Review Problem 29

- Draw the state diagram of a machine that continuously outputs a true once at least two 0’s and at least two 1’s (in any order, not necessarily consecutively) have been seen, not including current input.
Traffic Light Controller (cont.)

- State Diagram

Diagram with transitions and states labeled with conditions such as 'TS/HY, FR, START', 'TL+/-C/HY, FR, START', and 'Reset'.
= vs. \leq

\begin{itemize}
\item $= \; \text{("Blocking") assign immediately}$
\item $\leq \; \text{("Non-Blocking") first eval all righthand sides, then do all assignments simultaneously.}$
\end{itemize}

\begin{verbatim}
module swap1();
    ...
    logic [3:0] val0, val1;
    always_ff @(posedge clk) begin
        if (swap) begin
            val0 = val1;
            val1 = val0;
        end
        out = val1;
    end
endmodule

module swap2();
    ...
    logic [3:0] val0, val1;
    always_ff @(posedge clk) begin
        if (swap) begin
            val0 <= val1; // Note: set val0 to B
            val1 <= val0; // Note: set val1 to A
        end
        out <= val1; // Note: set out to B
    end
endmodule
\end{verbatim}
= vs. <= in practice

- = in combinational logic: always_comb, assign
- <= in sequential: always_ff @(posedge clk)
- NEVER mix in one always block!
- Each variable written in only one always block

```vhdl
// Output logic
always_comb begin
  out = (ps == A);
end

// Next State Logic
always_comb begin
  case (ps)
    A: if (w) ns = B;
       else ns = A;
    B: if (w) ns = C;
       else ns = A;
    C: if (w) ns = C;
       else ns = A;
  endcase
end

// Sequential Logic
always_ff @(posedge clk) begin
  if (reset)
    ps <= A;
  else
    ps <= ns;
end
```
Subdividing FSMs

- Some problems best solved with multiple pieces

- Psychic Tester:
  - Machine generates pattern of 4 values (on or off)
  - If user guesses 8 patterns in a row, they’re psychic

- States?

24 = 16 patterns

0...7 = 8 guesses

Pat 0000
Guess 0

Pat 0001
Guess 1

Pat 0000
Guess 7

Pat 1111
Guess 0

Pat 1111
Guess 1

Call for CIA

128 states
Subdividing FSMs (cont.)

- Pieces?

- Pick a pattern (16 state FSM)

- Count correct guesses 0...8 (9 state FSM)

- Use input (4 switches)

- Right?