPUT))
(port (rename B_6 "B(6)") (direction INPUT))
(port (rename B_7 "B(7)") (direction INPUT))
(port carry (direction OUTPUT))
(port (rename sum_0 "sum(0)") (direction OUTPUT))
(port (rename sum_1 "sum(1)") (direction OUTPUT))
(port (rename sum_2 "sum(2)") (direction OUTPUT))
(port (rename sum_3 "sum(3)") (direction OUTPUT))
(port (rename sum_4 "sum(4)") (direction OUTPUT))
(port (rename sum_5 "sum(5)") (direction OUTPUT))
(port (rename sum_6 "sum(6)") (direction OUTPUT))
(port (rename sum_7 "sum(7)") (direction OUTPUT))
)
)
```

syn_noclockbuf

Attribute

Turns off automatic clock buffer usage.

Vendor	Technology
Microsemi	all

syn_noclockbuf Values

Value	Description
0/false (Default)	Turns on clock buffering.
1/true	Turns off clock buffering.

Description

The synthesis tool uses clock buffer resources, if they exist in the target module, and puts them on the highest fanout clock nets. You can turn off automatic clock buffer usage by using the `syn_noclockbuf` attribute. For example, you can put a clock buffer on a lower fanout clock that has a higher frequency and a tighter timing constraint.

You can turn off automatic clock buffering for nets or specific input ports. Set the Boolean value to 1 or true to turn off automatic clock buffering.

You can attach this attribute to a port or net in any hard architecture or module whose hierarchy will not be dissolved during optimization.

Constraint File Syntax and Example

Global Support	Object
Yes	module/architecture

```
define_attribute {clock_port} syn_noclockbuf {0|1}
```

```
define_global_attribute syn_noclockbuf {0|1}
```

For example:

```
define_attribute {clk} syn_noclockbuf {1}
```

```
define_global_attribute syn_noclockbuf {1}
```

FDC Example

The `syn_noclockbuf` attribute can be applied in the SCOPE window as shown:

	Enabled	Object Type	Object	Attribute	Value	Val Type	Description
1	☒	global	<global>	syn_noclockbuf	1	boolean	Use normal input buffer

Verilog Syntax and Examples

```
object !* synthesis syn_noclockbuf = 1 | 0 *!;
```

```
module ckbufg (d,clk,rst,set,q);
input d,rst,set;
input clk /*synthesis syn_noclockbuf=1*/;
output reg q;
always@(posedge clk)
begin
if(rst)
q<=0;
else if(set)
q<=1;
else
q<=d;
end
endmodule
```

VHDL Syntax and Examples

```
attribute syn_noclockbuf of object : objectType is true | false;
```

```
library IEEE;
use IEEE.std_logic_1164.all;
entity d_ff_srss is
port (d,clk,reset,set : in STD_LOGIC;
      q : out STD_LOGIC);
```

:

```
attribute syn_noclockbuf: Boolean;
attribute syn_noclockbuf of clk : signal is false;
end d_ff_srss;
architecture d_ff_srss of d_ff_srss is
begin
  process(clk)
  begin
    if clk'event and clk='1' then
      if reset='1' then
        q <= '0';
      elsif set='1' then
        q <= '1';
      else
        q <= d;
      end if;
    end if;
  end process;
end d_ff_srss;
```

Effect of Using syn_noclockbuf

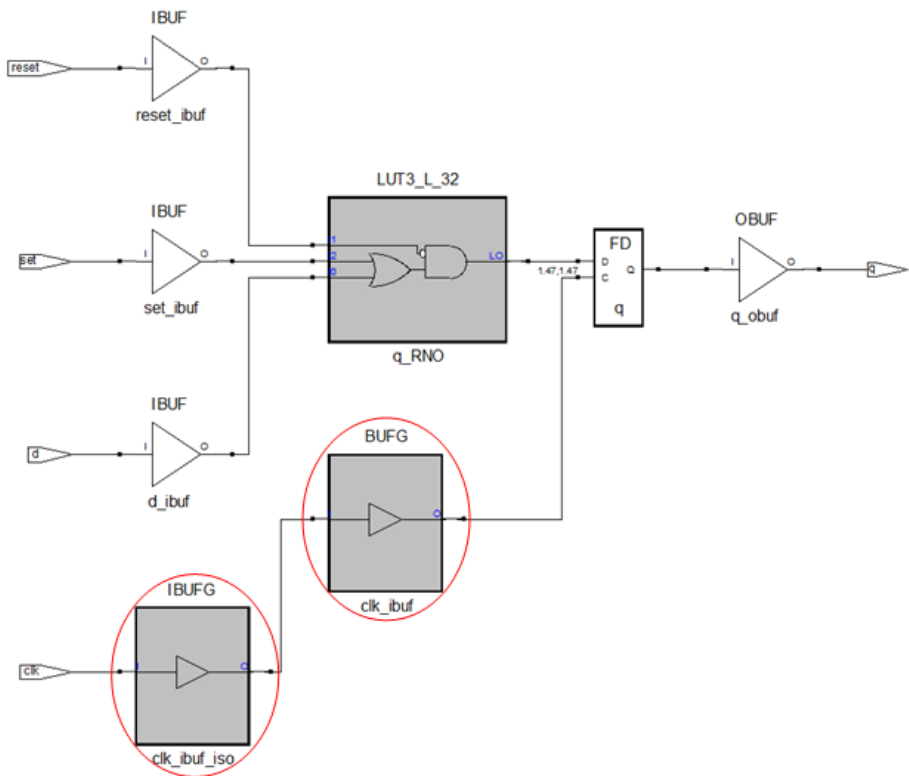
The following graphic shows a design without the `syn_noclockbuf` attribute.

```
Verilog  input clk  /*synthesis syn_noclockbuf=0*/;
```

```
VHDL    attribute syn_noclockbuf: Boolean;
        attribute syn_noclockbuf of clk : signal is false;
```

Global buffers are inferred

I

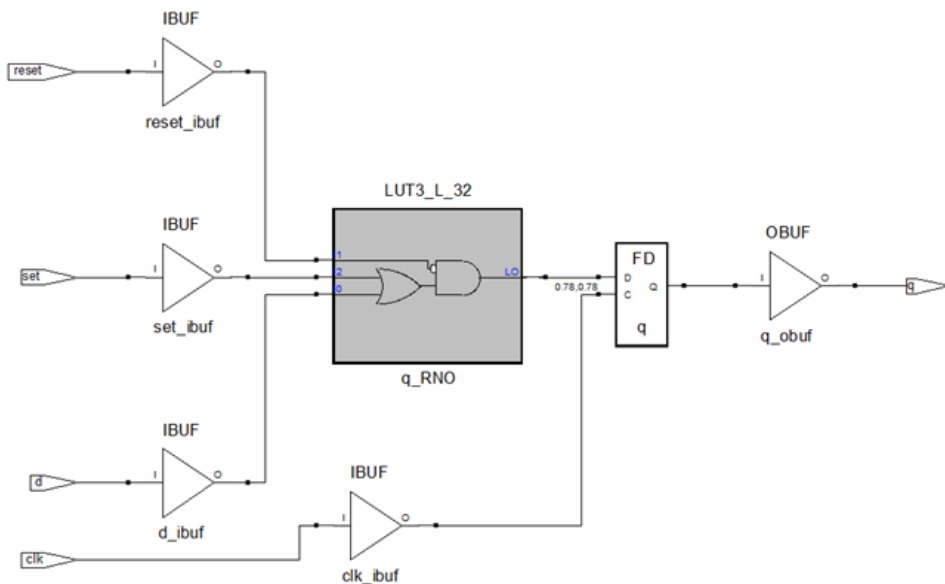


The following graphic shows a design with the syn_noclockbuf attribute.

:

```
Verilog  input clk  /*synthesis syn_noclockbuf=1*/;  
VHDL    attribute syn_noclockbuf: Boolean;  
        attribute syn_noclockbuf of clk : signal is true;
```

No global buffers inferred

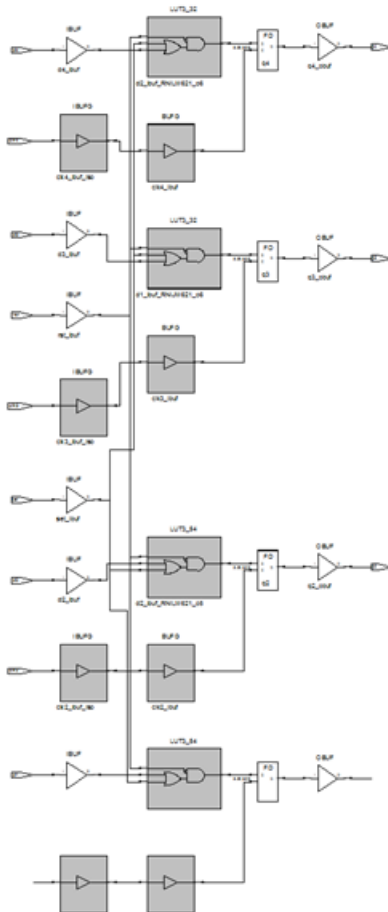


Global Support

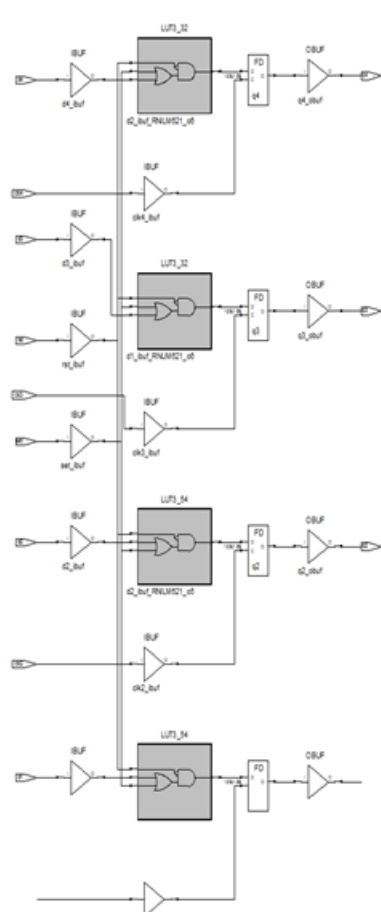
When `syn_noclockbuf` attribute is applied globally, global buffers are inferred by default. If the `syn_noclockbuf` attribute value is set to 1, global buffers are not inferred.

HDL	<pre> module ckbufg(d1,d2,d3,d4,clk1,clk2,clk3,clk4,rst,set,q1,q2,q3,q4)/*synthesis syn_noclockbuf=1*/; </pre>
FDC	<pre> define_global_attribute {syn_noclockbuf} {1} </pre>

Before Applying attribute



After applying attribute



syn_noprune

Directive

Prevents optimizations for instances and black-box modules (including technology-specific primitives) with unused output ports.

Vendor	Technology	Global	Object
All	All	No	Verilog module/instance VHDL architecture/component

syn_noprune Values

Value	Description
0 false (Default)	Allows instances and black-box modules with unused output ports to be optimized away.
1 true	Prevents optimizations for instances and black-box modules with unused output ports.

Description

Use this directive to prevent the removal of instances, black-box modules, and technology-specific primitives with unused output ports during optimization.

By default, the synthesis tool removes any module that does not drive logic as part of the synthesis optimization process. If you want to keep such an instance in the design, use the `syn_noprune` directive on the instance or module, along with `syn_hier` set to `hard`.

The `syn_noprune` directive can prevent a hierarchy from being dissolved or flattened. To ensure that a design with multiple hierarchies is preserved, apply this directive on the leaf hierarchy, which is the lower-most hierarchical level. This is especially important when hierarchies cannot be accessed or edited.

For further information about this and other directives used for preserving logic, see [Comparison of `syn\_keep`, `syn\_preserve`, and `syn\_noprune`, on page 106](#), and [Preserving Objects from Being Optimized Away, on page 393](#) in the *User Guide*.

syn_noprune Syntax

Verilog	<i>object</i> /* synthesis syn_noprune = 1 */;	Verilog Examples
VHDL	attribute syn_noprune : boolean attribute syn_noprune of <i>object</i> : <i>objectType</i> is true;	VHDL Examples

Verilog Examples

This section contains code snippets and examples.

Verilog Example 1: Module Declaration

syn_noprune can be applied in two places: on the module declaration or in the top-level instantiation. The most common place to use syn_noprune is in the declaration of the module. By placing it here, all instances of the module are protected.

```
module top (a,b,c,d,x,y); /* synthesis syn_noprune=1 */;

// Other code
```

The results for this example are shown in [Effect of Using syn_noprune: Example 1, on page 145](#).

Verilog Black Box Declaration

Here is a snippet showing syn_noprune used on black box instances. If your design uses multiple instances with a single module declaration, the synthesis comment must be placed before the comma (,) following the port list for each of the instances.

```
my_design my_design1(out,in,clk_in) /* synthesis syn_noprune=1 */;
my_design my_design2(out,in,clk_in) /* synthesis syn_noprune=1 */;
```

In this example, only the instance my_design2 will be removed if the output port is not mapped.

Verilog Example 2: Hierarchical Design

In this example, `syn_noprune` is applied on the leaf-level module `sub1`. Although `syn_noprune` has not been applied to the intermediate level hierarchy, the directive is specified on an instance of module `sub1` that includes `inst1`, `inst2`, and `inst3`. The software propagates this directive upwards in the hierarchy chain. See [Effect of Using `syn\_noprune`: Example 2, on page 146](#).

VHDL Examples

This section contains code snippets and examples.

Architecture Declaration

The `syn_noprune` directive is normally associated with the names of architectures. Once it is associated, any component instantiation of the architecture (design unit) is protected from being deleted.

```
library ieee;
architecture mydesign of rtl is

    attribute syn_noprune : boolean;
    attribute syn_noprune of mydesign : architecture is true;

    -- Other code
```

VHDL Example 3: Component Declaration

The results for this example are shown in [Effect of Using `syn\_noprune`: Example 3, on page 148](#).

VHDL Example: Component Instance Declaration

The `syn_noprune` directive works the same on component instances as with a component declaration.

VHDL Example 4: Black Box

The results for this example are shown in [Effect of Using `syn\_noprune`: Example 4, on page 149](#).

Mixed Language Example

The `syn_noprune` directive can be specified on a module or architecture in a mixed Verilog and VHDL design.

Example 5: Mixed Language Design

The `syn_noprune` directive is specified on module `sub` in the top-level Verilog file.

```
module top (input a1,b1,c1,d1,
            input a2,b2,c2,d2,
            output x,y
            );

    sub inst1 (a1,b1,c1,d1,,)/*synthesis syn_noprune=1*/;
    sub inst2 (a2,b2,c2,d2,x,y);

endmodule
```

The architecture `sub` is defined in the following VHDL library file.

