Labs/08-traffic_lights

GitHub Link

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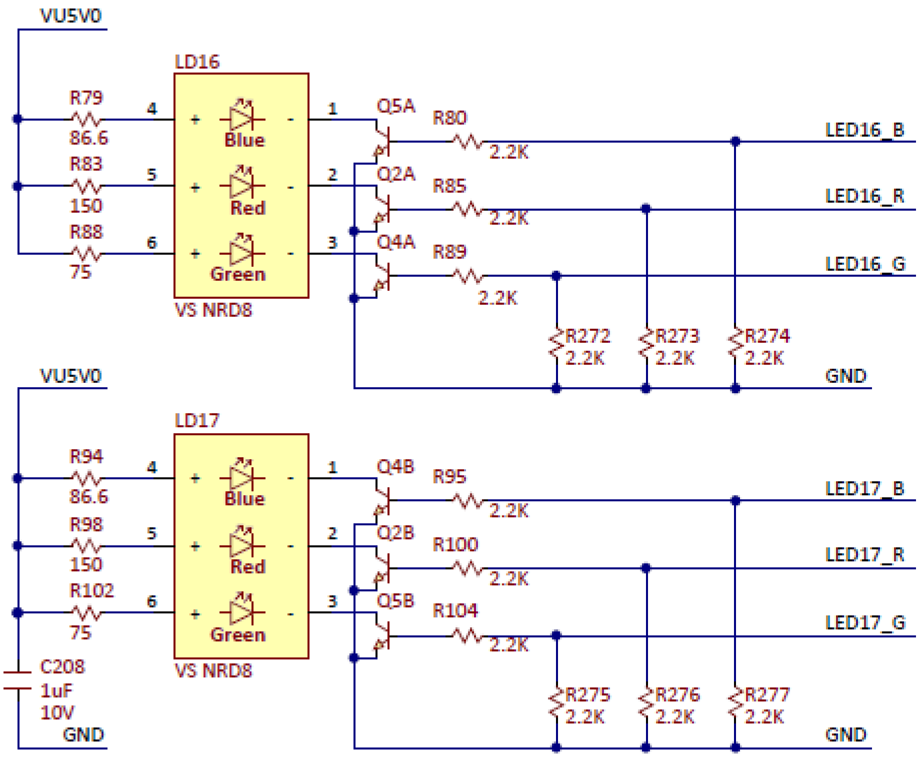
1. Preparation tasks

State table

Input P	0	0	1	1	0	1	0	1	1	1	1	0	0	1	1	1
Clock	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
State	A	A	B	C	C	D	A	B	C	D	B	B	B	C	D	B
Output R	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0

