Verilog HDL:
Time Scale

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Outline

- `timescale
- $timeformat
- $printtimescale
- Measure time

timescale

- Defines time units and precision for simulation
- Syntax: timescale <time_unit> / <time_precision>
- Example: timescale 1ns / 1ps
  - Time unit: 1 nanosecond.
  - Time precision: 1 picosecond
- Affects simulation timing and delay calculations.

Example: timescale

```
1   `timescale 1ns/1ps
2   module timescale_example;
3     initial begin
4       #10 $display("Time: %t", $time);
5     end
6   endmodule
7
8   module tb_timescale_example;
9     timescale_example uut();
10    initial #20 $finish;
11  endmodule
```

Output:

```
Time: 10
```

$timeformat

- Controls how simulation time is displayed in output
- Syntax:
  - $timeformat(unit, precision, suffix, min_field_width);
- Parameters:
  - unit: Base time unit (e.g., 0 for seconds, -9 for nanoseconds)
  - precision: Number of decimal places
  - suffix: Character string to display after time (e.g., "ns")
  - min_field_width: Minimum width of displayed time value
- Example: $timeformat(-9, 2, " ns", 10);

Example: $timeformat

```
1   module timeformat_example;
2     initial begin
3       $timeformat(-9, 2, " ns", 10);
4       #5 $display("Formatted Time: %t", $time);
5     end
6   endmodule
7
8   module tb_timeformat_example;
9     timeformat_example uut();
10    initial #10 $finish;
11  endmodule
```

Output:

```
Formatted Time: 5 ns
```

$printtimescale

- Displays the current timescale settings of a module
- Syntax: $printtimescale(<module_name>)

```
1  module printtimescale_example;
2    initial $printtimescale(printtimescale_example);
3  endmodule
4
5  module tb_printtimescale_example;
6    printtimescale_example uut();
7    initial #5 $finish;
8  endmodule
```

Output:

```
Time scale of (printtimescale_example) is 1 ns / 1 ps
```

Comparison Between $time, $stime, and $realtime

Function	Data Type	Precision	Use Case
$time	Integer	Low	Coarse time measurement
$stime	32-bit Integer	Medium	Medium precision timing
$realtime	Real Number	High	High-precision time measurement

Comparison Between $time, $stime, and $realtime

```
1   module time_comparison;
2     initial begin
3       $display("$time: %t", $time);
4       $display("$stime: %0d", $stime);
5       $display("$realtime: %0.3f", $realtime);
6     end
7   endmodule
8
9   module tb_time_comparison;
10    time_comparison uut();
11    initial #10 $finish;
12  endmodule
```

Output:

```
$time: 0
$stime: 0
$realtime: 0.000
```

Example 1 - Using $time and $realtime in a Counter

```
1   module counter_example;
2     reg clk;
3     integer count = 0;
4     initial begin
5       clk = 0;
6       forever #5 clk = ~clk;
7     end
8     always @(posedge clk) begin
9       count = count + 1;
10      $display("Time: %d ns, Count: %d", $time, count);
11    end
12  endmodule
13
14  module tb_counter_example;
15    counter_example uut();
16    initial #50 $finish;
17  endmodule
```

Output:

```
Time: 5 ns, Count: 1
Time: 15 ns, Count: 2
Time: 25 ns, Count: 3
...
```

Example 2 - Measuring Delay Using $realtime

```
1  module delay_measure;
2    reg signal;
3    real start_time, end_time, delay;
4    initial begin
5      signal = 0;
6      #7 signal = 1;
7      start_time = $realtime;
8      #12 signal = 0;
9      end_time = $realtime;
10     delay = end_time - start_time;
11     $display("Measured delay: %0.3f ns", delay);
12   end
13 endmodule
14
15 module tb_delay_measure;
16   delay_measure uut();
17   initial #30 $finish;
18 endmodule
```

Output:

```
Measured delay: 12.000 ns
```

Example 3 – Time Test

```
1   module time_test;
2     initial begin
3       $timeformat(-9, 2, " ns", 10);
4       #5 $display("Current Simulation Time: %t", $time);
5       #10 $display("Current Simulation Time: %t", $time);
6     end
7   endmodule
8
9   module tb_time_test;
10    time_test uut();
11    initial #20 $finish;
12  endmodule
```

Output:

```
Current Simulation Time: 5 ns
Current Simulation Time: 15 ns
```

Summary

- Accurate timing is essential for simulation and verification of digital designs.
- `timescale sets the resolution and precision of simulation delays.
- $timeformat customizes the format of time values in output displays.
- $printtimescale helps verify module timescale settings during simulation.
- $time, $realtime, and $stime allow designers to measure and track simulation time, useful in debugging and testbench analysis.

Thank you !

Happy Learning