طراحی سیستم های دیجیتال

پروژه

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الف)

ابتدا باید **module** را طراحی کنیم که طراحی آن به شکل زیر است:

```
module parking_management_system (
    input wire clk,
    input wire reset,
    input wire car_entered,
    input wire car_exited,
    input wire is_uni_car_entered,
    input wire is_uni_car_exited,
    output reg [9:0] uni_parked_car, // Number of university cars currently
parked
    output reg [9:0] parked_car, // Number of non-university cars currently
parked
    output reg [9:0] uni_vacated_space, // Number of vacated spaces reserved for
university cars
    output reg [9:0] vacated_space, // Number of vacated spaces for non-
university cars
    output reg uni_is_vacated_space, // indicates if there is a vacated space for
university cars
    output reg is_vacated_space //  Indicates if there is a vacated space for
non-university cars
);

    parameter MAX_PARKING_SPACE = 700; // Total maximum parking spaces available
    parameter MAX_UNI_SPACE = 500; // Maximum parking spaces reserved for
university cars
    parameter CLK_FREQ = 100_000_000; // Frequency of the clock signal (in Hz)
    parameter NON_UNI_BASE_SPACE = 200; // Initial base space reserved for non-
university cars

    // these regs are used to adjust the non_uni_space
    reg [31:0] elapsed_time_cycles;
    reg [9:0] non_uni_space;
    reg [3:0] time_threshold;

    always @(posedge clk or posedge reset) begin
        if (reset) begin
            elapsed_time_cycles <= 0;
            time_threshold <= 0;
            uni_parked_car <= 0;
            parked_car <= 0;
            uni_vacated_space <= MAX_UNI_SPACE;
            vacated_space <= NON_UNI_BASE_SPACE;
```

```
            non_uni_space <= NON_UNI_BASE_SPACE;
            uni_is_vacated_space <= 1;
            is_vacated_space <= 1;
        end else begin
            elapsed_time_cycles <= elapsed_time_cycles + 1;

            // Update time threshold based on elapsed time
            if (elapsed_time_cycles >= CLK_FREQ * 300 * 60) begin
                time_threshold <= 4;
            end else if (elapsed_time_cycles >= CLK_FREQ * 240 * 60) begin
                time_threshold <= 3;
            end else if (elapsed_time_cycles >= CLK_FREQ * 180 * 60) begin
                time_threshold <= 2;
            end else if (elapsed_time_cycles >= CLK_FREQ * 120 * 60) begin
                time_threshold <= 1;
            end else begin
                time_threshold <= 0;
            end

            // Adjust non-uni space allocation based on time threshold
            if (time_threshold == 0) begin
                non_uni_space <= NON_UNI_BASE_SPACE;
            end else if (time_threshold == 1) begin
                non_uni_space <= 250;
            end else if (time_threshold == 2) begin
                non_uni_space <= 300;
            end else if (time_threshold == 3) begin
                non_uni_space <= 350;
            end else if (time_threshold == 4) begin
                non_uni_space <= MAX_UNI_SPACE;
            end

            // Handle university car entered
            if (car_entered && is_uni_car_entered) begin
                if (uni_parked_car < MAX_UNI_SPACE && uni_parked_car + parked_car
< MAX_PARKING_SPACE) begin
                    uni_parked_car <= uni_parked_car + 1;
                    uni_vacated_space <= uni_vacated_space - 1;
                end
                // Directly implement the logic of update_space_availability
                if (uni_parked_car < MAX_UNI_SPACE && uni_parked_car + parked_car
< MAX_PARKING_SPACE) begin
                    uni_is_vacated_space <= 1;
                end else begin
                    uni_is_vacated_space <= 0;
```

```
                end
                if (parked_car < non_uni_space && uni_parked_car + parked_car <
MAX_PARKING_SPACE) begin
                    is_vacated_space <= 1;
                end else begin
                    is_vacated_space <= 0;
                end
            // Handle university car exited
            end else if (car_exited && is_uni_car_exited) begin
                if (uni_parked_car > 0) begin
                    uni_parked_car <= uni_parked_car - 1;
                    uni_vacated_space <= uni_vacated_space + 1;
                    uni_is_vacated_space <= 1;
                end
            // Handle non-university car entered
            end else if (car_entered && !is_uni_car_entered) begin
                if (parked_car + uni_parked_car < MAX_PARKING_SPACE && parked_car
< non_uni_space) begin
                    parked_car <= parked_car + 1;
                    vacated_space <= vacated_space - 1;
                end
                // Directly implement the logic of update_space_availability
                if (uni_parked_car < MAX_UNI_SPACE && uni_parked_car + parked_car
< MAX_PARKING_SPACE) begin
                    uni_is_vacated_space <= 1;
                end else begin
                    uni_is_vacated_space <= 0;
                end
                if (parked_car < non_uni_space && uni_parked_car + parked_car <
MAX_PARKING_SPACE) begin
                    is_vacated_space <= 1;
                end else begin
                    is_vacated_space <= 0;
                end
            // Handle non-university car exited
            end else if (car_exited && !is_uni_car_exited) begin
                if (parked_car > 0) begin
                    parked_car <= parked_car - 1;
                    vacated_space <= vacated_space + 1;
                    is_vacated_space <= 1;
                end
            end
        end
    end
endmodule
```