Schematic of RGB LEDs connection



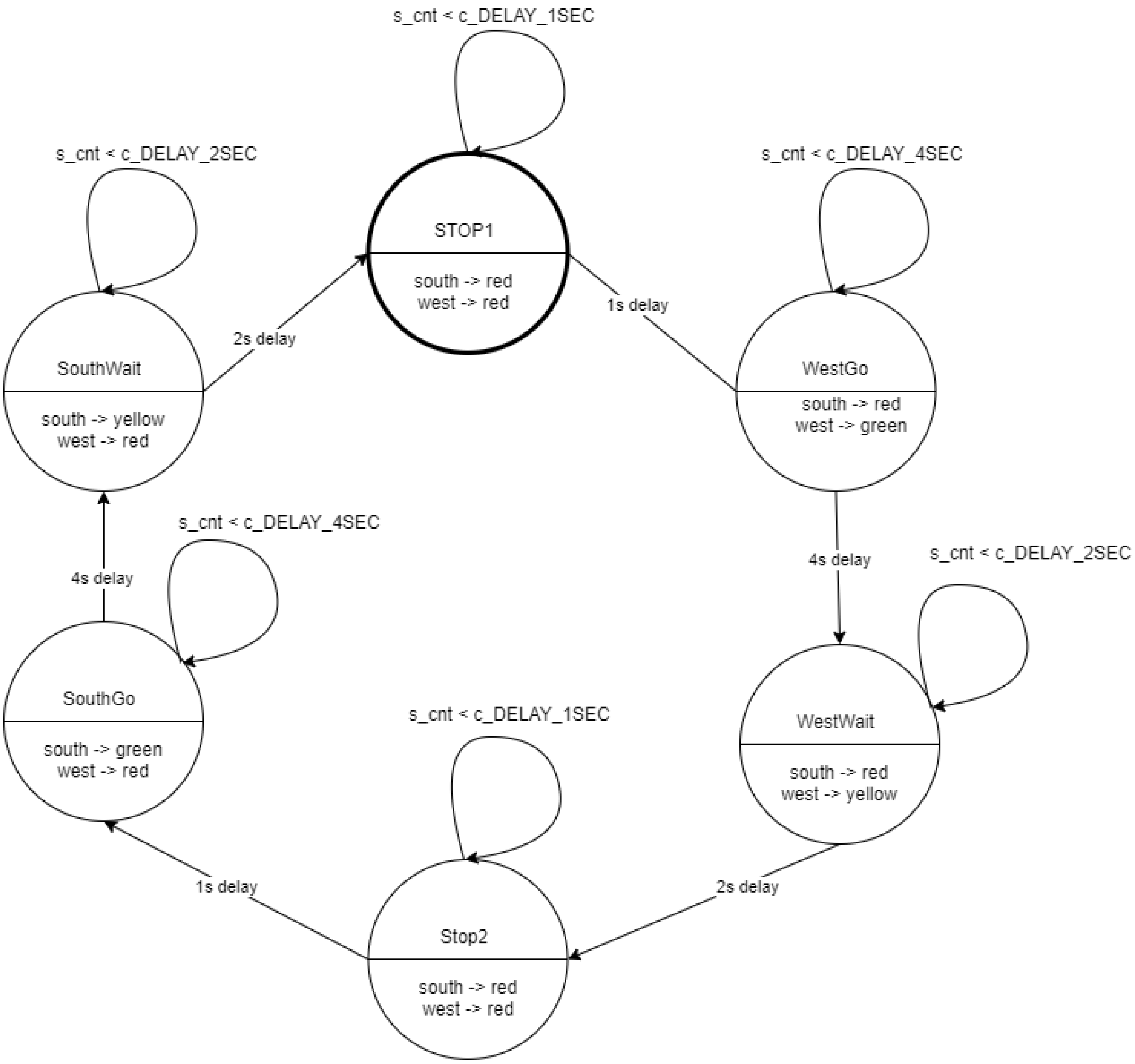
RGB LEDs connection and control

RGB LED	**Artix-7 pin names**	**Red**	**Yellow**	**Green**

RGB LED	Artix-7 pin names	Red	Yellow	Green
LD16	N15, M16, R12	`1,0,0`	`1,1,0`	`0,1,0`
LD17	N16, R11, G14	`1,0,0`	`1,1,0`	`0,1,0`

2. Traffic light controller

State diagram



Sequential process

```
p_traffic_fsm : process(clk)
    begin
        if rising_edge(clk) then
            if (reset = '1') then       -- Synchronous reset
                s_state <= STOP1 ;      -- Set initial state
                s_cnt   <= c_ZERO;      -- Clear all bits

            elsif (s_en = '1') then
                -- Every 250 ms, CASE checks the value of the s_state
                -- variable and changes to the next state according
                -- to the delay value.
                case s_state is

                    -- If the current state is STOP1, then wait 1 sec
                    -- and move to the next GO_WAIT state.
                    when STOP1 =>
                        -- Count up to c_DELAY_1SEC
                        if (s_cnt < c_DELAY_1SEC) then
                            s_cnt <= s_cnt + 1;
                        else
                            -- Move to the next state
                            s_state <= WEST_GO;
                            -- Reset local counter value
                            s_cnt   <= c_ZERO;
                        end if;

                    when WEST_GO =>
                        -- WRITE YOUR CODE HERE
                         if (s_cnt < c_DELAY_GO) then
                            s_cnt <= s_cnt + 1;
                        else
                            s_state <= WEST_WAIT;
                            s_cnt   <= c_ZERO;
                        end if;

                    when WEST_WAIT =>
                         if (s_cnt < c_DELAY_WAIT) then
                            s_cnt <= s_cnt + 1;
                        else
                            s_state <= STOP2;
                            s_cnt   <= c_ZERO;
                        end if;

                    when STOP2 =>
                         if (s_cnt < c_DELAY_1SEC) then
                            s_cnt <= s_cnt + 1;
                        else
                            s_state <= SOUTH_GO;
                            s_cnt   <= c_ZERO;
                        end if;


                   when SOUTH_GO =>
                         if (s_cnt < c_DELAY_GO) then
                            s_cnt <= s_cnt + 1;
                        else
                            s_state <= SOUTH_WAIT;
                            s_cnt   <= c_ZERO;
                        end if;
```