```
library ieee;
use ieee.std_logic_1164.all;
entity sub is
port (a, b, c, d : in std_logic;
      x,y : out std_logic);
end sub;

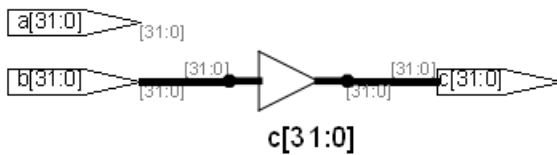
architecture behave of sub is
attribute syn_hier : string;
attribute syn_hier of behave : architecture is "hard";
begin
x <= a and b;
y <= c and d;
end behave;
```

The results for this example are shown in [Effect of Using `syn\_noprune` in a Mixed Language Design](#), on page 150.

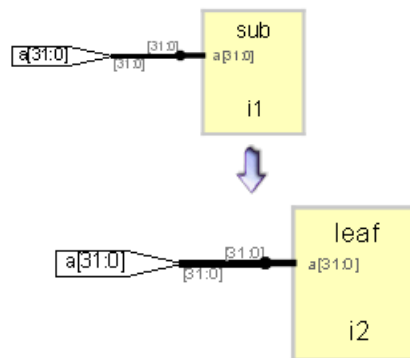
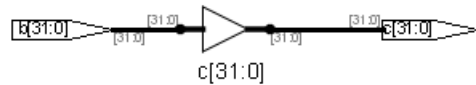
Effect of Using `syn_noprune`: Example 1

The following RTL view shows that the design hierarchy is preserved when the `syn_noprune` directive is applied on the module leaf. Otherwise, the design hierarchies are dissolved.

Without syn_noprune

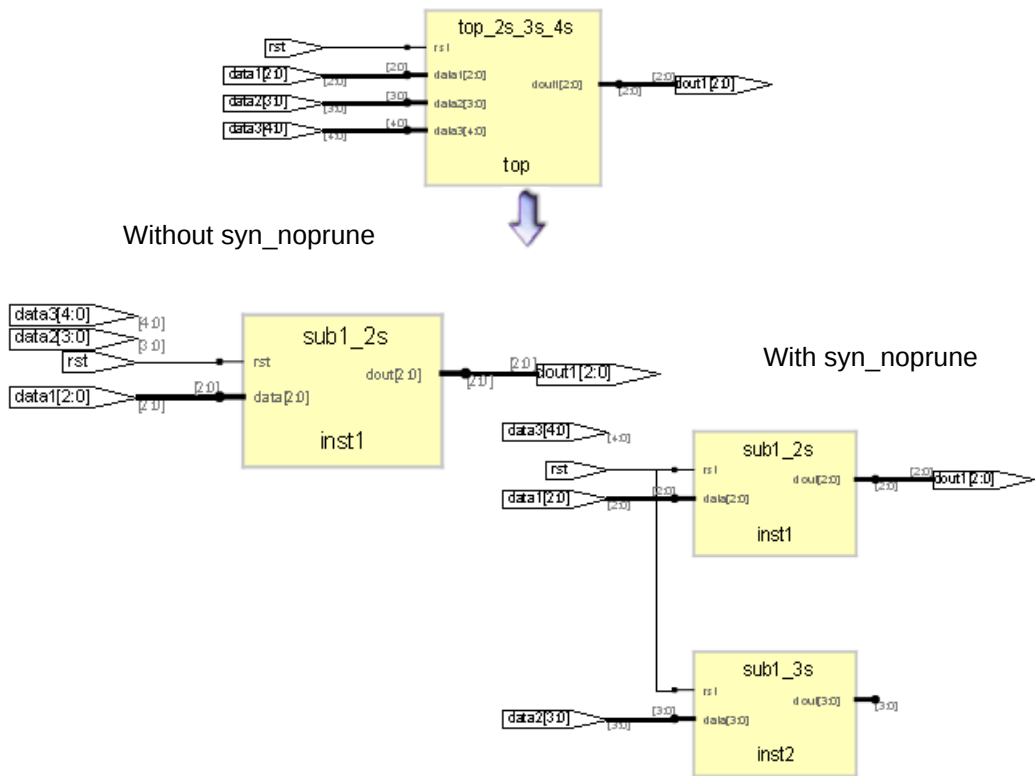


With syn_noprune



Effect of Using syn_noprune: Example 2

In this example, the software preserves the lower-most leaf hierarchy inst2 and the hierarchy above it. When syn_noprune is not applied, inst2 is not preserved.



In this example, the software propagates the syn_noprune directive downwards in the hierarchy chain.

```
//Top module
module top (input int a, b, output int c);
assign c=b;
sub i1 (a);
endmodule

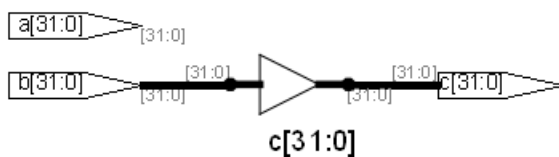
//Hier1
module sub (input int a);
interm1 i2 (a);
endmodule
```

:

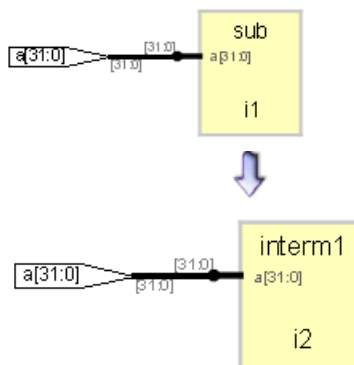
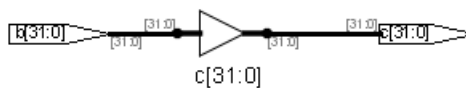
```
//Hier2
module interm1 (input int a) /* synthesis syn_noprune=1*/;
interm2 i3 (a);
endmodule

//Hier3
module interm2 (input int a);
leaf i4 (a);
endmodule
```

Without syn_noprune

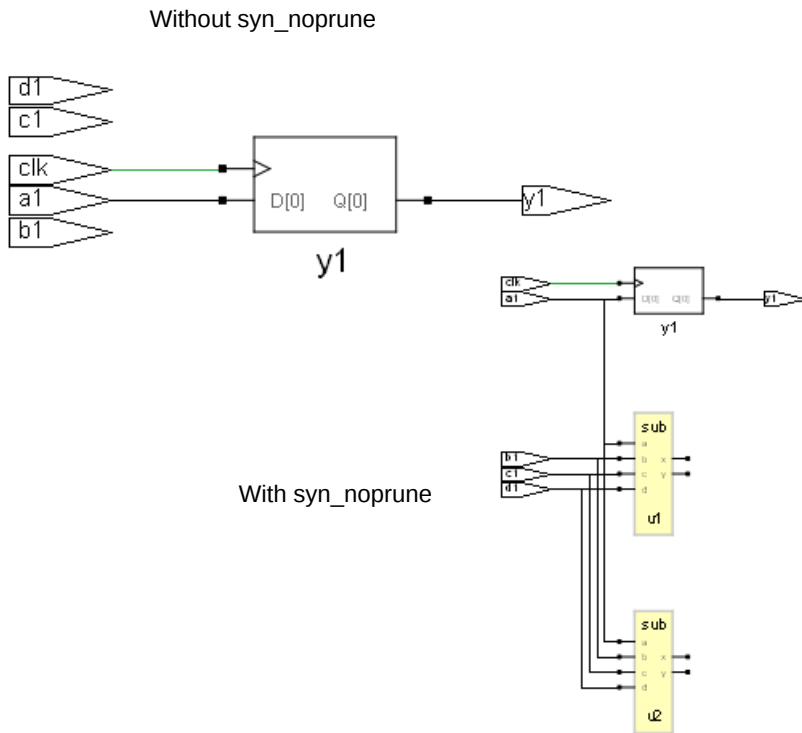


With syn_noprune



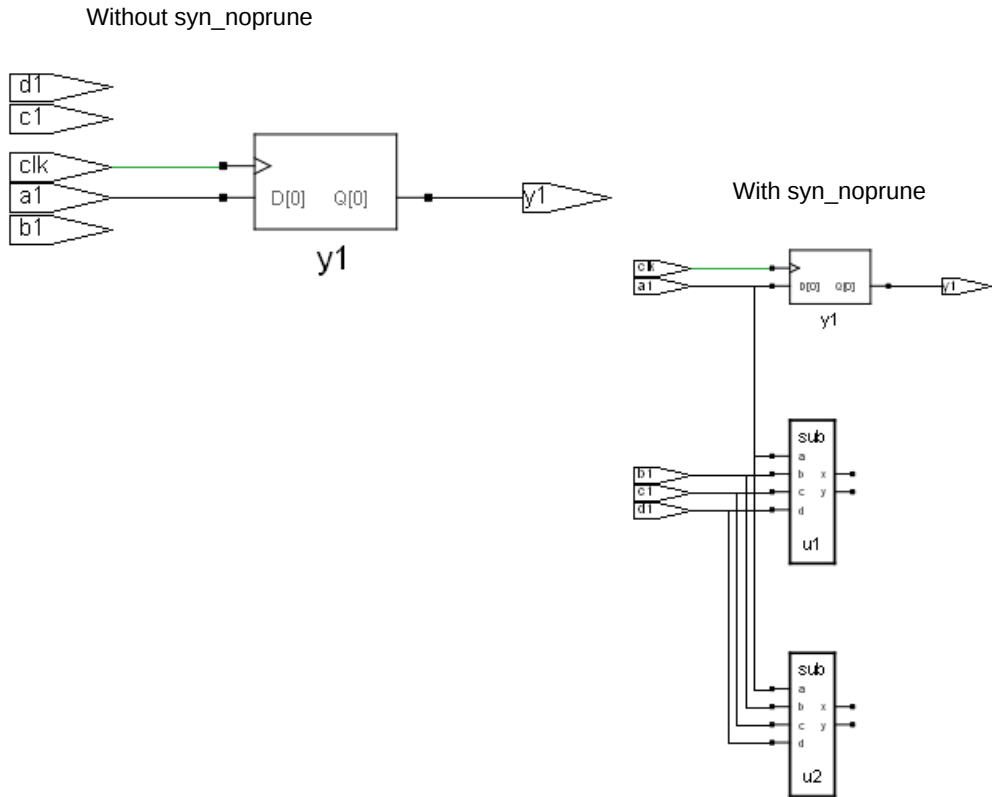
Effect of Using syn_noprune: Example 3

The following RTL views show that the design hierarchy is preserved when the `syn_noprune` directive is applied for the component `sub`.



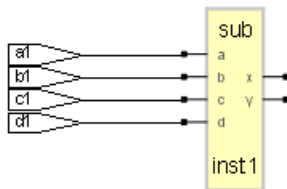
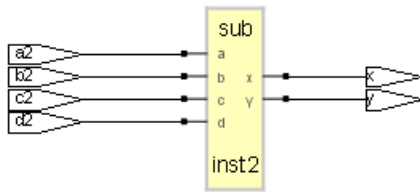
Effect of Using syn_noprune: Example 4

The following RTL views show that the instance and black box module are not optimized away when `syn_noprune` is applied.



Effect of Using `syn_noprune` in a Mixed Language Design

The following RTL view shows that the design hierarchy is preserved when the `syn_noprune` directive is applied on `sub`.



syn_pad_type

Attribute

Specifies an I/O buffer standard.

Vendor	Technology
--------	------------

Microsemi	IGLOO and newer families
-----------	--------------------------

syn_pad_type Values

Value	Description
{buffer}_{standard} For example: IBUF_LVCMOS_18	Specifies the port I/O standard.

Description

Specifies an I/O buffer standard. Refer to [I/O Standards, on page 171](#) and to the vendor-specific documentation for a list of I/O buffer standards available for the selected device family.

syn_pad_type Syntax

Default	Global Attribute	Object
Not Applicable	No	Port
FDC	define_io_standard -default <i>portType</i> { <i>port</i> } -delay_type <i>portType</i> syn_pad_type { <i>io_standard</i> } For example: <code>define_io_standard {p} -delay_type output syn_pad_type {LVCMOS_18}</code>	FDC Example
Verilog	object !* synthesis syn_pad_type = <i>io_standard</i> */	Verilog Example
VHDL	attribute syn_pad_type of <i>object</i> : <i>objectType</i> is <i>io_standard</i> ;	VHDL Example

FDC Example

	Enable	Object Type	Object	Attribute	Value
1	☒	port	p:output	syn_pad_type	LVC MOS_18
2					

-default_portType *PortType* can be input, output, or bidir. Setting default_input, default_output, or default_bidir causes all ports of that type to have the same I/O standard applied to them.

-delay_type portType *PortType* can be input, output, or bidir.

syn_pad_type {io_standard} Specifies I/O standard (see following table).

Constraint File Examples

To set ...	Use this syntax ...
The default for all input ports to the AGP1X pad type	define_io_standard -default_input -delay_type input syn_pad_type {AGP1X}
All output ports to the GTL pad type	define_io_standard -default_output -delay_type output syn_pad_type {GTL}
All bidirectional ports to the CTT pad type	define_io_standard -default_bidir -delay_type bidir syn_pad_type {CTT}

The following are examples of pad types set on individual ports. You cannot assign pad types to bit slices.

```
define_io_standard {in1} -delay_type input
    syn_pad_type {LVCMOS_15}

define_io_standard {out21} -delay_type output
    syn_pad_type {LVCMOS_33}

define_io_standard {bidirbit} -delay_type bidir
    syn_pad_type {LVTTL_33}
```

Verilog Example

```
module top (clk,A,B,PC,P);

input clk;
input A ;
input B,PC;
output reg P/* synthesis syn_pad_type = "OBUF_LVCMOS_18" */;

reg a_d,b_d;
reg m;

always @(posedge clk)
begin
    a_d <= A;
    b_d <= B;
    m   <= a_d + b_d;
    P   <= m + PC;
end

endmodule
```

VHDL Example

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

library synplify;
use synplify.attributes.all;

entity top is
    port (clk : in std_logic;
          A : in std_logic_vector(1 downto 0);
```

```
B : in std_logic_vector(1 downto 0);
PC : in std_logic_vector(1 downto 0);
P : out std_logic_vector(1 downto 0));

attribute syn_pad_type : string;
attribute syn_pad_type of P : signal is "OBUF_LVCMOS_18";
end top;

architecture rtl of top is
signal m : std_logic_vector(1 downto 0);

begin
    process(clk)
    begin
        if (clk'event and clk = '1') then
            m <= A + B;
            P <= m + PC;
        end if;
    end process;
end rtl;
```

Effect of Using syn_pad_type

The following figure shows the netlist output after the attribute is applied:

```
Verilog output reg P /*synthesis syn_pad_type = "OBUF_LVCMOS_18"*/;
```

```
VHDL attribute syn_pad_type of P : signal is "OBUF_LVCMOS_18";
```

Net list

```
95      )
96      (instance m_2_4 (viewRef PRIM (cellRef LUT2_L (libraryRef VIRTEX)))
97        (property INIT (string "4'h6"))
98      )
99      (instance P_2_2 (viewRef PRIM (cellRef LUT2_L (libraryRef VIRTEX)))
100        (property INIT (string "4'h6"))
101      )
102      (instance P_obuf (viewRef PRIM (cellRef OBUF (libraryRef VIRTEX)))
103        (property IOSTANDARD (string "LVCMOS18"))
104      )
105      (instance PC_ibuf (viewRef PRIM (cellRef IBUF (libraryRef VIRTEX)))
```

P&R Files

We can see the effect of syn_pad_type in the following P&R files

```
<projectdirectory>\rev_1\pr_1\top.pad(412):
```

```
T17|P|IOB|IO_L1P_GC_24|OUTPUT|LVCMOS18|24|12|SLOW|||UNLOCATED|NO|NONE|
```

```
<projectdirectory>\rev_1\pr_1\top.pad.txt(413
```

```
|T17|P|IOB|IO_L1P_GC_24|OUTPUT|LVCMOS18|24|12|SLOW|||UNLOCATED
```

syn_preserve

Directive

Prevents sequential optimizations such as constant propagation, inverter push-through, and FSM extraction.

Technology	Global	Object
All	Yes	Register definition signal, module (Verilog) Output port or internal signal that holds the value of the register or architecture (VHDL)

syn_preserve Values

Value	Description
1 true	Preserves register logic.
0 false (Default)	Optimizes registers as needed.

Description

The `syn_preserve` directive controls whether objects are optimized away. Use `syn_preserve` to retain registers for simulation, or to preserve the logic of registers driven by a constant 1 or 0. You can set `syn_preserve` on individual registers or on the module/architecture so that the directive is applied to all registers in the module.

For example, assume that the input of a flip-flop is always driven to the same value, such as logic 1. By default, the synthesis tool ties that signal to VCC and removes the flip-flop. Using `syn_preserve` on the registered signal prevents the removal of the flip-flop. This is useful when you are not finished with the design but want to do a preliminary run to find the area utilization.

Another use for this attribute is to preserve a particular state machine. When the FSM compiler is enabled, it performs various state-machine optimizations. Use `syn_preserve` to retain a particular state machine and prevent it from being optimized away.

