Verilog: wire vs. reg

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1 Introduction

Sections 1.1 to 1.3 discuss the difference between wire and reg in Verilog, and when to use each of them.

1.1 wire Elements (Combinational logic)

wire elements are simple wires (or busses of arbitrary width) in Verilog designs. The following are syntax rules when using wires:

1. wire elements are used to connect input and output ports of a module instantiation together with some other element in your design.

2. wire elements are used as inputs and outputs within an actual module declaration.

3. wire elements must be driven by something, and cannot store a value without being driven.

4. wire elements cannot be used as the left-hand side of an = or <= sign in an always@ block.

5. wire elements are the only legal type on the left-hand side of an assign statement.

6. wire elements are a stateless way of connecting two pieces in a Verilog-based design.

7. wire elements can only be used to model combinational logic.

Program 1 shows various legal uses of the wire element.

Program 1 Legal uses of the wire element

```
wire A, B, C, D, E; // simple 1-bit wide wires
wire [8:0] Wide;  // a 9-bit wide wire
reg I;

assign A = B & C;  // using a wire with an assign statement

always @(B or C) begin
  I = B | C;  // using wires on the right-hand side of an always@
              // assignment
end

mymodule mymodule_instance (.In (D),
                          .Out(E));  // using a wire as the output of a module
```
1.2 \texttt{reg} Elements (Combinational and Sequential logic)

\texttt{reg} are similar to wires, but can be used to store information (‘state’) like registers. The following are syntax rules when using \texttt{reg} elements.

1. \texttt{reg} elements can be connected to the input port of a module instantiation.
2. \texttt{reg} elements cannot be connected to the output port of a module instantiation.
3. \texttt{reg} elements can be used as outputs within an actual module declaration.
4. \texttt{reg} elements cannot be used as inputs within an actual module declaration.
5. \texttt{reg} is the only legal type on the left-hand side of an \texttt{always@} block = or <= sign.
6. \texttt{reg} is the only legal type on the left-hand side of an \texttt{initial} block = sign (used in Test Benches).
7. \texttt{reg} cannot be used on the left-hand side of an \texttt{assign} statement.
8. \texttt{reg} can be used to create registers when used in conjunction with \texttt{always@(posedge Clock)} blocks.
9. \texttt{reg} can, therefore, be used to create both combinational and sequential logic.

Program 2 shows various legal uses of the \texttt{reg} element.

Program 2 Legal uses of the \texttt{reg} element

\begin{verbatim}
wire A, B;
reg I, J, K; // simple 1-bit wide reg elements
reg[8:0] Wide; // a 9-bit wide reg element

always @(A or B) begin
  I = A | B; // using a reg as the left-hand side of an \texttt{always@} assignment
end

initial begin
  J = 1'b1;
  #1
  J = 1'b0;
end

always @(posedge Clock) begin
  K <= I; // using a reg to create a positive-edge-triggered register
end
\end{verbatim}

1.3 When \texttt{wire} and \texttt{reg} Elements are Interchangible

\texttt{wire} and \texttt{reg} elements can be used interchangably in certain situations:

1. Both can appear on the right-hand side of \texttt{assign} statements and \texttt{always@} block = or <= signs.
2. Both can be connected to the input ports of module instantiations.