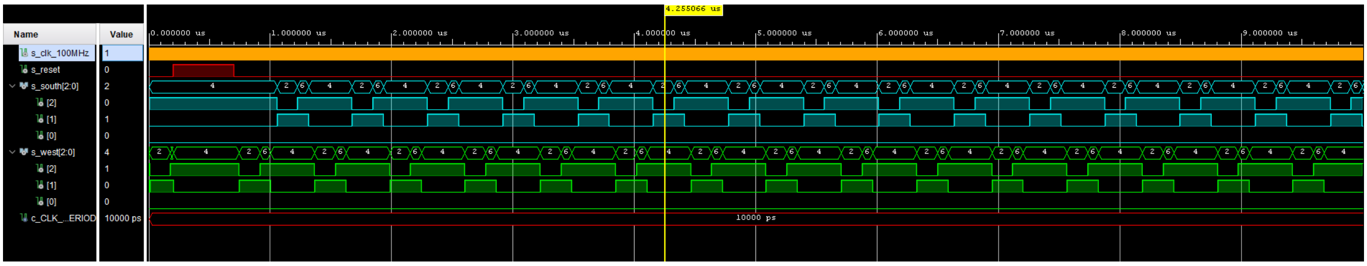
```
                  when SOUTH_WAIT =>
                        if (s_cnt < c_DELAY_WAIT) then
                           s_cnt <= s_cnt + 1;
                       else
                           s_state <= STOP1;
                           s_cnt   <= c_ZERO;
                       end if;

                   -- It is a good programming practice to use the
                   -- OTHERS clause, even if all CASE choices have
                   -- been made.
                   when others =>
                       s_state <= STOP1;

               end case;
           end if; -- Synchronous reset
       end if; -- Rising edge
   end process p_traffic_fsm;
```

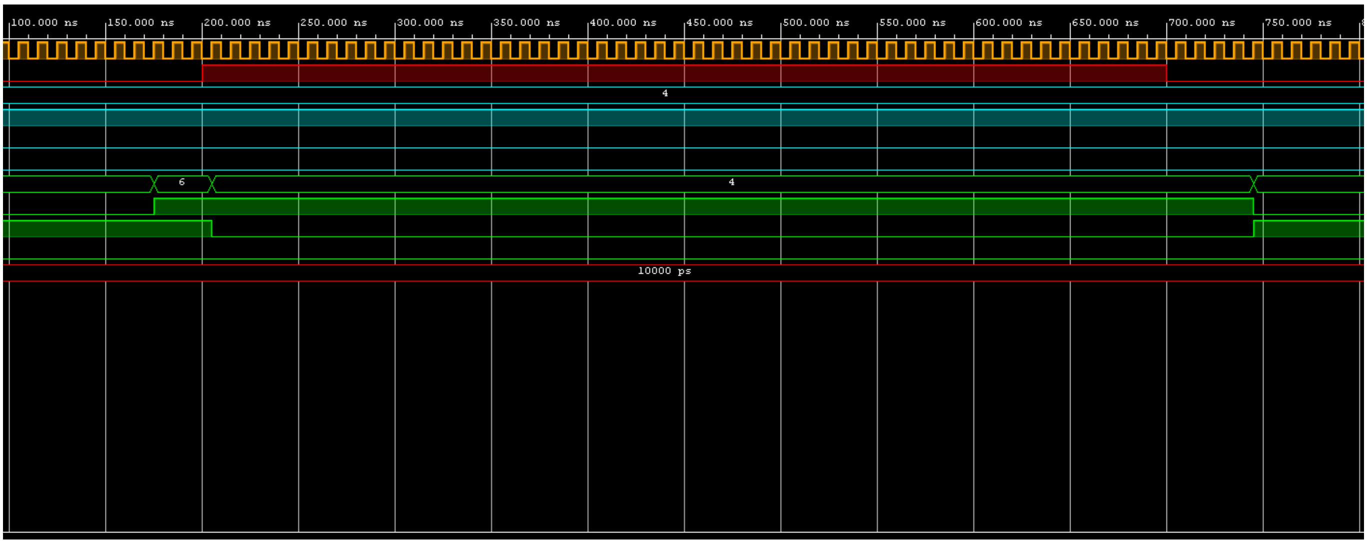
Combinatorial process

```
p_output_fsm : process(s_state)
   begin
       case s_state is
           when STOP1 =>
               south_o <= "100";   -- Red (RGB = 100)
               west_o  <= "100";   -- Red (RGB = 100)
           when WEST_GO =>
               -- WRITE YOUR CODE HERE
               south_o <= "100";   -- Red (RGB = 100)
               west_o  <= "010";   -- Green (RGB = 010)
           when WEST_WAIT =>
               -- WRITE YOUR CODE HERE
               south_o <= "100";   -- Red (RGB = 100)
               west_o  <= "110";   -- Yellow (RGB = 110)
           when STOP2 =>
               -- WRITE YOUR CODE HERE
               south_o <= "100";   -- Red (RGB = 100)
               west_o  <= "100";   -- Red (RGB = 100)
           when SOUTH_GO =>
               -- WRITE YOUR CODE HERE
               south_o <= "010";   -- Green (RGB = 010)
               west_o  <= "100";   -- Red (RGB = 100)
          when SOUTH_WAIT =>
               -- WRITE YOUR CODE HERE
               south_o <= "110";   -- Yellow (RGB = 110)
               west_o  <= "100";   -- Red (RGB = 100)
```

```
            when others =>
                south_o <= "100";   -- Red
                west_o  <= "100";   -- Red
        end case;
    end process p_output_fsm;
```