When registers are removed during synthesis, the tool issues a warning message in the log file. For example:

```
@W:...Register bit out2 is always 0, optimizing ...
```

The `syn_preserve` directive is similar to `syn_keep` and `syn_noprune`, in that it preserves logic. For more information, see [Comparison of syn_keep, syn_preserve, and syn_noprune, on page 106](#), and [Preserving Objects from Being Optimized Away, on page 393](#) in the *User Guide*.

syn_preserve Syntax

Verilog	<code>object /* synthesis syn_preserve = 0 1 */</code>	Verilog Example
VHDL	attribute <code>syn_preserve</code> of <code>object</code> : <code>objectType</code> is true false;	VHDL Examples

Verilog Example

In the following example, `syn_preserve` is applied to all registers in the module to prevent them from being optimized away. For the results, see [Effect of using syn_preserve, on page 160](#).

```
module mod_preserve (out1,out2,clk,in1,in2)
    /* synthesis syn_preserve=1 */;
    output out1, out2;
    input clk;
    input in1, in2;
    reg out1;
    reg out2;
    reg reg1;
    reg reg2;

    always@ (posedge clk)begin
        reg1 <= in1 &in2;
        reg2 <= in1&in2;
        out1 <= !reg1;
        out2 <= !reg1 & reg2;
    end
endmodule
```

This is an example of setting `syn_preserve` on a state register:

```
reg [3:0] curstate /* synthesis syn_preserve = 1 */;
```

VHDL Examples

This section contains some VHDL code examples:

Example 1

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

entity simplifiedff is
  port (q : out std_logic_vector(7 downto 0);
        d : in std_logic_vector(7 downto 0);
        clk : in std_logic);

  -- Turn on flip-flop preservation for the q output
  attribute syn_preserve : boolean;
  attribute syn_preserve of q : signal is true;
end simplifiedff;

architecture behavior of simplifiedff is
begin
  process(clk)
  begin
    if rising_edge(clk) then
      -- Notice the continual assignment of "11111111" to q.
      q <= (others => '1');
    end if;
  end process;
end behavior;
```

Example 2

In this example, `syn_preserve` is used on the signal `curstate` that is later used in a state machine to hold the value of the state register.

```
architecture behavior of mux is
begin
  signal curstate : state_type;
  attribute syn_preserve of curstate : signal is true;

  -- Other code
```

Example 3

The results for the following example are shown in [Effect of using syn_preserve, on page 160](#).

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

entity mod_preserve is
  port (out1 : out std_logic;
        out2 : out std_logic;
        in1,in2,clk : in std_logic);
end mod_preserve;

architecture behave of mod_preserve is
  attribute syn_preserve : boolean;
  attribute syn_preserve of behave: architecture is true;
  signal reg1 : std_logic;
  signal reg2 : std_logic;
begin
  process
  begin
    wait until clk'event and clk = '1';
    reg1 <= in1 and in2;
    reg2 <= in1 and in2;
    out1 <= not (reg1);
    out2 <= (not (reg1) and reg2);
  end process;
end behave;
```

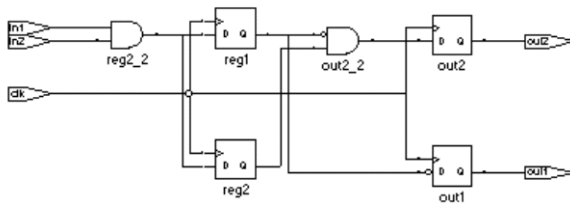
Effect of using syn_preserve

The following figure shows reg1 and out2 are preserved during optimization with syn_preserve.

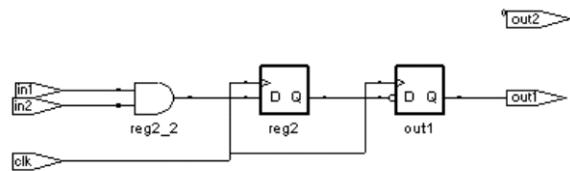
When syn_preserve is not set, reg1 and reg2 are shared because they are driven by the same source. out2 gets the result of the AND of reg2 and NOT reg1. This is equivalent to the AND of reg1 and NOT reg1, which is a 0. As this is a constant, the tool removes out2 and the output out2 is always 0.

Verilog	mod_preserve /* synthesis syn_preserve = 1 */
---------	---

VHDL	attribute syn_preserve of behave : architecture is true;
------	--



With syn_preserve



Without syn_preserve

syn_probe

Attribute

Inserts probe points for testing and debugging the internal signals of a design.

syn_probe Values

Value	Description
1/true	Inserts a probe, and automatically derives a name for the probe port from the net name.
0/false	Disables probe generation.
portName	Inserts a probe and generates a port with the specified name. If you include empty square brackets, [], the probe names are automatically indexed to the net name.

Description

syn_probe works as a debugging aid, inserting probe points for testing and debugging the internal signals of a design. The probes appear as ports at the top level. When you use this attribute, the tool also applies syn_keep to the net.

You can specify values to name probe ports and assign pins to named ports for selected technologies. Pin-locking properties of probed nets will be transferred to the probe port and pad. If empty square brackets [] are used, probe names will be automatically indexed, according to the index of the bus being probed.

The table below shows how to apply syn_probe values to nets, buses, and bus slices. It indicates what port names will appear at the top level. When the syn_probe value is 0, probe generation is disabled; when syn_probe is 1, the probe port name is derived from the net name.

Net Name	syn_probe Value	Probe Port	Comments
n:ctrl	1	ctrl_probe_1	Probe port name generated by the synthesis tool.
n:ctr	test_pt	test_pt	For string values on a net, the port name is identical to the syn_probe value.
n:aluout[2]	test_pt	test_pt	For string values on a bus slice, the port name is identical to the syn_probe value.
n:aluout[2]	test_pt[]	test_pt[2]	The empty square brackets [] indicate that port names will be indexed to net names.
n:aluout[2:0]	test_pt[]	test_pt[2] test_pt[1] test_pt[0]	The empty square brackets [] indicate that port names will be indexed to net names.
n:aluout[2:0]	test_pt	test_pt, test_pt_0, test_pt_1	If a syn_probe value without brackets is applied to a bus, the port names are adjusted.

syn_probe Syntax

Global	Object	Default
No	Net	None

The following table shows the syntax used to define this attribute in different files:

FDC	define_attribute {n:netName} syn_probe {probePortname 1 0}	FDC Example
Verilog	object /* synthesis syn_probe = "string" 1 0 */;	Verilog Example
VHDL	attribute syn_probe of object : signal is "string" 1 0;	VHDL Example

FDC Example

The following examples insert a probe signal into a net and assign pin locations to the ports.

```
define_attribute {n:inst2.DATA0_*[7]} syn_probe {test_pt[]}  
define_attribute {n:inst2.DATA0_*[7]} syn_loc  
    {14,12,11,5,21,18,16,15}
```

Enable	Object Type	Object	Attribute	Value	Value Type	Description
☒	<any>	<Global>	syn_probe	1	string	Send a signal to out...

Verilog Example

The following example inserts probes on bus alu_tmp [7:0] and assigns pin locations to each of the ports inserted for the probes.

```
module alu(out1, opcode, clk, a, b, sel);  
    output [7:0] out1;  
    input [2:0] opcode;  
    input [7:0] a, b;  
    input clk, sel;  
    reg [7:0] alu_tmp /* synthesis syn_probe="alu1_probe[]" */  
        syn_loc="A5,A6,A7,A8,A10,A11,A13,A14" */;  
    reg [7:0] out1;  
    // Other code  
    always @(opcode or a or b or sel)  
    begin  
        case (opcode)  
            3'b000: alu_tmp <= a+b;  
            3'b000: alu_tmp <= a-b;  
            3'b000: alu_tmp <= a^b;  
            3'b000: alu_tmp <= sel ? a:b;  
            default: alu_tmp <= a|b;  
        endcase  
    end  
  
    always @(posedge clk)  
    out1 <= alu_tmp;  
endmodule
```

VHDL Example

The following example inserts probes on bus `alu_tmp(7 downto 0)` and assigns pin locations to each of the ports inserted for the probes.

```

library ieee;
use ieee.std_logic_1164.all;
entity alu is
port (a : in std_logic_vector(7 downto 0);
      b : in std_logic_vector(7 downto 0);
      opcode : in std_logic_vector(2 downto 0);
      clk : in std_logic;
      out1 : out std_logic_vector(7 downto 0));
end alu;
architecture rtl of alu is
signal alu_tmp : std_logic_vector (7 downto 0);

attribute syn_probe : string;
attribute syn_probe of alu_tmp : signal is "test_pt";
attribute syn_loc : string;
attribute syn_loc of alu_tmp : signal is
    "A5,A6,A7,A8,A10,A11,A13,A14";

begin
    process (clk)
    begin
        if (clk'event and clk = '1') then
            out1 <= alu_tmp;
        end if;
    end process;
    process (opcode,a,b)
    begin
        case opcode is
            when "000" => alu_tmp <= a and b;
            when "001" => alu_tmp <= a or b;
            when "010" => alu_tmp <= a xor b;
            when "011" => alu_tmp <= a nand b;
            when others => alu_tmp <= a nor b;
        end case;
    end process;

end rtl;

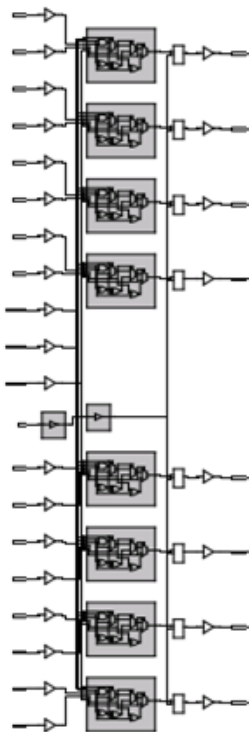
```

Effect of Using syn_probe

Before applying syn_probe:

Verilog	reg [7:0] alu_tmp /* synthesis syn_probe="0"*/
---------	--

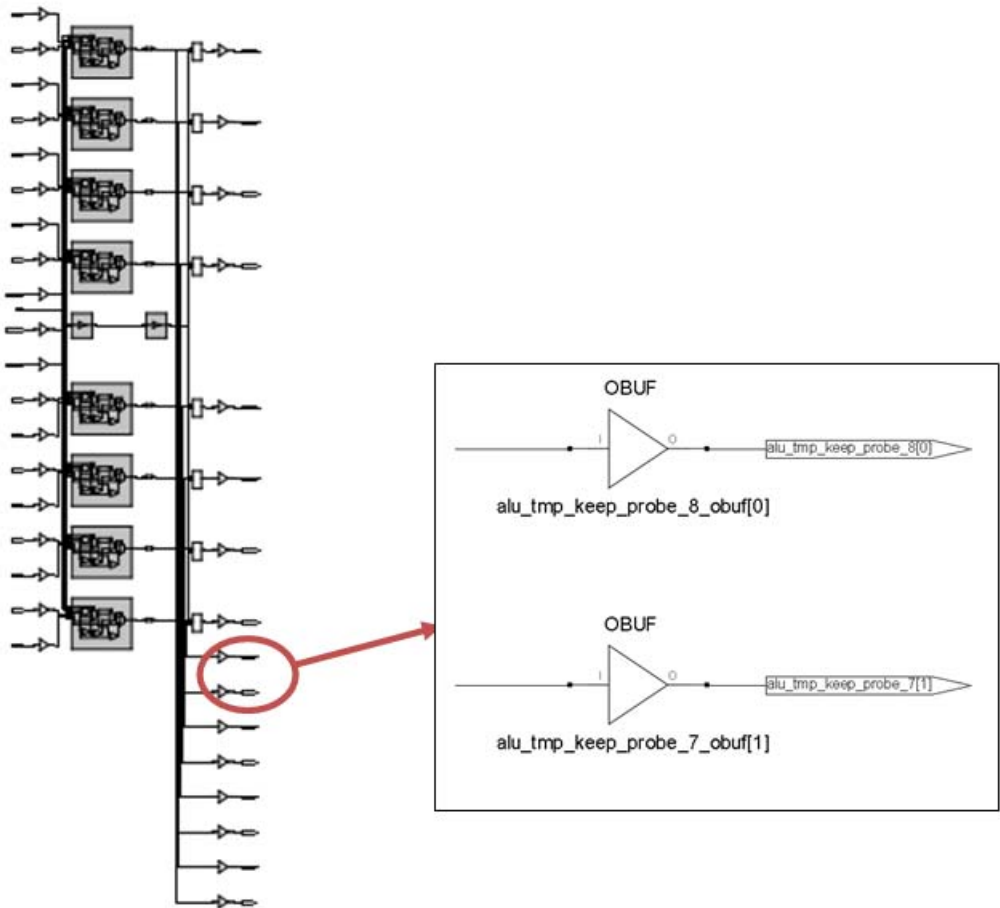
VHDL	attribute syn_probe of alu_tmp : signal is "0";
------	---



After applying syn_probe with 1:

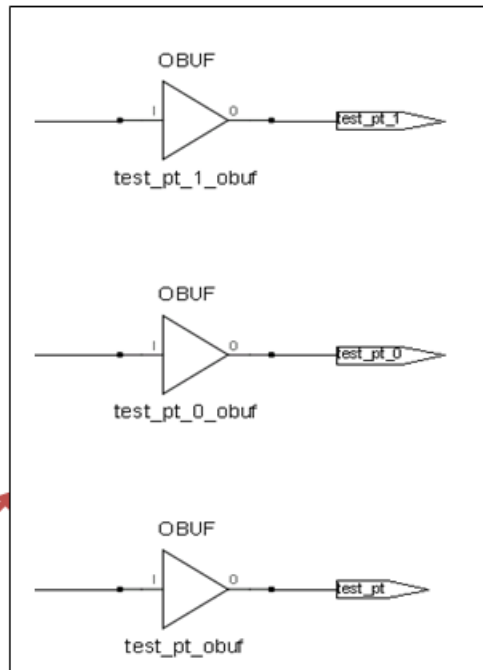
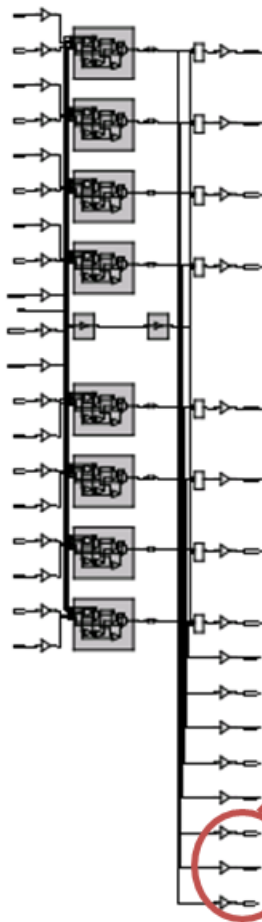
Verilog	reg [7:0] alu_tmp /* synthesis syn_probe="1"*/
---------	--

VHDL	attribute syn_probe of alu_tmp : signal is "1";
------	---



After applying `syn_probe` with `test_pt`:

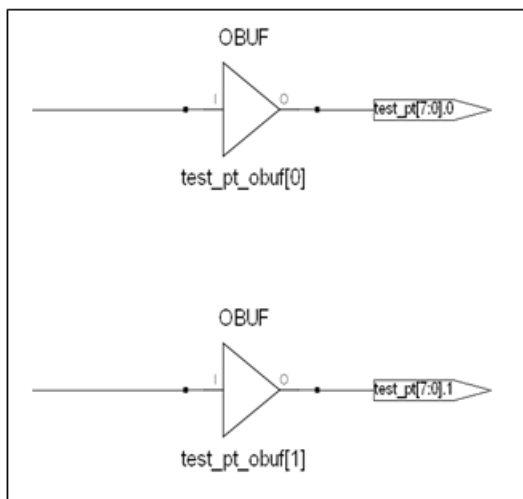
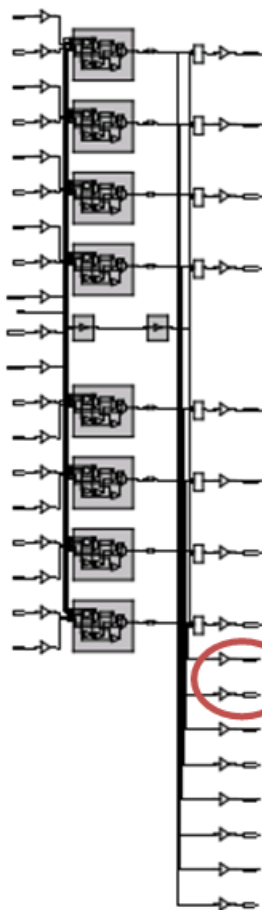
Verilog	<code>reg [7:0] alu_tmp /* synthesis syn_probe="test_pt"*/</code>
VHDL	<code>attribute syn_probe of alu_tmp : signal is "test_pt";</code>



After applying syn_probe with test_pt[]:

Verilog	reg [7:0] alu_tmp /* synthesis syn_probe="test_pt[]" */
---------	---

VHDL	attribute syn_probe of alu_tmp : signal is "test_pt[]";
------	---



syn_radhardlevel

Attribute

Implements designs with high reliability, using radiation-resistant techniques.

