



SNS COLLEGE OF ENGINEERING

Coimbatore-35
An Autonomous Institution



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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19EC505–VLSI DESIGN

III YEAR/ V SEMESTER

UNIT 5-SPECIFICATION USING VERILOG HDL

TOPIC 5 & 6 –OPERATORS AND TIMING CONTROLS

OPERATORS AND TIMING CONTROLS /19EC505-VLSI
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OUTLINE

- INTRODUCTION-HISTORY
- OPERATORS USED IN VERILOG
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OPERATORS USED IN VERILOG

■ VERILOG LANGUAGE OPERATORS

Arithmetic Operators	+, -, *, /, %
Relational Operators	<, <=, >, >=
Equality Operators	==, !=, ===, !==
Logical Operators	!, &&,
Bit-Wise Operators	~, &, , ^, ~^
Unary Reduction	&, ~&, , ~ , ^, ~^
Shift Operators	>>, <<
Conditional Operators	?:
Concatenations	{}



VERILOG HDL



■ Precedence Rules for Operators

Operator Precedence Rules	
! ~	highest precedence
* / %	
+ -	
<< >>	
< <= > >=	
== != === !==	
&	
^ ^~	
&&	
?: (ternary operator)	lowest precedence



OPERATORS USED IN VERILOG (CONT.)



- The Relational Operators Defined

Relational Operators	
$a < b$	a less than b
$a > b$	a greater than b
$a \leq b$	a less than or equal to b
$a \geq b$	a greater than or equal to b

- The Equality Operators Defined

Equality Operators	
$a === b$	a equal to b, including x and z
$a !== b$	a not equal to b, including x and z
$a == b$	a equal to b, result may be unknown
$a != b$	a not equal to b, result may be unknown

EQUALITY AND IDENTITY OPERATORS

■ equality operator

=	0	1	x	z
0	1	0	x	x
1	0	1	x	x
x	x	x	x	x
z	x	x	x	x

```

a = 2'b0x
b = 2'b0x
if (a == b)
    $display("a is equal to b");
else
    $display("a is not equal to b");
result : a is not equal to b
    
```

■ identity operator

===	0	1	x	z
0	1	0	0	0
1	0	1	0	0
x	0	0	1	0
z	0	0	0	1

```

a = 2'b0x
b = 2'b0x
if (a === b)
    $display("a is identity to b");
else
    $display("a is not identity to b");
result : a is identity to b
    
```



OPERATORS



■ *Operators*

- **Unary Operator** assign $a = \sim b$;
- **Binary Operator** assign $a = b \& c$;
- **Ternary Operator** assign $out = sel ? a : b$; //2-to-1 multiplexer

■ *Comments*

➤ **One Line Comment**

// this is an example of one line comment

➤ **Multiple Line Comment**

/* this is an example of multiple line comment */

➤ **Error Comment Remarks**

/* Error comment remark */ */



OPERATORS USED IN VERILOG



- **Index:**
 - example: a[11:6], b[2], ...
- **Concatenation:** {n{<exp> <, <exp>>*}} adder4
a1(sum,carry,{a[2],a[2:0]},b[3:0]); assign {carry, sum} = a+b+ci;
sign = {4{in[3]}, in}; temp = 2'b01;
out = {2{2'b10}, 2'b11, temp}; //out=8'b1010_1101
- **Arithmetic operation: +,-,***
 - example: a=b+c;
- **Condition: =, !=, >, <, >=, <=, ...**
 - example: assign b = (a == 0) ;

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OPERATORS AND TIMING CONTROLS
19EC505-VLSI
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NSCT

x=y*z;



LITERAL NUMBERS

- Literal integers are interpreted as decimal numbers in the machine word size (32 bits) by default.
- Size and base may be explicitly specified
- **<size>'<base><value>**
 - <size>: size in bits as a decimal number.
 - <base>: b(binary), o(octal), h(hex), d(decimal).
 - <value>: 0-9, a-f, x, z, ? (must be legal number in <base>)
- Four types of logic value
0 (logical 0), **1** (logical 1), **x** (unknown), **z** (high impedance)



LITERAL NUMBERS (CONT.)

▪ *Examples*

- 12
- 8'd45
- 10'hF1
- 1'B1
- 32'bz
- 6'b001_010
- 32-bit decimal
- 8-bit decimal
- 10-bit hex (left-extended with zero)
- 1-bit binary
- 32-bit Z
- 6-bit binary with underscore for readability.

Underscores are ignored.

X and Z values are automatically extended.

A question mark ? in <value> is interpreted as a Z.