Simulation screenshots





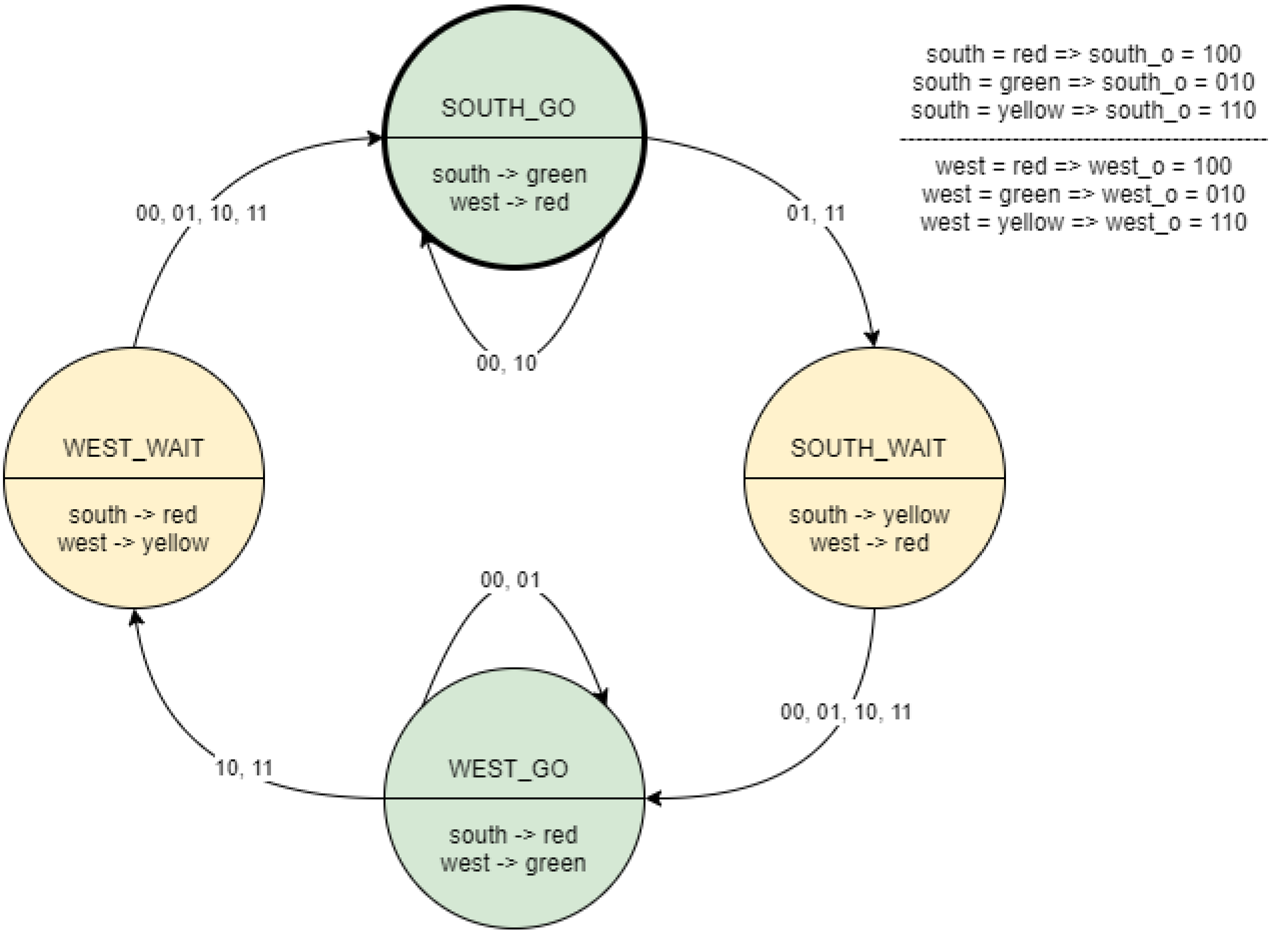
3. Smart controller

State table - actual state

State number	State name	Output S,W	No cars	Only west	Only south	Both
0	`SOUTH_GO`	`010, 100`	`SOUTH_GO`	`SOUTH_WAIT`	`SOUTH_GO`	`SOUTH_WAIT`
1	`SOUTH_WAIT`	`110, 100`	`WEST_GO`	`WEST_GO`	`WEST_GO`	`WEST_GO`
2	`WEST_GO`	`100, 010`	`WEST_GO`	`WEST_GO`	`WEST_WAIT`	`WEST_WAIT`
3	`WEST_WAIT`	`100, 110`	`SOUTH_GO`	`SOUTH_GO`	`SOUTH_GO`	`SOUTH_GO`

State number	State name	Output S,W	No cars	Only west	Only south	Both
Actual state ->			*Next state ->*			

State diagram



Sequential process

```
p_smart_traffic_fsm : process(clk)
    begin
        if rising_edge(clk) then
            if (reset = '1') then        -- Synchronous reset
                s_state <= SOUTH_GO;     -- Set initial state
                s_cnt   <= c_DELAY_ZERO; -- Clear all bits

            elsif (s_en = '1') then
                -- Every 250 ms, CASE checks the value of the s_state
                -- variable and changes to the next state according
                -- to the delay value.
                case s_state is
```

```
                    -- If the current state is STOP1, then wait 1 sec
                    -- and move to the next GO_WAIT state.
                    when SOUTH_GO =>
                        -- Count up to c_DELAY_1SEC
                        if (s_cnt < c_DELAY_GO and (sensor_i = "00" or sensor_i = "10")) then
                            s_cnt <= s_cnt + 1;
                        else
                            -- Move to the next state