Vendor	Technologies
Microsemi	Anti-fuse (RT, RH and RD radhard devices) ProASIC3, ProASIC3E, ProASIC3L Fusion, SmartFusion, SmartFusion2 RTG4 IGLOO, IGLOO+, IGLOOE, IGLOO2

syn_radhardlevel for Microsemi

Some high reliability techniques are not available or appropriate for all Microsemi families. Use a design technique that is valid for the project. Contact Microsemi technical support for details.

You can apply `syn_radhardlevel` globally to the top-level module/architecture or on an individual register output signal (or inferred register in VHDL), and the tool uses the attribute value in conjunction with the Microsemi macro files supplied with the software. For more details about using this attribute, see [Specifying syn_radhardlevel in the Source Code, on page 542](#) and [Working with Radhard Designs, on page 541](#) in the *User Guide*.

syn_radhardlevel Values (Microsemi)

none	Default Uses standard design techniques, and does not insert any triple register logic.
tmr	<i>Anti-fuse (RT, RH, and RD radhard devices) ProASIC3, ProASIC3E, ProASIC3L, Fusion, SmartFusion, SmartFusion2, RTG4, IGLOO, IGLOO+, IGLOOE, IGLOO2</i> Uses triple module redundancy or triple voting to implement registers. Each register is implemented by three flip-flops or latches that “vote” to determine the state of the register. This option can potentially affect area and timing QoR because of the additional logic inserted, so be sure to check your area and timing goals when you use this option.

syn_radhardlevel Syntax (Microsemi)

Name	Global Attribute	Object
syn_radhardlevel	No	Module, architecture, register Verilog: output signal VHDL: architecture, signal

The following table summarizes the syntax in different files:

FDC	<code>define_attribute {object} syn_radhardlevel {none tmr}</code>	Constraint File Example
Verilog	<code>object /* synthesis syn_radhardlevel = none tmr */</code>	Verilog syn_radhardlevel Example
VHDL	<code>attribute syn_rardhardlevel : boolean; attribute syn_radhardlevel of object : object type is none tmr;</code>	VHDL syn_radhardlevel Example

Constraint File Example

```
define_attribute {dataout[3:0]} syn_radhardlevel {tmr}
```

Verilog syn_radhardlevel Example

```
//Top level
module top (clk, dataout, a, b);
input clk;
input a;
input b;
output [3:0] dataout;
M1 inst_M1 (a1, M3_out1, clk, rst, M1_out);
// Other code

//Sub modules subjected to DTMR
module M1 (a1, a2, clk, rst, q)
  /* synthesis syn_radhardlevel="tmr" */;
input clk;
input signed [15:0] a1,a2;
input clk, rst;
output signed [31:0] q;
// Other code
```

VHDL syn_radhardlevel Example

See [VHDL Attribute and Directive Syntax, on page 302](#) for alternate methods for specifying VHDL attributes and directives.

```
library synplify;
architecture top of top is
  attribute syn_radhardlevel : string;
  attribute syn_radhardlevel of top: architecture is "tmr";

  -- Other code
```

syn_ramstyle

Attribute

Specifies the implementation for an inferred RAM.

Vendor	Devices
Microsemi	ProASIC3, Fusion, SmartFusion2, IGLOO2, RTG4

syn_ramstyle Values

Default	Global Attribute	Object
block_ram	Yes	View, module, entity, RAM instance

The values for `syn_ramstyle` vary with the target technology. The following table lists all the valid `syn_ramstyle` values, some of which apply only to certain technologies. For details about using `syn_ramstyle`, see [RAM Attributes, on page 368](#) in the *User Guide*.

block_ram	Specifies that the inferred RAM be mapped to the appropriate device-specific memory. It uses the dedicated memory resources in the FPGA. By default, the software uses deep block RAM configurations instead of wide configurations to get better timing results. Using deeper RAMs reduces the output data delay timing by reducing the MUX logic at the output of the RAMs. By default the software does not use the parity bit for data with this option. Alternatively, you can specify a <code>ramType</code> value. See RAM Type Values and Implementations, on page 175 for details of how memory is implemented for different devices.
-----------	---

<code>no_rw_check</code>	By default, the synthesis tool inserts bypass logic around the inferred RAM to avoid simulation mismatches caused by indeterminate output values when reads and writes are made to the same address. When this option is specified, the synthesis tool does not insert glue logic around the RAM. You cannot use it with the <code>rw_check</code> option, as the two are mutually exclusive. There are other read-write check controls. See Read-Write Address Checks, on page 176 for details about the differences.
<code>no_rw_check_diff_clk</code>	When enabled, the synthesis tool prevents the insertion of bypass logic around the RAM. If you know your design has RAM that has a read clock and a write clock that are asynchronous, use <code>no_rw_check_diff_clk</code> to prevent the insertion of bypass logic. If this option is enabled, you should not set the asynchronous clock groups in your FDC file. For example, if you set the following, do not use this option: <pre>create_clock {p:clkr} -period {10} create_clock {p:clkw} -period {20} set_clock_groups -derive -asynchronous -name {async_clkgroup} -group { {c:clkw} }</pre> Note: The <code>no_rw_check</code>, <code>rw_check</code>, and <code>no_rw_check_diff_clk</code> options for the <code>syn_ramstyle</code> attribute are mutually exclusive and must not be used together. Whenever synthesis conflicts exist, the software uses the following order of precedence: first the <code>syn_ramstyle</code> attribute, the <code>syn_rw_conflict</code> attribute, and then the Automatic Read/Write check Insertion for RAM option on the Implementation Option panel.
<code>ramType</code>	Specifies a device-specific RAM implementation. Valid values for Microsemi include: <code>lsram</code>, <code>uram</code> See RAM Type Values and Implementations, on page 175 for details of how memory is implemented for different devices.
<code>registers</code>	Specifies that an inferred RAM be mapped to registers (flip-flops and logic), not technology-specific RAM resources.

<code>rw_check</code>	When enabled, the synthesis tool inserts bypass logic around the RAM to prevent a simulation mismatch between the RTL and post-synthesis simulations. You cannot use it with the <code>no_rw_check</code> option, as the two are mutually exclusive. There are other read-write check controls. See Read-Write Address Checks, on page 176 for details about the differences.
-----------------------	--

RAM Type Values and Implementations

The table lists RAM implementation information.

Vendor	Values	Implementation	Technology
Microsemi	ecc, set	RAM1K18_RT RAM64x18_RT	RTG4
	registers	Default: block_ram Registers	ProASIC3/ ProASIC3E/ ProASIC3L SmartFusion, Fusion IGLOO+, IGLOO IGLOOe
	lsram	RAM1K18, RAM1K18_RT	SmartFusion2, IGLOO2, RTG4
	uram	RAM64X18, RAM64X18_RT	
	registers	Registers	

Description

The `syn_ramstyle` attribute specifies the implementation to use for an inferred RAM. You can apply the attribute globally, to a module, or a RAM instance. You can also use `syn_ramstyle` to prevent the inference of a RAM, by setting it to `registers`. If your RAM resources are limited, you can map additional RAMs to registers instead of RAM resources using this setting.

The `syn_ramstyle` values vary with the technology.

Read-Write Address Checks

When reads and writes are made to the same address, the output could be indeterminate, and this can cause simulation mismatches. By default, the synthesis tool inserts bypass logic around an inferred RAM to avoid these mismatches. The synthesis tool offers multiple ways to specify how to handle read-write address checking:

Read Write Control	Use when ...
<code>syn_ramstyle</code>	You know your design does not read and write to the same address simultaneously and you want to specify the RAM implementation. The attribute has two mutually-exclusive read-write check options: • Use <code>no_rw_check</code> to eliminate bypass logic. If you enable global RAM inference with the Read Write Check on RAM option, you can use <code>no_rw_check</code> to selectively disable glue logic insertion for individual RAMs. • Use <code>rw_check</code> to insert bypass logic. If you disable global RAM inference with the Read Write Check on RAM option, you can use <code>rw_check</code> to selectively enable glue logic insertion for individual RAMs.
Read Write Check on RAM	You want to globally enable or disable glue logic insertion for all the RAMs in the design.

If there is a conflict, the software uses the following order of precedence:

- `syn_ramstyle` attribute settings
- `syn_rw_conflict_logic` attribute
- Read Write Check on RAM option on the Device panel of the Implementation Options dialog box.

`syn_ramstyle` Syntax

FDC	<code>define_attribute {signalname [bitRange]} -syn_ramstyle value</code> <code>define_global_attribute syn_ramstyle value</code>	FDC Example
Verilog	<code>object /* synthesis syn_ramstyle = value */</code>	Verilog Example
VHDL	<code>attribute syn_ramstyle of object : objectType is value ;</code>	VHDL Example

FDC Example

	Enabled	Object Type	Object	Attribute	Value	Val Type	Description
1	☒	<any>	<global>	syn_ramstyle	select_ram	string	Special implementation of inferred RAM

If you edit a constraint file to apply `syn_ramstyle`, be sure to include the range of the signal with the signal name. For example:

```
define_attribute {mem[7:0]} syn_ramstyle {registers};
define_attribute {mem[7:0]} syn_ramstyle {block_ram};
```

Verilog Example

```
module RAMB4_S4 (data_out, ADDR, data_in, EN, CLK, WE, RST);
output[3:0] data_out;
input [7:0] ADDR;
input [3:0] data_in;
input EN, CLK, WE, RST;
reg [3:0] mem [255:0] /* synthesis syn_ramstyle="block_ram" */;
reg [3:0] data_out;

always@(posedge CLK)
    if(EN)
        if(RST == 1)
            data_out <= 0;
        else
            begin
                if(WE == 1)
                    data_out <= data_in;
                else
                    data_out <= mem[ADDR];
            end
end

always @(posedge CLK)
if (EN && WE) mem[ADDR] = data_in;
endmodule
```

VHDL Example

```
library ieee;
use ieee.std_logic_1164.all;
USE ieee.numeric_std.ALL;
library synplify;
```

:

```
entity RAMB4_S4 is
  port (ADDR: in std_logic_vector(7 downto 0);
        data_in : in std_logic_vector(3 downto 0);
        WE : in std_logic;
        CLK : in std_logic;
        RST : in std_logic;
        EN : in std_logic;
        data_out : out std_logic_vector(3 downto 0));
end RAMB4_S4;

architecture rtl of RAMB4_S4 is
  type mem_type is array (255 downto 0) of std_logic_vector (3 downto 0);
  signal mem : mem_type;
  -- mem is the signal that defines the RAM
  attribute syn_ramstyle : string;
  attribute syn_ramstyle of mem : signal is "block_ram";

begin
  process (CLK)
  begin
    IF (CLK'event AND CLK = '1') THEN
      IF (EN = '1') THEN
        IF (RST = '1') THEN
          data_out <= "0000";
        ELSE
          IF (WE = '1') THEN
            data_out <= data_in;
          ELSE
            data_out <= mem(to_integer(unsigned(ADDR)));
          END IF;
        END IF;
      END IF;
    END IF;
  end process;

  process (CLK)
  begin
    IF (CLK'event AND CLK = '1') THEN
      IF (EN = '1' AND WE = '1') THEN
        mem(to_integer(unsigned(ADDR))) <= data_in;
      END IF;
    END IF;
  end process;

end rtl;
```

syn_reference_clock

Attribute

Specifies a clock frequency other than the one implied by the signal on the clock pin of the register.

Vendor	Technology	Default Value	Global	Object
Microsemi	SmartFusion2, ProASIC3	-	-	Register

Description

`syn_reference_clock` is a way to change clock frequencies other than using the signal on the clock pin. For example, when flip-flops have an enable with a regular pattern, such as every second clock cycle, use `syn_reference_clock` to have timing analysis treat the flip-flops as if they were connected to a clock at half the frequency.

To use `syn_reference_clock`, define a new clock, then apply its name to the registers you want to change.

FDC	<code>define_attribute {register} syn_reference_clock {clockName}</code>	FDC Example
-----	---	-----------------------------

FDC Example

```
define_attribute {register} syn_reference_clock {clockName}
```

For example:

```
define_attribute {myreg[31:0]} syn_reference_clock {sloClock}
```

You can also use `syn_reference_clock` to constrain multiple-cycle paths through the enable signal. Assign the find command to a collection (`clock_enable_col`), then refer to the collection when applying the `syn_reference_clock` constraint.

The following example shows how you can apply the constraint to all registers with the enable signal `en40`:

```
define_scope_collection clock_enable_col {find -seq * -filter
  (@clock_enable==en40)}
define_attribute {$clock_enable_col} syn_reference_clock {clk2}
```

:

Enable	Object Type	Object	Attribute	Value	Value Type	Description
☒	<any>	<Global>	syn_reference_clock	1	string	Override the default ...

Note: You apply `syn_reference_clock` only in a constraint file; you cannot use it in source code.

Effect of using `syn_reference_clock`

The following figure shows the report before applying the attribute:

Performance Summary *****							
Worst slack in design: 499.379							
Starting Clock	Requested Frequency	Estimated Frequency	Requested Period	Estimated Period	Slack	Clock Type	Clock Group
clk	2.0 MHz	1609.5 MHz	500.000	0.621	499.379	declared	default_clkgroup_0
ref_clk	1.0 MHz	NA	1000.000	NA	NA	declared	default_clkgroup_1

This is the report after applying the attribute:

Performance Summary *****							
Worst slack in design: 999.379							
Starting Clock	Requested Frequency	Estimated Frequency	Requested Period	Estimated Period	Slack	Clock Type	Clock Group
clk	2.0 MHz	NA	500.000	NA	NA	declared	default_clkgroup_0
ref_clk	1.0 MHz	1609.5 MHz	1000.000	0.621	999.379	declared	default_clkgroup_1

syn_replicate

Attribute

Controls replication of registers during optimization.

Vendor	Technologies
Microsemi	SmartFusion and older families

syn_replicate values

Value	Default	Global	Object	Description
0	No	Yes	Register	Disables duplication of registers
1	Yes	Yes	Register	Allows duplication of registers

Description

The synthesis tool automatically replicates registers while optimizing the design and fixing fanouts, packing I/Os, or improving the quality of results.

If area is a concern, you can use this attribute to disable replication either globally or on a per-register basis. When you disable replication globally, it disables I/O packing and other QoR optimizations. When it is disabled, the synthesis tool uses only buffering to meet maximum fanout guidelines.

