

# Digital System Design with HDL (I)

## Lecture 2

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## In This Session

- Lexical Conventions
- Data Type Declarations

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## Lexical Conventions

### White Space Characters

SPACE, TAB, and blank lines are ignored.

### Comments

// begins a single line comment, terminated by a newline.

/\* begins a multi-line comment, terminated by a \*/.

### Case Sensitivity

Verilog is case sensitive.

### Statement/Declaration Termination

with semicolon ";"

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## Lexical Conventions

### Identifiers

Identifiers are the names of variables and elements

- Begin with a letter (a-z, A-Z) or an underscore \_ .
- Composed of a sequence of
  - letters
  - digits (0 to 9)
  - underscore \_ and \$ symbol

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## Lexical Conventions

### Logic Values

The Verilog HDL has **four** logic values:

- **0** = logic value 0
- **1** = logic value 1
- **z, Z, or ?** = tri-state (high impedance or floating)
- **x or X** = unknown or uninitialized

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## Lexical Conventions

### Logic Values

Why **x**?

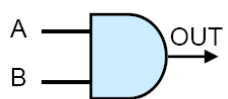
- Could be drivers conflicting to a wire.
- Could be lack of initialization of a register
- Output of a gate with z inputs

Why **z**?

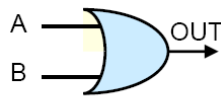
- Nothing driving the signal (Tri-states)

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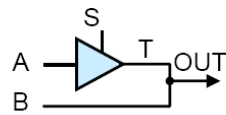
### Logic Values



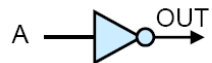
A	B	OUT
0	0	0
0	1	0
1	1	1
0	x	0
0	z	0
1	x	x
1	z	x



A	B	OUT
0	0	0
0	1	1
1	1	1
0	x	x
0	z	x
1	x	1
1	z	1



S	A	T	B	OUT
0	0	z	z	z
0	1	z	x	x
0	x	z	1	1
0	z	z	0	0
1	0	0	1	x
1	0	0	z	0
1	1	1	z	1
1	x	x	z	x
1	z	x	0	x



A	OUT
0	1
1	0
x	x
z	x

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## Lexical Conventions

### Numbers

Representation: **[size] ['radix] value**

size

- number of **BITS** regardless of radix used
- **default** to at least 32 ...

#### radices

- decimal (d or D) – **default** if no base specified!
- hexadecimal (h or H)
- octal (o or O)
- binary (b or B)

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## Lexical Conventions

### Numbers

- An `_` (underscore) is ignored (used to enhance readability).
- When size is larger than value and the left-most bit of value is 0 or 1, zeros are left-extended to fill the size.
- If the left-most bit of value is X, the X is left-extended to fill the size.
- If the left-most bit of value is Z, the Z is left-extended to fill the size.

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## Lexical Conventions

### Numbers

#### Examples

Number	Decimal	Binary
4'd3	3	0011
8'ha	10	00001010
5'b111	7	00111
8'b0101_1101	93	01011101
8'bx1101		xxxx1101
10	10	0...01010 (32 bits)

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## Data Type Declarations

### Types

- *net*: represents interconnections between structural entities such as gates.
- *register*: stores a value from one assignment to the next.
- *memory*: an array of vectors.
- *parameter*: defines constants.

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## Data Type Declarations

### Net Data Types

- A *net* represents a node in a circuit.
- Doesn't store value, just a connection
- Input, output, inout are default "wire"
- Used when a signal is on the left-hand side of a continuous assignment.

**net\_type [size] net\_name , net\_name , ... ;**

size: the range of [*msb* : *lsb*]

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## Data Type Declarations

### Net Data Types

net\_type:

- **wire**: used to connect an output of one logic element to an input of another logic element.

Examples:        wire x;

- **tri**: used for tri-state circuit nodes.

Examples:        tri [7:0] DataOut;

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## Data Type Declarations

### Register Data Types

- A *register* is an abstraction of data storage element, which stores a value from one assignment to the next.
- Storage element (modeling sequential circuit)
- Assignment in “always” block

**register\_type [size] variable\_name , variable\_name , ... ;**

size: the range of [*msb* : *lsb*]

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## Data Type Declarations

### Register Data Types

register\_types:

- **reg**: unsigned variable of any bit size to be defined
- **integer**: signed 32-bit variable

Examples:

reg [2:0] Count;    // 3-bit unsigned variable

integer k;        // 32-bit signed variable

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## Data Type Declarations

### Register Data Types

- The original Verilog used *register* to refer to **reg** and **integer** types, which has been replaced by *variable* in Verilog 2001.
- Do not confuse the term *registers* in Verilog with hardware registers built from edge triggered flip-flops.
- In Verilog, the term *register* only means a variable that can hold a value until another value is placed onto it.

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## Data Type Declarations

### Memory Data Types

A memory is a one-dimensional array of registers.

**register\_type [size] *memory\_name* [array\_size];**

array\_size: the range of [ first\_address : last\_address];  
either ascending or descending address order may be used.

Examples:

```
reg [7:0] R [3:0];    // declare four 8-bit variables
R[3]                // access the individual variable
R[3][7]             // access the left-most bit of R[3]
```

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## Data Type Declarations

### Parameter Data Types

A **parameter** associates an identifier name with a constant.

**parameter *constant\_name* = value, *constant\_name* = value, ... ;**

Example: An n-bit adder

```
module addern (carryin, X, Y, S);
  parameter n = 32;
  input carryin;
  input [n-1:0] X, Y;
  output reg [n-1:0] S;

  always @(X, Y, carryin)
    S = X + Y + carryin;
endmodule
```

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