                            s_state <= SOUTH_WAIT;
                            -- Reset local counter value
                            s_cnt   <= c_DELAY_ZERO;
                        end if;

                    when SOUTH_WAIT =>
                        if (s_cnt < c_DELAY_WAIT) then
                            s_cnt <= s_cnt + 1;
                        else
                            s_state <= WEST_GO;
                            s_cnt <= c_DELAY_ZERO;
                        end if;

                    when WEST_GO =>
                        if (s_cnt < c_DELAY_GO and (sensor_i = "00" or sensor_i = "01")) then
                            s_cnt <= s_cnt + 1;
                        else
                            s_state <= WEST_WAIT;
                            s_cnt <= c_DELAY_ZERO;
                        end if;

                    when WEST_WAIT =>
                        if (s_cnt < c_DELAY_WAIT) then
                            s_cnt <= s_cnt + 1;
                        else
                            s_state <= SOUTH_GO;
                            s_cnt <= c_DELAY_ZERO;
                        end if;

                    -- It is a good programming practice to use the
                    -- OTHERS clause, even if all CASE choices have
                    -- been made.
                    when others =>
                        s_state <= SOUTH_GO;

                end case;
            end if; -- Synchronous reset
        end if; -- Rising edge
    end process p_smart_traffic_fsm;
```