To disable I/O packing on specific registers, set the attribute to 0. Similarly, you can use it on a register between clock boundaries to prevent replication. Take an example where the tool replicates a register that is clocked by clk1 but whose fanin cone is driven by clk2, even though clk2 is an unrelated clock in another clock group. By setting the attribute for the register to 0, you can disable this replication.

syn_replicate Syntax Specification

FDC	<code>define_global_attribute syn_replicate {0 1};</code>	FDC Example
Verilog	<code>object /* synthesis syn_replicate = 1 0 */;</code>	Verilog Example
VHDL	<code>attribute syn_replicate : boolean; attribute syn_replicate of object : signal is true false;</code>	VHDL Example

FDC Example

Enabled	Object Type	Object	Attribute	Value	Val Type	Description	Comment
☒	global	<global>	syn_replicate	0	boolean	Controls replication of registers	

Verilog Example

```

module norep (Reset, Clk, Drive, OK, ADPad, IPad, ADOut);
input Reset, Clk, Drive, OK;
input [6:0] ADOut;
inout [6:0] ADPad;
output [6:0] IPad;
reg [6:0] IPad;
reg DriveA /* synthesis syn_replicate = 0 */;
assign ADPad = DriveA ? ADOut : 32'bz;

always @(posedge Clk or negedge Reset)
  if (!Reset)
    begin
      DriveA <= 0;
      IPad <= 0;
    end
  else
    begin
      DriveA <= Drive & OK;
      IPad <= ADPad;
    end
endmodule

```

VHDL Example

```

library IEEE;
use ieee.std_logic_1164.all;

entity norep is
  port (Reset : in std_logic;
        Clk : in std_logic;
        Drive : in std_logic;
        OK : in std_logic;
        ADPad : inout std_logic_vector (6 downto 0);
        IPad : out std_logic_vector (6 downto 0);
        ADOut : in std_logic_vector (6 downto 0) );
end norep;

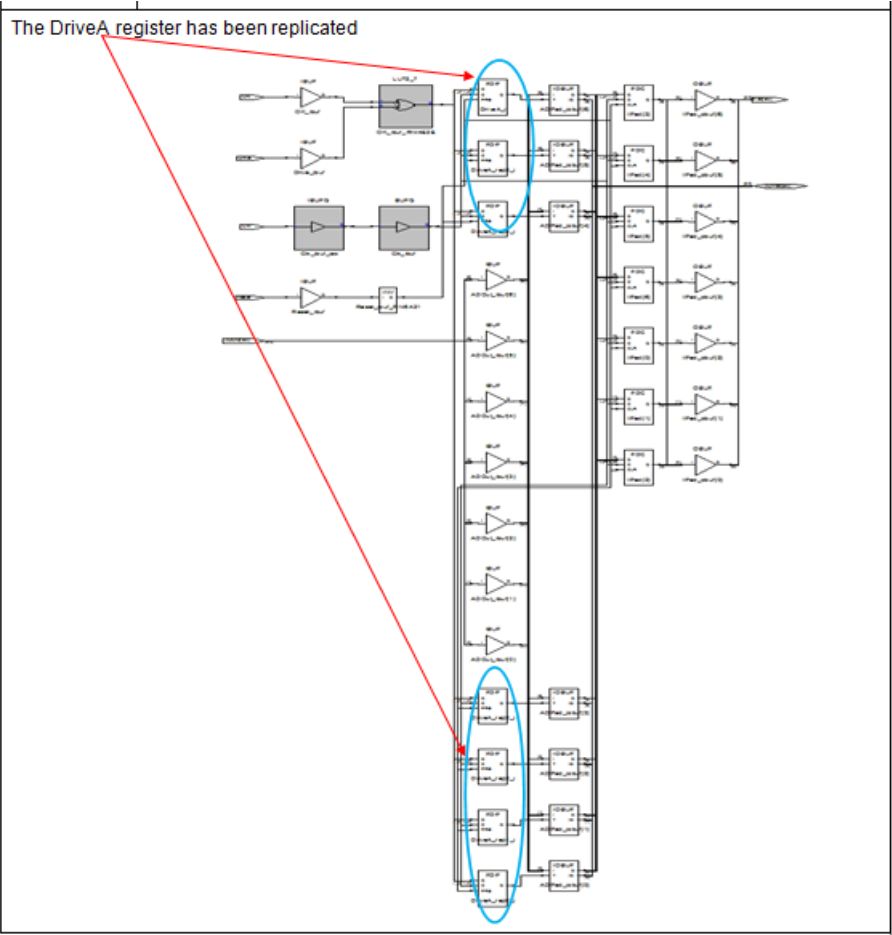
architecture archnorep of norep is
  signal DriveA : std_logic;
  attribute syn_replicate : boolean;
  attribute syn_replicate of DriveA : signal is false;
begin
  ADPad <= ADOut when DriveA='1' else (others => 'Z');
  process (Clk, Reset)
  begin
    if Reset='0' then
      DriveA <= '0';
      IPad <= (others => '0');
    elsif rising_edge(clk) then
      DriveA <= Drive and OK;
      IPad <= ADPad;
    end if;
  end process;
end archnorep;

```

Effect of Using syn_replicate

The following example shows a design without the syn_replicate attribute:

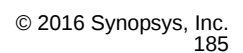
Verilog	reg DriveA /*synthesis syn_replicate=1*/
VHDL	attribute syn_replicate : boolean; attribute syn_replicate of DriveA : signal is true;



When you apply `syn_replicate`, the registers are not duplicated:

Verilog `reg DriveA /*synthesis syn_replicate=0*/`

VHDL `attribute syn_replicate : boolean;`
 `attribute syn_replicate of DriveA : signal is false;`



syn_resources

Attribute

Specifies the resources used inside a black box.

Vendor	Technology
Microsemi	ProASIC3, IGLOO, Fusion, and SmartFusion families

syn_resources Values

Global Support	Object
No	Module or architecture

The value for this attribute can be specified with any combination of the following:

Value	Description
blockrams = <i>integer</i>	Number of RAM resources
corecells = <i>integer</i>	Number of core cells

Description

Specifies the resources used inside a black box. This attribute is applied to Verilog black-box modules and VHDL architectures or component definitions.

syn_resources Syntax

The following table summarizes the syntax in different files.

FDC	<code>define_attribute {v:moduleName} syn_resources {corecells=<i>integer</i> blockrams=<i>integer</i>}</code>	FDC Example
Verilog	<code>object /* synthesis syn_resources = value */;</code>	Example – Verilog syn_resources (Microsemi)
VHDL	<code>attribute syn_resources : string; attribute syn_resources of <i>object</i> : <i>objectType</i> is <i>value</i>;</code>	Example – VHDL syn_resources (Microsemi)

FDC Example

	Enable	Object Type	Object	Attribute	Value	Value Type	Description
1	☒	<any>	v:bb	syn_resources	corecells=300, blockrams=5	string	Specifies the resources used inside a black box

You can apply the attribute to more than one kind of resource at a time by separating assignments with a comma (,). For example:

```
define_attribute {v:bb} syn_resources {corecells=300, blockrams=5}
```

Example – Verilog syn_resources (Microsemi)

In Verilog, you can only attach this attribute to a module. Here is the example,

Example – VHDL syn_resources (Microsemi)

In VHDL, this attribute can be placed on either an architecture or a component declaration.

Effect of Using syn_resources (Microsemi)

You can check the Resource Utilization report in the log file to verify how resources are actually mapped.

```
Target Part: A3P015_QFN68_-1
Report for cell top.top_rtl
Core Cell usage:
      cell count      area count*area
corecells    300      1.0      300.0 (blackbox):bb
      GND        1      0.0        0.0
      VCC        1      0.0        0.0

      -----
      TOTAL      2              300.0

IO Cell usage:
      cell count
INBUF      1
OUTBUF     1
      -----
      TOTAL      2

Core Cells      : 300 of 384 (78%)
IO Cells       : 2
Mapper successful!
```

syn_safe_case

Directive

This directive enables/disables the safe case option.

Vendor Technologies

Microsemi

syn_safe_case Values

Value	Description	Default	Global
false 0	Turns off the safe case option.	false 0	No
true 1	Turns on the safe case option.		

Description

This directive enables/disables the safe case option. When enabled, the high reliability safe case option turns off sequential optimizations for counters, FSM, and sequential logic to increase the reliability of the circuit. If you set this directive on a module or architecture, the module or architecture is treated as safe and all case statements within it are implemented as safe.

The `syn_safe_case` directive can perform operations on FSMs and pmuxes to preserve default states and inject fault recovery logic to the default case. Using this directive might produce different results than the Preserve and Decode Unreachable States option.

For more information, see [Specifying Safe FSMs, on page 362](#)

syn_safe_case Syntax

Verilog	<code>module /* syn_safe_case = "1 0" */;</code>	Verilog Example
VHDL	<code>attribute syn_safe_case : boolean; attribute syn_safe_case of architectureName: architecture is "true false";</code>	VHDL Example

Verilog Example

For example:

```
module top (input a, output b) /* synthesis syn_safe_case =1 */
```

VHDL Example

For example:

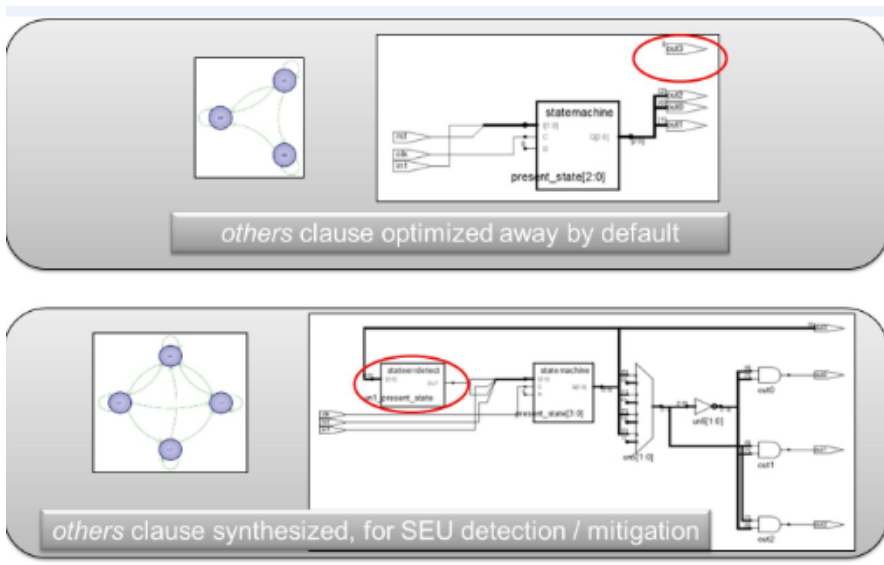
```
library ieee;
use ieee.std_logic_1164.all;

entity test is
port (a input std_logic;
      b: out std_logic);
end test;

architecture rtl of test is
attribute syn_safe_case: boolean;
attribute syn_safe_case of rtl : architecture is "TRUE";
```

Effect of Using syn_safe_case

This example shows the others clause optimized away; then synthesized for SEU detection and mitigation when the syn_safe_case directive is enabled.



syn_sharing

Directive

Enables or disables the sharing of operator resources during the compilation stage of synthesis.

Technology	Default Value	Global	Object
All	On	Yes	Component, module

syn_sharing Values

Value	Description
off	Does not share resources during the compilation stage of synthesis.
on (Default)	Optimizes the design to perform resource sharing during the compilation stage of synthesis.

Description

The `syn_sharing` directive controls resource sharing during the compilation stage of synthesis. This is a compiler-specific optimization that does not affect the mapper; this means that the mapper might still perform resource sharing optimizations to improve timing, even if `syn_sharing` is disabled.

You can also specify global resource sharing with the Resource Sharing option in the Project view, from the Project->Implementation Options->Options panel, or with the `set_option -resource_sharing Tcl` command.

If you disable resource sharing globally, you can use the `syn_sharing` directive to turn on resource sharing for specific modules or architectures. See [Sharing Resources, on page 402](#) in the *User Guide* for a detailed procedure.

syn_sharing Syntax

Verilog	<code>object /* synthesis syn_sharing="on off" */;</code>	Verilog Example
VHDL	<code>attribute syn_sharing of object : objectType is "true false";</code>	VHDL Example

Verilog Example

```
module add (a, b, x, y, out1, out2, sel, en, clk)
    /* synthesis syn_sharing=off */;

    input a, b, x, y, sel, en, clk;
    output out1, out2;
    wire tmp1, tmp2;
    assign tmp1 = a * b;
    assign tmp2 = x * y;
    reg out1, out2;

    always@(posedge clk)
        if (en)
            begin
                out1 <= sel ? tmp1: tmp2;
            end
        else
            begin
                out2 <= sel ? tmp1: tmp2;
            end
    end
endmodule
```

VHDL Example

```
library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;
entity add is
    port (a, b : in std_logic_vector(1 downto 0);
          x, y : in std_logic_vector(1 downto 0);
          clk, sel, en: in std_logic;
          out1 : out std_logic_vector(3 downto 0);
          out2 : out std_logic_vector(3 downto 0)
    );
end add;
architecture rtl of add is

    attribute syn_sharing : string;
    attribute syn_sharing of rtl: architecture is "true";

    signal tmp1, tmp2: std_logic_vector(3 downto 0);
begin
    tmp1 <= a * b;
    tmp2 <= x * y;

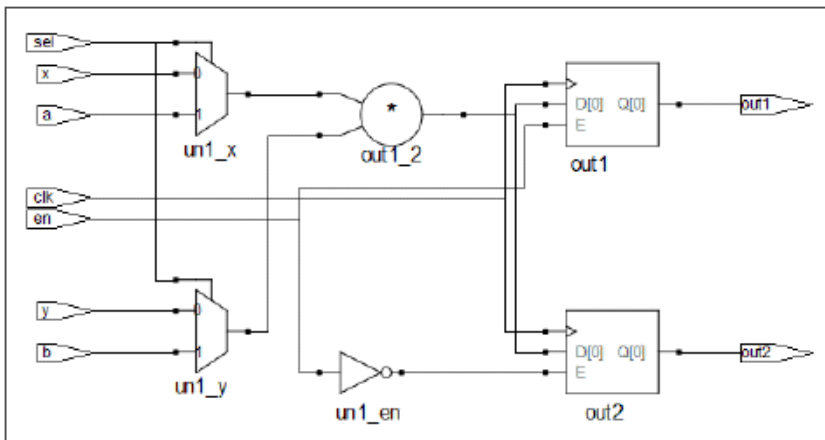
    process(clk) begin
        if clk'event and clk='1' then
            if (en='1') then
                if (sel='1') then
                    out1 <= tmp1;
                else
                    out1 <= tmp2;
                end if;
            else
                if (sel='1') then
                    out2 <= tmp1;
                else
                    out2 <= tmp2;
                end if;
            end if;
        end if;
    end process;
end rtl;
```

Effect of Using syn_sharing

The following example shows the default setting, where resource sharing in the compiler is on:

Verilog module add /* synthesis syn_sharing = "on" */;

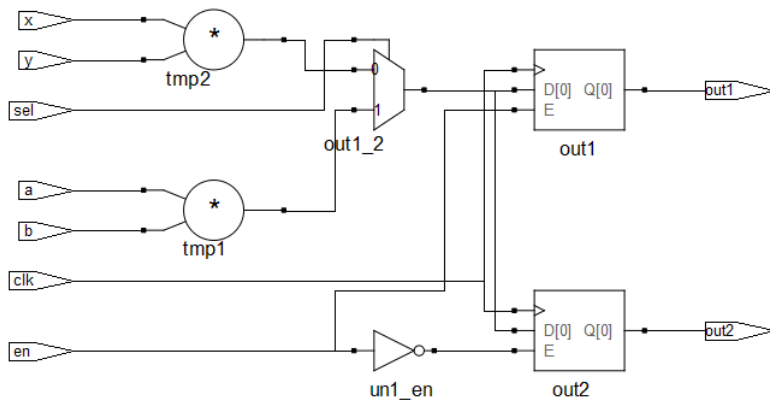
VHDL attribute syn_sharing of add : architecture is "on";



The next figure shows the same design when resource sharing is off, and two adders are inferred:

Verilog `module add /* synthesis syn_sharing = "off" */;`

VHDL `attribute syn_sharing of add : component is "off";`



syn_shift_resetphase

Attribute

Allows you to remove the flip-flop on the inactive clock edge, built by the reset recovery logic for an FSM when a single event upset (SEU) fault occurs.

Vendor	Technology
Microsemi	SmartFusion/2, RT ProASIC3, ProASIC3/3E/3L, IGLOO/+ /E/2

syn_shift_resetphase Values

Value	Description
1 (Default)	The flip-flop on the inactive clock edge is present.
0	Removes the flip-flop on the inactive clock edge.

Description

When a single event upset (SEU) fault occurs, the FSM can transition to an unreachable state. The `syn_encoding` attribute with a value of `safe` provides a mechanism to build additional logic for recovery to the specified reset state. For an FSM with asynchronous reset, the software inserts an additional flip-flop to the recovery logic path on the opposite edge of the design clock, isolating the reset. You can use the `syn_shift_resetphase` attribute to remove this additional flip-flop on the inactive clock edge, if necessary.