ACTIVITY

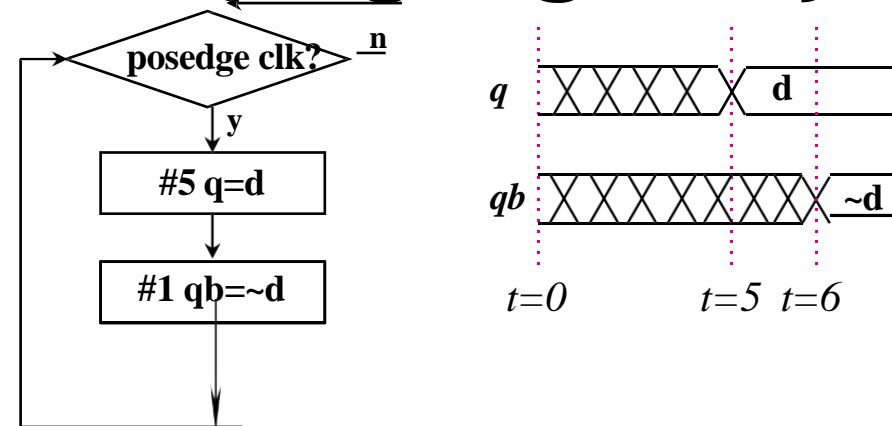
DEBATE



PROCEDURAL TIMING CONTROLS



- Three Types of Timing Controls
- #<delay> : Simple delay.
- @(<signal>) : Event control with edge-trigger and level-sensitive controls. wait(<expr>) : Level-sensitive control.
- Edge-Trigger Control
- posedge: positive edge. EX: always @(posedge clk) negedge:
negative edge. EX: always @(negedge clk)
- Examples

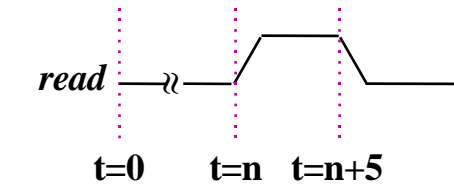
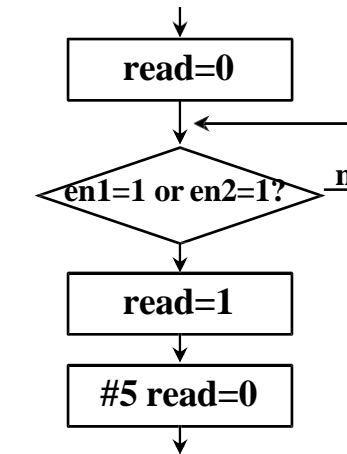




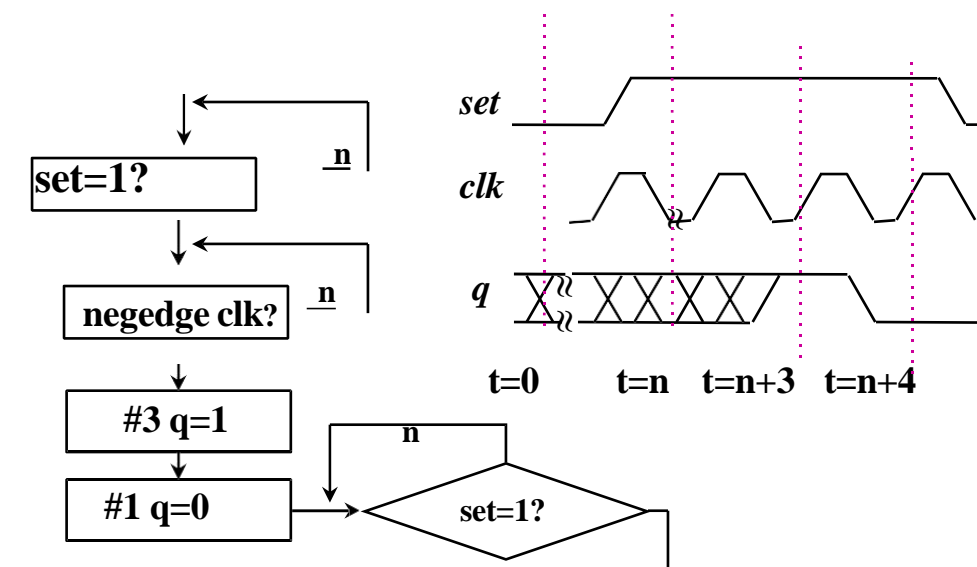
PROCEDURAL TIMING CONTROLS



```
initial begin read=0;  
wait(en1|en2) read=1;  
#5 read=0;  
end
```



```
always wait(set)  
begin  
@(negedge clk); #3  
q=1;  
#1 q=0;  
wait(!set); end
```





INTRA-ASSIGNMENT TIMING CONTROL



- **Previously described timing control.**

```
#100 clk = ~ clk; @(posedge clock) q = d;
```

- **Intra-assignment timing control.**

```
clk = #100 ~ clk;
```

```
q = @(posedge clock) d;
```

- **Simulators perform two steps when encounter an intra assignment timing control statement.**
 - Evaluate the RHS immediately.
 - Execute the assignment after a proper delay.



VERILOG-HDL STRUCTURAL LANGUAGE



Intra-Assignment Timing Control

- Intra-assignment timing control can be accomplished by using the following constructs

With intra-assignment construct	With intra-assignment construct
<code>a = #10 b;</code>	<code>begin temp = b; #10 a = temp; end</code>
<code>a = @(posedge clk) b;</code> <small>15</small>	<code>begin temp = b; @ (posedge clk) a = temp; end</code>
<code>a = repeat(3)@(posedge clk) b;</code>	<code>begin temp = b; @ (posedge clk) @ (posedge clk) @ (posedge clk) a = temp; end</code>



ASSESSMENT

1. List out the Operators with precedence

2. `< >'< > < >` - fill up Literal numbers syntax

3. Tell me the literal numbers

- 12
- 8'd45
- 10'hF1
- 1'B1
- 32'bz
- 6'b001_010

4. `#<?????>` : Simple delay.

`@(<??????>)`

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SUMMARY & THANK YOU