For more information about the `syn_encoding` attribute, see [syn_encoding, on page 57](#).

syn_shift_resetphase Syntax

Global Support	Object
Yes	FSM instance

The following table summarizes the syntax in different files:

FDC	define_attribute <i>object</i> {syn_shift_resetphase} {1 0} define_global_attribute {syn_shift_resetphase} {1 0}	SCOPE Example
Verilog	<i>object</i> /* synthesis syn_shift_resetphase = "1 0" */;	Verilog Example
VHDL	attribute syn_shift_resetphase of <i>state</i> : signal is "true false";	VHDL Example

SCOPE Example

	Enable	Object Type	Object	Attribute	Value	Value Type	Description	Comment
1	☒	instance	i:present_state[11:0]	syn_shift_resetphase	0			

The Tcl equivalent is shown below:

```
define_attribute {i:present_state[11:0]}{syn_shift_resetphase}{0}
```

Verilog Example

Apply the syn_shift_resetphase attribute on the top module or state register as shown in the Verilog code segment below.

```
module test (clk, rst, in, out)
  /* synthesis syn_shift_resetphase = 0 */;
  ...

  reg [3:0] present_state
    /* synthesis syn_shift_resetphase = 0 */, next_state;

  ...

endmodule
```

VHDL Example

Here is a VHDL code segment showing how to use the syn_shift_resetphase attribute.

```
entity fsm is
  ...

end fsm;
```

```

architecture rtl of fsm is
  signal present_state : std_logic_vector(3 downto 0);

  -- Specifying on the architecture

  attribute syn_shift_resetphase : boolean;
  attribute syn_shift_resetphase of rtl : architecture is false;

  -- Specifying on the state signal

  attribute syn_shift_resetphase : boolean;
  attribute syn_shift_resetphase of present_state : signal is false;
begin

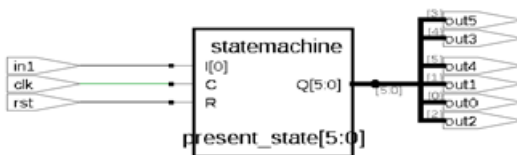
  ...

end rtl;

```

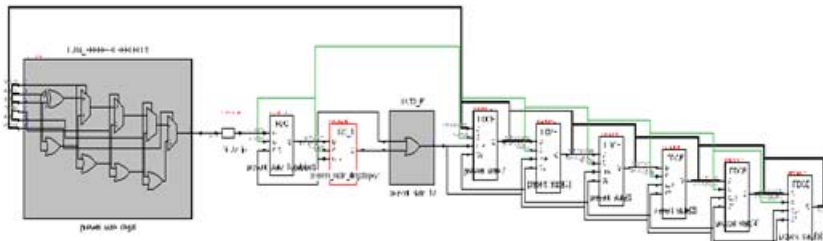
Effect of Using syn_shift_resetphase

Safe encoding is implemented for the following state machine.



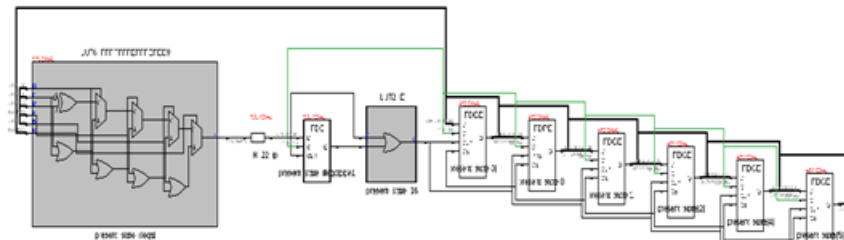
This example shows Technology view results before the `syn_shift_resetphase` attribute is applied.

Enable	Object Type	Object	Attribute	Value
✓	<any>	ipresent_state[5:0]	syn_encoding	safe,onehot



This example shows Technology view results after the syn_shift_resetphase attribute is applied.

Enable	Object Type	Object	Attribute	Value
✓	<any>	ipresent_state[5:0]	syn_encoding	safe,onehot
✓	<any>	<Global>	syn_shift_resetphase	0



syn_srlstyle

Attribute

Determines how to implement sequential shift components.

Vendor	Devices
Microsemi	SmartFusion2, IGLOO2, RTG4

syn_srlstyle Values

Default	Global	Object
Registers	Yes	view, module, entity, seqshift instance

Value	Description
Registers	seqshifts are inferred as registers.
URAM	seqshift is inferred as: • RAM64x18 for SmartFusion2 and IGLOO2 devices • RAM64x18_RT for RTG4 device.

Description

URAM inference for sequential shift registers is supported for SmartFusion2, IGLOO2, and RTG4 technologies.

By default, seqshift is implemented using registers. The syn_srlstyle attribute is used to override the default behavior of seqshift implementation using URAM.

The attribute can be applied on the top level module or on a seqshift instance in the RTL view, by dragging and dropping the instance to the SCOPE editor.

If the attribute is applied on the top level module, the tool infers URAM for all the seqshifts in the design, using the following threshold values:

Depth ≥ 8 and Depth*Width > 84

If the attribute is applied on the seqshift instance, the tool infers URAM irrespective of the threshold values.

syn_srlstyle Syntax

FDC	define_attribute {object} syn_srlstyle {registers uram } define_global_attribute syn_srlstyle {registers uram }
Verilog	object /* synthesis syn_srlstyle = "registers uram " */ ;
VHDL	attribute syn_srlstyle : string; attribute syn_srlstyle of object : signal is "registers uram ";

FDC Example

	Enable	Object Type	Object	Attribute	Value	Value Type	Description
1	☒	register	i tmp[7:0]	syn_srlstyle	uram	string	Determines how seq. shift ...

Verilog Example

The tool infers a seqshift primitive for the given RTL:

```
module p_seqshift (clk, we, din, dout) ;

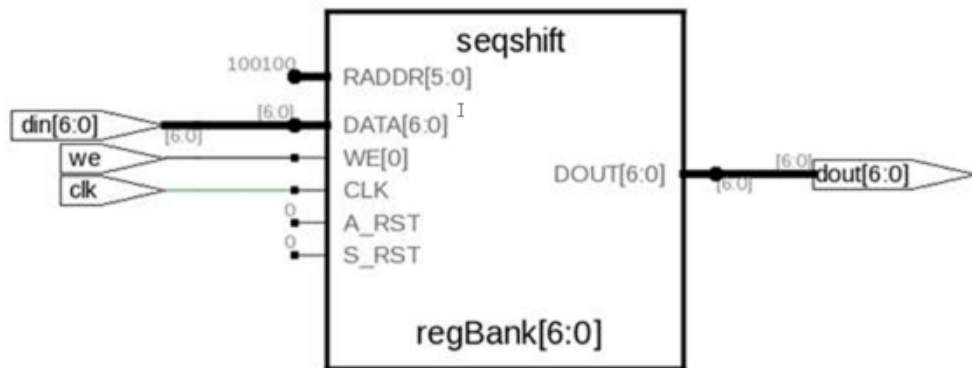
parameter SRL_WIDTH = 7;
parameter SRL_DEPTH = 37;

input clk, we;
input [SRL_WIDTH-1:0] din;
output [SRL_WIDTH-1:0] dout;
reg [SRL_WIDTH-1:0] regBank[SRL_DEPTH-1:0] /*synthesis syn_srlstyle
= "uram"*/ ;
integer i;
```

```
always @(posedge clk) begin
    if (we) begin
        for (i=SRL_DEPTH-1; i>0; i=i-1) begin
            regBank[i] <= regBank[i-1];
        end
        regBank[0] <= din;
    end
end

assign dout = regBank[SRL_DEPTH-1];
endmodule
```

The following graphic displays seqshift for the RTL above in technology view.



syn_state_machine

Directive

Enables/disables state-machine optimization on individual state registers in the design.

Technology	Default Value	Global	Object
All	Default is determined by the global FSM Compiler option. set_option -symbolic_fsm_compiler 1	Yes	Component, module

syn_state_machine Values

Value	Description
off false	Does not extract state machines automatically.
on true	Automatically extracts state machines.

Description

Enables/disables state-machine optimization on individual state registers in the design. When you disable the FSM Compiler, state-machines are not automatically extracted. To extract some state machines, use this directive with a value of 1 on just those individual state-registers to be extracted. Conversely, when the FSM Compiler is enabled and there are state machines in your design that you do not want extracted, use syn_state_machine with a value of 0 to override extraction on just those individual state registers.

Also, when the FSM Compiler is enabled, all state machines are usually detected during synthesis. However, on occasion there are cases in which certain state machines are not detected. You can use this directive to declare those undetected registers as state machines.

syn_state_machine Syntax

Verilog	<code>object /* synthesis syn_state_machine = "0 1" */;</code>	Example – Verilog syn_state_machine
VHDL	<code>attribute syn_state_machine of state : signal is "false true";</code>	Example – VHDL syn_state_machine

For Verilog:

- *object* is a state register.
- Data type is Boolean: 0 does not extract an FSM, 1 extracts an FSM.

```
reg [7:0] current_state /* synthesis syn_state_machine=1 */;
```

For VHDL:

- *state* is a signal that holds the value of the state machine.
- Data type is Boolean: false does not extract an FSM, true extracts an FSM.

```
attribute syn_state_machine of current_state: signal is true;
```

Example – Verilog syn_state_machine

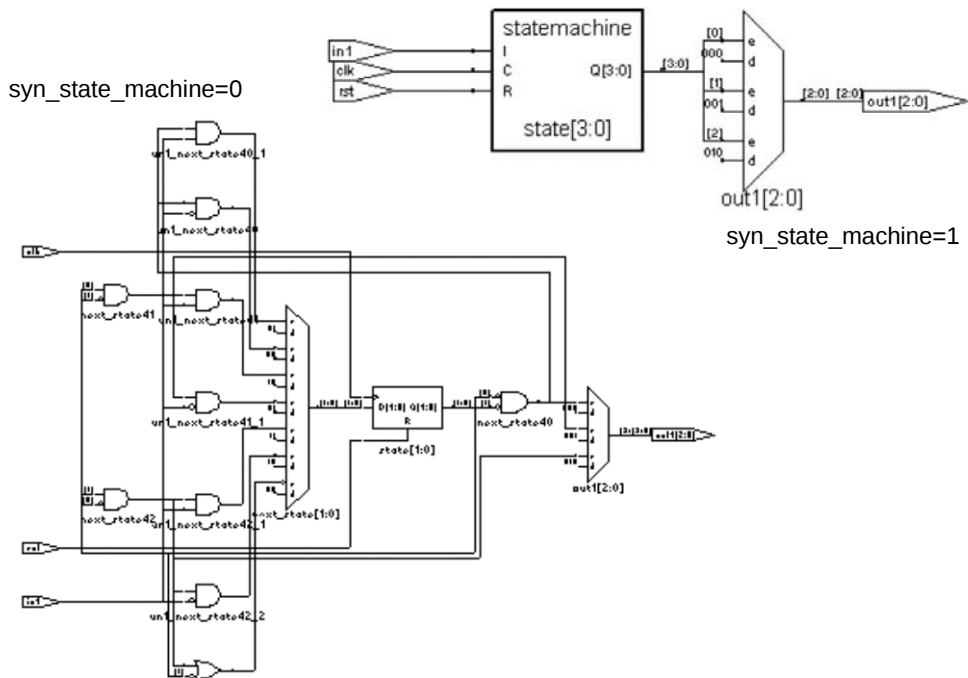
This is the Verilog source code used for the example in the following figure.

Example – VHDL syn_state_machine

This is the VHDL source code used for the example in the following figure.

Effect of Using syn_state_machine

The following figure shows an example of two implementations of a state machine: one with the `syn_state_machine` directive enabled, the other with the directive disabled.



See the following HDL syntax and example sections for the source code used to generate the schematics above. See also:

- [syn_encoding](#), on page 57 for information on overriding default encoding styles for state machines.
- For VHDL designs, [syn_encoding Compared to syn_enum_encoding](#), on page 68 for usage information about these two directives.

syn_tco<n>

Directive

Supplies the clock to output timing-delay through a black box.

Description

Used with the syn_black_box directive; supplies the clock to output timing-delay through a black box.

The syn_tco<n> directive is one of several directives that you can use with the syn_black_box directive to define timing for a black box. See [syn_black_box](#), on [page 50](#) for a list of the associated directives.

syn_tco<n> Syntax

Verilog *object* **!*** syn_tcon = "[!]clock -> bundle = value" *!;

VHDL **attribute** syn_tcon of *object* : *objectType* is "[!]clock -> bundle = value";

The syn_tco<n> directive can be entered as an attribute using the Attributes panel of the SCOPE editor. The information in the Object, Attribute, and Value fields must be manually entered. This is the constraint file syntax for the directive:

```
define_attribute {v:blackboxModule} syn_tcon {![]clock->bundle=value}
```

For details about the syntax, see the following table:

v:	Constraint file syntax that indicates the directive is attached to the view.
<i>blackboxModule</i>	The symbol name of the black-box.
<i>n</i>	A numerical suffix that lets you specify different clock to output timing delays for multiple signals/bundles.
!	The optional exclamation mark indicates that the clock is active on its falling (negative) edge.
<i>clock</i>	The name of the clock signal.

bundle A bundle is a collection of buses and scalar signals. The objects of a bundle must be separated by commas with no intervening spaces. A valid bundle is A,B,C, which lists three signals. To assign values to bundles, use the following syntax:

`[!]clock->bundle=value`

The values are in ns.

value Clock to output delay value in ns.

Constraint file example:

```
define_attribute {v:work.test} {syn_tsu4} {clk->tout=1.0}
```

Verilog Example

object /* `syn_tcon = "[!]clock -> bundle = value" */;`

See [syn_tco<n> Syntax, on page 208](#) for syntax explanations. The following example defines syn_tco<n> and other black-box constraints:

```
module test(myclk, a, b, tout,)
    /*synthesis syn_black_box syn_tco1="clk->tout=1.0"
      syn_tpd1="b->tout=8.0" syn_tsu1="a->myclk=2.0" */;
  input myclk;
  input a, b;
  output tout;
endmodule

//Top Level
module top (input clk, input a, b, output fout);
  test U1 (clk, a, b, fout);
endmodule
```

VHDL Example

In VHDL, there are ten predefined instances of each of these directives in the synply library: syn_tco1, syn_tco2, syn_tco3, ... syn_tco10. If you are entering the timing directives in the source code and you require more than 10 different timing delay values for any one of the directives, declare the additional directives with an integer greater than 10. For example:

```
attribute syn_tco11 : string;
attribute syn_tco12 : string;
```

See [syn_tco<n> Syntax, on page 208](#) for other syntax explanations.

See [VHDL Attribute and Directive Syntax, on page 302](#) for alternate methods for specifying VHDL attributes and directives.

The following example defines syn_tco<n> and other black-box constraints:

```
library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;
entity test is
generic (size: integer := 8);
port (tout : out std_logic_vector (size- 1 downto 0);
      a : in std_logic_vector (size- 1 downto 0);
      b : in std_logic_vector (size- 1 downto 0);
      myclk : in std_logic);

attribute syn_isclock : boolean;
attribute syn_isclock of myclk: signal is true;
end;

architecture rtl of test is
attribute syn_black_box : boolean;
attribute syn_black_box of rtl: architecture is true;
begin
end;

-- TOP Level--
library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;
entity top is
generic (size: integer := 8);
port (fout : out std_logic_vector(size- 1 downto 0);
      a : in std_logic_vector (size- 1 downto 0);
      b : in std_logic_vector (size- 1 downto 0);
      clk : in std_logic
    );
end;

architecture rtl of top is
component test
generic (size: integer := 8);
port (tout : out std_logic_vector(size- 1 downto 0);
      a : in std_logic_vector (size- 1 downto 0);
      b : in std_logic_vector (size- 1 downto 0);
      myclk : in std_logic
```

```
);  
end component;  
  
attribute syn_tco1 : string;  
attribute syn_tco1 of test : component is  
    "clk->tout = 1.0";  
attribute syn_tpd1 : string;  
attribute syn_tpd1 of test : component is  
    "b->tout= 2.0";  
attribute syn_tsu1 : string;  
attribute syn_tsu1 of test : component is  
    "a-> myclk = 1.2";  
begin  
U1 : test port map(fout, a, b, clk);  
end;
```

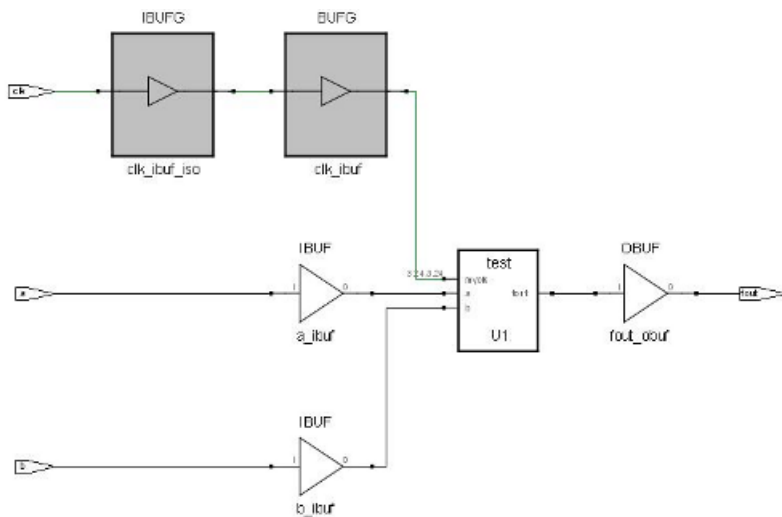
Verilog-Style Syntax in VHDL for Black Box Timing

In addition to the syntax used in the code above, you can also use the following Verilog-style syntax to specify black-box timing constraints:

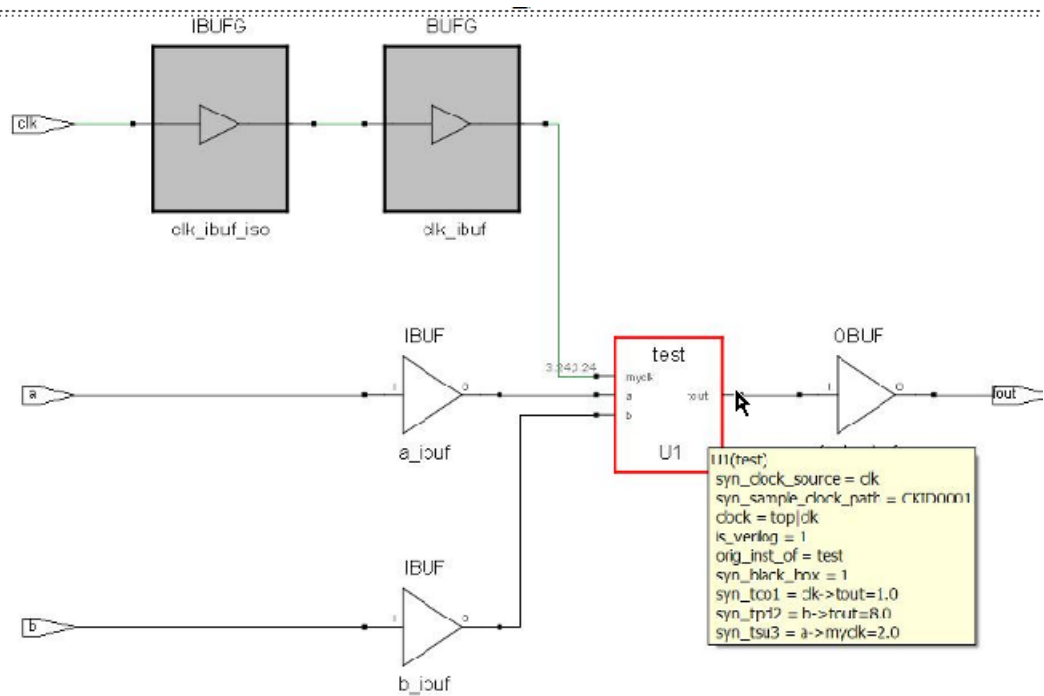
```
attribute syn_tco1 of inputfifo_coregen : component is  
    "rd_clk->dout [48:0]=3.0";
```

Effect of using syn_tco

This figure shows the HDL Analyst Technology view before using syn_tco:



This figure shows the HDL Analyst Technology view after using syn_tco:



syn_tpd<n>

Directive

Supplies information on timing propagation for combinational delays through a black box.

Description

Used with the syn_black_box directive; supplies information on timing propagation for combinational delay through a black box.

The syn_tpd<n> directive is one of several directives that you can use with the syn_black_box directive to define timing for a black box. See [syn_black_box](#), on page 50 for a list of the associated directives.

syn_tpd<n> Syntax

Verilog *object !* syn_tpdn = "bundle -> bundle = value" *!;*

VHDL **attribute syn_tpdn of object : objectType is "bundle -> bundle = value";**

You can enter the syn_tpd<n> directive as an attribute using the Attributes panel of the SCOPE editor. The information in the Object, Attribute, and Value fields must be manually entered. This is the constraint file syntax:

define_attribute {v:blackboxModule} syn_tpdn {bundle->bundle=value}

For details about the syntax, see the following table:

v:	Constraint file syntax that indicates the directive is attached to the view.
<i>blackboxModule</i>	The symbol name of the black-box.

<i>n</i>	A numerical suffix that lets you specify different input to output timing delays for multiple signals/bundles.
<i>bundle</i>	A bundle is a collection of buses and scalar signals. The objects of a bundle must be separated by commas with no intervening spaces. A valid bundle is A,B,C, which lists three signals. "bundle->bundle=value" The values are in ns.
<i>value</i>	Input to output delay value in ns.

Constraint file example:

```
define_attribute {v:MEM} syn_tpd1 {MEM_RD->DATA_OUT[63:0]=20}
```

Verilog Example

See [syn_tpd<n> Syntax, on page 214](#) for an explanation of the syntax. This is an example of syn_tpd<n> along with some of the other black-box timing constraints:

```
module test(myclk, a, b, tout,)
  /*synthesis syn_black_box syn_tcol="clk->tout=1.0"
    syn_tpd1="b->tout=8.0" syn_tsul="a->myclk=2.0" */;
  input myclk;
  input a, b;
  output tout;
endmodule

//Top Level
module top(input clk, input a, b, output fout);
  test U1 (clk, a, b, fout);
endmodule
```

VHDL Example

In VHDL, there are 10 predefined instances of each of these directives in the synplify library, for example: syn_tpd1, syn_tpd2, syn_tpd3, ... syn_tpd10. If you are entering the timing directives in the source code and you require more than 10 different timing delay values for any one of the directives, declare the additional directives with an integer greater than 10. For example:

```
attribute syn_tpd11 : string;
attribute syn_tpd11 of bitreg : component is
    "di0,di1 -> do0,do1 = 2.0";
attribute syn_tpd12 : string;
attribute syn_tpd12 of bitreg : component is
    "di2,di3 -> do2,do3 = 1.8";
```

See [syn_tpd<n> Syntax, on page 214](#) for an explanation of the syntax.

See [VHDL Attribute and Directive Syntax, on page 302](#) for different ways to specify VHDL attributes and directives.

The following is an example of assigning syn_tpd<n> along with some of the black box constraints. See [Verilog-Style Syntax in VHDL for Black Box Timing, on page 211](#) for another way.

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

entity test is
generic (size: integer := 8);
port (tout : out std_logic_vector(size- 1 downto 0);
      a : in std_logic_vector (size- 1 downto 0);
      b : in std_logic_vector (size- 1 downto 0);
      myclk : in std_logic);
attribute syn_isclock : boolean;
attribute syn_isclock of myclk: signal is true;
end;

architecture rtl of test is
attribute syn_black_box : boolean;
attribute syn_black_box of rtl: architecture is true;
begin
end;
```

```

-- TOP Level--
library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;
entity top is
generic (size: integer := 8);
port (fout : out std_logic_vector(size- 1 downto 0);
      a : in std_logic_vector (size- 1 downto 0);
      b : in std_logic_vector (size- 1 downto 0);
      clk : in std_logic
      );
end;

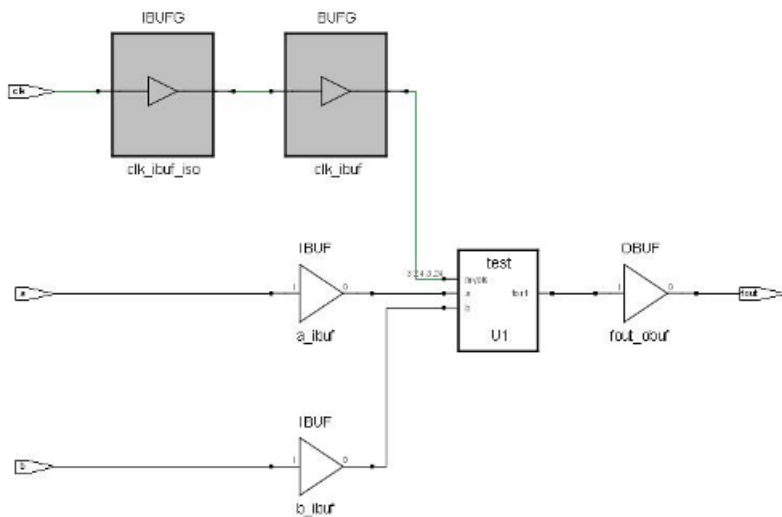
architecture rtl of top is
component test
generic (size: integer := 8);
port (tout : out std_logic_vector(size- 1 downto 0);
      a : in std_logic_vector (size- 1 downto 0);
      b : in std_logic_vector (size- 1 downto 0);
      myclk : in std_logic
      );
end component;

attribute syn_tcol : string;
attribute syn_tcol of test : component is
"clk->tout = 1.0";
attribute syn_tpd1 : string;
attribute syn_tpd1 of test : component is
"b->tout= 2.0";
attribute syn_tsu1 : string;
attribute syn_tsu1 of test : component is
"a-> myclk = 1.2";
begin
U1 : test port map(fout, a, b, clk);
end;

```

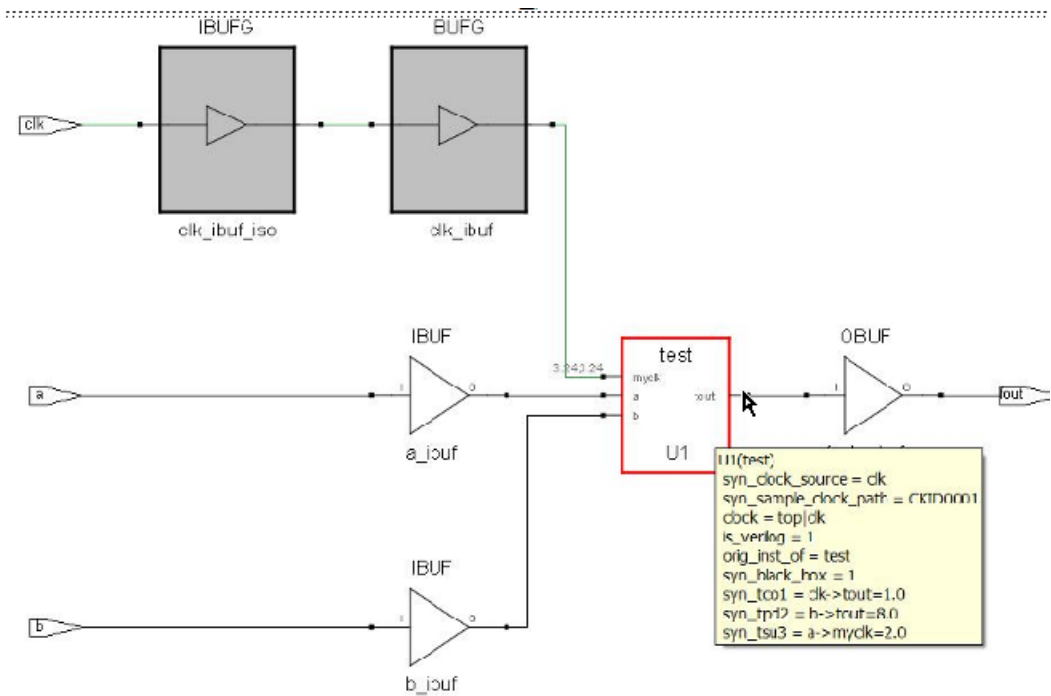
Effect of using syn_tpd

This figure shows the HDL Analyst Technology view before using syn_tpd:



After using syn_tpd

This figure shows the HDL Analyst Technology view after using syn_tpd:



syn_tristate

Directive

Specifies that an output port on a black box is a tristate.

syn_tristate Values

Value	Default
0	Yes
1	

Description

You can use this directive to specify that an output port on a module defined as a black box is a tristate. This directive eliminates multiple driver errors if the output of a black box has more than one driver. A multiple driver error is issued unless you use this directive to specify that the outputs are tristate.

syn_tristate Syntax

Verilog	<i>object</i> /* synthesis syn_tristate = 1 */;
VHDL	attribute syn_tristate : boolean; attribute syn_tristate of tout: signal is true;

Verilog Example

```
module test(myclk, a, b, tout) /* synthesis syn_black_box */;
input myclk;
input a, b;
output tout/* synthesis syn_tristate = 1 */;
endmodule

//Top Level
module top(input [1:0]en, input clk, input a, b, output reg fout);
wire tmp;
assign tmp = en[0] ? (a & b) : 1'bz;
assign tmp = en[1] ? (a | b) : 1'bz;
always@(posedge clk)
```

```

begin
fout <= tmp;
end
test U1 (clk, a, b, tmp);
endmodule

```

VHDL Example

```

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

entity test is
port (tout : out std_logic;
      a : in std_logic;
      b : in std_logic;
      myclk : in std_logic);

attribute syn_tristate : boolean;
attribute syn_tristate of tout: signal is true;
end;

architecture rtl of test is
attribute syn_black_box : boolean;
attribute syn_black_box of rtl: architecture is true;
begin
end;

-- TOP Level--
library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;
entity top is
port (fout : out std_logic;
      a : in std_logic;
      b : in std_logic;
      en: in std_logic_vector(1 downto 0);
      clk : in std_logic
      );
end;

architecture rtl of top is
signal tmp : std_logic;
component test
port (tout : out std_logic;
      a : in std_logic;

```

```
        b :    in std_logic;
        myclk : in std_logic
    );
end component;

begin
tmp <= (a and b)when en(0) = '1' else 'Z';
tmp <= (a or b) when en(1) = '1' else 'Z';
process (clk)
begin
    if (clk = '1' and clk'event) then
        fout <= tmp;
    end if;
end process;

U1 : test port map(fout, a, b, clk);
end;
```

syn_tsu<n>

Directive

Sets information on timing setup delay required for input pins in a black box.

Description

Used with the syn_black_box directive; supplies information on timing setup delay required for input pins (relative to the clock) in the black box.

The syn_tsu<n> directive is one of several directives that you can use with the syn_black_box directive to define timing for a black box. See [syn_black_box, on page 50](#) for a list of the associated directives.

syn_tsu<n> Syntax

Verilog *object /* syn_tsun = "bundle -> [!]clock = value" */;*

VHDL **attribute syn_tsun of object : objectType is "bundle -> [!]clock = value";**

The syn_tsu<n> directive can be entered as an attribute using the Attributes panel of the SCOPE editor. The information in the Object, Attribute, and Value fields must be manually entered. The constraint file syntax for the directive is:

define_attribute {v:blackboxModule} syn_tsun {bundle->[!]clock=value}

For details about the syntax, see the following table:

v:	Constraint file syntax that indicates the directive is attached to the view.
<i>blackboxModule</i>	The symbol name of the black-box.
<i>n</i>	A numerical suffix that lets you specify different clock to output timing delays for multiple signals/bundles.
<i>bundle</i>	A collection of buses and scalar signals. The objects of a bundle must be separated by commas with no intervening spaces. A valid bundle is A,B,C, which lists three signals. The values are in ns. This is the syntax to define a bundle:

bundle->[!]clock=value

!	The optional exclamation mark indicates that the clock is active on its falling (negative) edge.
<i>clock</i>	The name of the clock signal.
<i>value</i>	Input to clock setup delay value in ns.

Constraint file example:

```
define_attribute {v:RTRV_MOD} syn_tsu4 {RTRV_DATA[63:0] ->!CLK=20}
```

Verilog Example

For syntax explanations, see [syn_tsu<n> Syntax](#), on page 223.

This is an example that defines syn_tsu<n> along with some of the other black-box constraints:

```
module test(myclk, a, b, tout,) /*synthesis syn_black_box
syn_tcol="clk->tout=1.0" syn_tpd1="b->tout=8.0"
syn_tsu1="a->myclk=2.0" */;
input myclk;
input a, b;
output tout;
endmodule

//Top Level
module top (input clk, input a, b, output fout);
test U1 (clk, a, b, fout);
endmodule
```

VHDL Examples

In VHDL, there are 10 predefined instances of each of these directives in the synplify library, for example: syn_tsu1, syn_tsu2, syn_tsu3, ... syn_tsu10. If you are entering the timing directives in the source code and you require more than 10 different timing delay values for any one of the directives, declare the additional directives with an integer greater than 10:

```
attribute syn_tsu11 : string;
attribute syn_tsu11 of bitreg : component is
    "di0,di1 -> clk = 2.0";
attribute syn_tsu12 : string;
attribute syn_tsu12 of bitreg : component is
    "di2,di3 -> clk = 1.8";
```

For other syntax explanations, see [syn_tsu<n> Syntax, on page 223](#).

See [VHDL Attribute and Directive Syntax, on page 302](#) for different ways to specify VHDL attributes and directives. For this directive, you can also use the following Verilog-style syntax to specify it, as described in [Verilog-Style Syntax in VHDL for Black Box Timing, on page 211](#).

The following is an example of assigning syn_tsu<n> along with some of the other black-box constraints:

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

entity test is
generic (size: integer := 8);
port (tout : out std_logic_vector(size- 1 downto 0);
      a : in std_logic_vector (size- 1 downto 0);
      b : in std_logic_vector (size- 1 downto 0);
      myclk : in std_logic);

attribute syn_isclock : boolean;
attribute syn_isclock of myclk: signal is true;
end;

architecture rtl of test is
attribute syn_black_box : boolean;
attribute syn_black_box of rtl: architecture is true;
begin
end;
```

```
-- TOP Level--
library ieee;
use ieee.std_logic_1164.all;
use ieee.std_logic_unsigned.all;

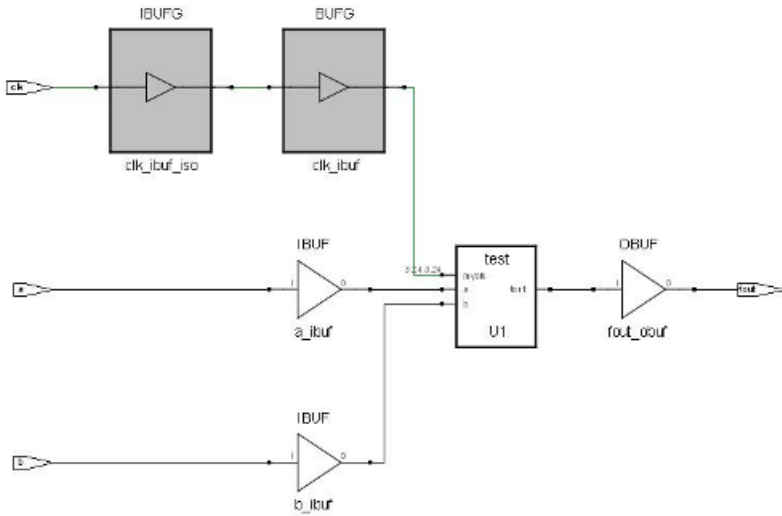
entity top is
generic (size: integer := 8);
port (fout : out std_logic_vector (size- 1 downto 0);
      a : in std_logic_vector (size- 1 downto 0);
      b : in std_logic_vector (size- 1 downto 0);
      clk : in std_logic
    );
end;

architecture rtl of top is
component test
generic (size: integer := 8);
port (tout : out std_logic_vector(size- 1 downto 0);
      a : in std_logic_vector (size- 1 downto 0);
      b : in std_logic_vector (size- 1 downto 0);
      myclk : in std_logic
    );
end component;

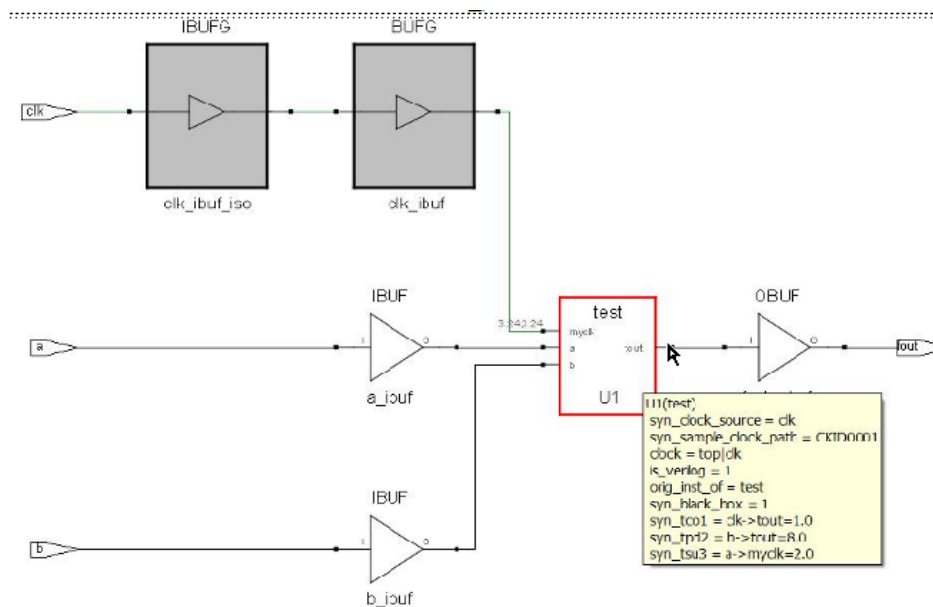
attribute syn_tcol : string;
attribute syn_tcol of test : component is
  "clk->tout = 1.0";
attribute syn_tpd1 : string;
attribute syn_tpd1 of test : component is
  "b->tout= 2.0";
attribute syn_tsu1 : string;
attribute syn_tsu1 of test : component is
  "a-> myclk = 1.2";
begin
U1 : test port map (fout, a, b, clk);
end;
```

Effect of using syn_tsu

This figure shows the HDL Analyst Technology view before using syn_tsu:



This figure shows the HDL Analyst Technology view after using syn_tsu:



translate_off/translate_on

Directive

Synthesizes designs originally written for use with other synthesis tools without needing to modify source code.

Description

Allows you to synthesize designs originally written for use with other synthesis tools without needing to modify source code. All source code that is between these two directives is ignored during synthesis.

Another use of these directives is to prevent the synthesis of stimulus source code that only has meaning for logic simulation. You can use `translate_off/translate_on` to skip over simulation-specific lines of code that are not synthesizable.

When you use `translate_off` in a module, synthesis of all source code that follows is halted until `translate_on` is encountered. Every `translate_off` must have a corresponding `translate_on`. These directives cannot be nested, therefore, the `translate_off` directive can only be followed by a `translate_on` directive.

See also, [pragma translate_off/pragma translate_on](#), on page 43. These directives are implemented the same in the source code.

translate_off/translate_on Syntax

Verilog	<code>/* synthesis translate_off */</code> <code>/* synthesis translate_on */</code>
---------	---

VHDL	<code>synthesis translate_off</code> <code>synthesis translate_on</code>
------	---

Verilog Example

```

module test(input a, b, output dout, Nout);
  assign dout = a + b;

  //Anything between pragma translate_off/translate_on is ignored by
  //the synthesis tool hence only
  //the adder circuit above is implemented not the multiplier circuit
  below:

  /* synthesis translate_off */
  assign Nout = a * b;
  /* synthesis translate_on */

endmodule

```

For SystemVerilog designs, you can alternatively use the `synthesis_off/synthesis_on` directives. The directives function the same as the `translate_off/translate_on` directives to ignore all source code contained between the two directives during synthesis.

For Verilog designs, you can use the synthesis macro with the Verilog `ifdef` directive instead of the `translate on/off` directives. See [synthesis Macro, on page 94](#) for information.

VHDL Example

For VHDL designs, you can alternatively use the `synthesis_off/synthesis_on` directives. Select Project->Implementation Options->VHDL and enable the Synthesis On/Off Implemented as Translate On/Off option. This directs the compiler to treat the `synthesis_off/on` directives like `translate_off/on` and ignore any code between these directives.

See [VHDL Attribute and Directive Syntax, on page 302](#) for different ways to specify VHDL attributes and directives.

```

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

```

```

entity test is
port
  a :   in std_logic_vector(1 downto 0);
  b :   in std_logic_vector(1 downto 0);
  dout : out std_logic_vector(1 downto 0);
  Nout : out std_logic_vector(3 downto 0)
);
end;

```

```

architecture rtl of test is
begin
  dout <= a + b;

```

--Anything between synthesis translate_off/translate_on is ignored by the synthesis tool hence only
 --the adder circuit above is implemented not the multiplier circuit below:

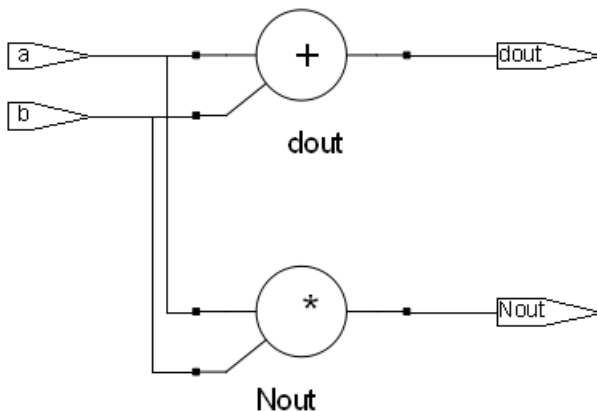
```

--synthesis translate_off
  Nout <= a * b;
--synthesis translate_on
end;

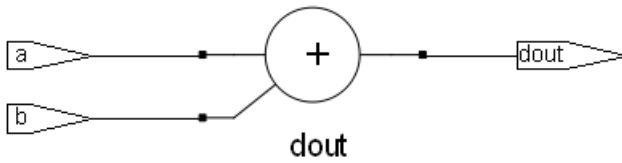
```

Effects of Using translate_off/translate_on

Here is the RTL view before applying the attribute.



This is the RTL view after applying the attribute.



APPENDIX C

Attributes and Directives Example Code

This appendix contains the code samples that are referenced by the corresponding chapter.

VHDL Example 3: Component Declaration

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

entity sub is
port (a, b, c, d : in std_logic;
x,y : out std_logic);
end sub;

architecture behave of sub is
attribute syn_hier : string;
attribute syn_hier of behave : architecture is "hard";
begin
x <= a and b;
y <= c and d;
end behave;

--Top level
library ieee;
use ieee.std_logic_1164.all;

entity top is
port (a1, b1 : in std_logic;
c1,d1,clk : in std_logic;
y1 :out std_logic);
end;

architecture behave of top is
component sub
```

```
port (a, b, c, d : in std_logic;
      x,y : out std_logic);
end component;

attribute syn_noprune : boolean;
attribute syn_noprune of sub : component is true;

signal x2,y2,x3,y3 : std_logic;

begin

u1: sub port map(a1, b1, c1, d1, x2, y2);
u2: sub port map(a1, b1, c1, d1, x3, y3);

process begin
wait until (clk = '1') and clk'event;
y1 <= a1;
end process;

end;
```

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VHDL Example: Component Instance Declaration

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

entity sub is
port (a, b, c, d : in std_logic;
x,y : out std_logic);
end sub;

architecture behave of sub is
attribute syn_hier : string;
attribute syn_hier of behave : architecture is "hard";
begin

x <= a and b;
y <= c and d;
end behave;

--Top level

library ieee;
use ieee.std_logic_1164.all;

entity top is
port (a1, b1 : in std_logic;
c1,d1,clk : in std_logic;
y1 :out std_logic);
end;

architecture behave of top is
component sub
port (a, b, c, d : in std_logic;
x,y : out std_logic);
```

```
end component;  
signal x2,y2,x3,y3 : std_logic;  
attribute syn_noprune : boolean;  
attribute syn_noprune of u1 : label is true;  
begin  
u1: sub port map(a1, b1, c1, d1, x2, y2);  
    --Instance with syn_noprune directive  
u2: sub port map(a1, b1, c1, d1, x3, y3);  
process begin  
wait until (clk = '1') and clk'event;  
y1 <= a1;  
end process;  
  
end;
```

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VHDL Example 4: Black Box

```
--Top level

library ieee;
use ieee.std_logic_1164.all;

entity top is
port (a1, b1 : in std_logic;
      c1,d1,clk : in std_logic;
      y1 :out std_logic);
end;

architecture behave of top is
  component sub
  port (a, b, c, d : in std_logic;
        x,y : out std_logic);
  end component;

  attribute syn_noprune : boolean;
  attribute syn_noprune of sub : component is true;

  signal x2,y2,x3,y3 : std_logic;
begin

  u1: sub port map(a1, b1, c1, d1, x2, y2);
  u2: sub port map(a1, b1, c1, d1, x3, y3);
process begin
  wait until (clk = '1') and clk'event;
  y1 <= a1;
end process;
end;
```

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Verilog Example 1 -- Module Declaration

```
//Top module
module top (input int a, b, output int c);
  assign c=b;
  sub i1 (a);
endmodule

//Intermediate sub level which does not specify syn_noprune
module sub (input int a);
  leaf i2 (a,);
endmodule

//Leaf level with syn_noprune directive
module leaf (input int a, output int b)
  /* synthesis syn_noprune=1*/;
  assign b = a;
endmodule
```

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Verilog Example 2: Hierarchical Design

```
//Leaf level module
module sub1 (data, rst, dout);
parameter width = 1;
input [width :0] data;
input rst;
output [width : 0] dout;
assign dout = rst?1'b0:data;
endmodule

//Intermediate Top level with 3 instances of sub1
module top (data1,data2,data3, rst, dout1);
parameter width1 = 2;
parameter width2 = 3;
parameter width3 = 4;
input [width1 :0] data1;
input [width2 :0] data2;
input [width3 :0] data3;
input rst;
output [width1 : 0] dout1;
sub1 #(width1) inst1 (data1,rst,dout1);
sub1 #(width2) inst2 (data2,rst,) /* synthesis syn_noprune=1 */;
sub1 #(width3) inst3 (data3,rst,);
endmodule

//Top level
module top1 (data1,data2,data3, rst, dout1);
parameter width1 = 2;
```

```
parameter width2 = 3;
parameter width3 = 4;
input [width1 :0] data1;
input [width2 :0] data2;
input [width3 :0] data3;
input rst;
output [width1 : 0] dout1;
top #(width1, width2, width3) top (data1,data2,data3, rst,
dout1);
endmodule
```

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Example: Verilog syn_resources (Microsemi)

```
module bb (o,i) /* synthesis syn_black_box syn_resources =  
    "corecells=300, blockrams=10" */;  
    input i;  
    output o;  
endmodule  
  
module top_bb (o,i);  
    input i;  
    output o;  
    bb u1 (o,i);  
endmodule
```

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Example: VHDL syn_resources (Microsemi)

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

entity top is
port (o : out std_logic;
      i : in std_logic
      );

end top;

architecture top_rtl of top is

    component bb
        port (o : out std_logic;
              i : in std_logic);
    end component;

begin

    U1: bb port map(o, i);
end top_rtl;

--black box entity

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

```
entity bb is
port (o : out std_logic;
      i : in std_logic
      );

end bb;

architecture rtl of bb is

attribute syn_resources : string;

attribute syn_resources of rtl: architecture is "corecells=300,
blockrams=10";

begin

end rtl;
```

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Example: Verilog syn_state_machine

```

module FSM1 (clk, in1, rst, out1);
  input clk, rst, in1;
  output [2:0] out1;
  `define s0 3'b000
  `define s1 3'b001
  `define s2 3'b010
  `define s3 3'bxxx
  reg [2:0] out1;
  reg [2:0] state /* xsynthesis syn_state_machine = 1 */;
  reg [2:0] next_state;
  always @(posedge clk or posedge rst)
    if (rst) state <= `s0;
    else state <= next_state;

  // Combined Next State and Output Logic
  always @(state or in1)
    case (state)
      `s0 : begin
        out1 <= 3'b000;
        if (in1) next_state <= `s1;
        else next_state <= `s0;
      end
      `s1 : begin
        out1 <= 3'b001;
        if (in1) next_state <= `s2;

```

```
    else next_state <= `s1;
  end
  `s2 : begin
    out1 <= 3'b010;
    if (in1) next_state <= `s3;
    else next_state <= `s2;
  end
  default : begin
    out1 <= 3'bxxx;
    next_state <= `s0;
  end
endcase
endmodule
```

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Example: VHDL syn_state_machine

```

library ieee;
use ieee.std_logic_1164.all;
entity FSM1 is
    port (clk,rst,in1 : in std_logic;
          out1 : out std_logic_vector (2 downto 0));
end FSM1;
architecture behave of FSM1 is
    type state_values is (s0, s1, s2,s3);
    signal state, next_state: state_values;
    attribute syn_state_machine : boolean;
    attribute syn_state_machine of state : signal is false;
begin
    process (clk, rst)
    begin
        if rst = '1' then
            state <= s0;
        elsif rising_edge(clk) then
            state <= next_state;
        end if;
    end process;
    process (state, in1) begin
        case state is
            when s0 =>
                out1 <= "000";
                if in1 = '1' then next_state <= s1;

```

```
        else next_state <= s0;
    end if;
when s1 =>
    out1 <= "001";
    if in1 = '1' then next_state <= s2;
        else next_state <= s1;
    end if;
when s2 =>
    out1 <= "010";
    if in1 = '1' then next_state <= s3;
        else next_state <= s2;
    end if;
when others =>
    out1 <= "XXX"; next_state <= s0;
end case;
end process;
end behave;
```

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