حالا باید با استفاده از تست بنچ، ماژول طراحی شده را تست کنیم.

من تست بنچ زیر را برای همین موضوع طراحی کرده ام:

```
`timescale 1ns / 1ps

module tb_parking_management_system;

    // Inputs
    reg clk;
    reg reset;
    reg car_entered;
    reg car_exited;
    reg is_uni_car_entered;
    reg is_uni_car_exited;

    // Outputs
    wire [9:0] uni_parked_car;
    wire [9:0] parked_car;
    wire [9:0] uni_vacated_space;
    wire [9:0] vacated_space;
    wire uni_is_vacated_space;
    wire is_vacated_space;

    // Clock period definition
    parameter CLK_PERIOD = 10; // 10 ns

    // Instantiate the DUT
    parking_management_system dut (
        .clk(clk),
        .reset(reset),
        .car_entered(car_entered),
        .car_exited(car_exited),
        .is_uni_car_entered(is_uni_car_entered),
        .is_uni_car_exited(is_uni_car_exited),
        .uni_parked_car(uni_parked_car),
        .parked_car(parked_car),
        .uni_vacated_space(uni_vacated_space),
        .vacated_space(vacated_space),
        .uni_is_vacated_space(uni_is_vacated_space),
        .is_vacated_space(is_vacated_space)
    );
```

```
    // Clock generation
    always #CLK_PERIOD clk = ~clk;

    // Initial conditions and test scenario
    initial begin
        // Initialize inputs
        clk = 0;
        reset = 1;
        car_entered = 0;
        car_exited = 0;
        is_uni_car_entered = 0;
        is_uni_car_exited = 0;

        // Wait for some time after reset
        #100;

        // Release reset
        reset = 0;

        // Test scenario 1: University car enters
        $display("Action 1: University car enters");
        is_uni_car_entered = 1;
        car_entered = 1;
        #20;
        car_entered = 0;
        is_uni_car_entered = 0;
        #100;

        // Test scenario 2: Non-university car enters
        $display("Action 2: Non-university car enters");
        is_uni_car_entered = 0;
        car_entered = 1;
        #20;
        car_entered = 0;
        is_uni_car_entered = 0;
        #100;

        // Test scenario 3: University car exits
        $display("Action 3: University car exits");
        is_uni_car_exited = 1;
        car_exited = 1;
        #20;
        car_exited = 0;
        is_uni_car_exited = 0;
        #100;
```

```
        // Test scenario 4: Non-university car exits
        $display("Action 4: Non-university car exits");
        is_uni_car_exited = 0;
        car_exited = 1;
        #20;
        car_exited = 0;
        is_uni_car_exited = 0;
        #100;

        // Test scenario 5: Fill all university parking spaces
        $display("Action 5: Fill all university parking spaces");
        repeat (500) begin
            is_uni_car_entered = 1;
            car_entered = 1;
            #20;
            car_entered = 0;
            is_uni_car_entered = 0;
            #20;
        end

        // Test scenario 6: Fill all non-university parking spaces
        $display("Action 6: Fill all non-university parking spaces");
        repeat (200) begin
            is_uni_car_entered = 0;
            car_entered = 1;
            #20;
            car_entered = 0;
            is_uni_car_entered = 0;
            #20;
        end

        // Test scenario 7: Attempt to park another university car (should fail)
        $display("Action 7: Attempt to park another university car (should
fail)");
        is_uni_car_entered = 1;
        car_entered = 1;
        #20;
        car_entered = 0;
        is_uni_car_entered = 0;
        #100;

        // Test scenario 8: Attempt to park another non-university car (should
fail)
```

```
        $display("Action 8: Attempt to park another non-university car (should
fail)");
        is_uni_car_entered = 0;
        car_entered = 1;
        #20;
        car_entered = 0;
        is_uni_car_entered = 0;
        #100;

        // Test scenario 9: University car exits
        $display("Action 9: University car exits");
        is_uni_car_exited = 1;
        car_exited = 1;
        #20;
        car_exited = 0;
        is_uni_car_exited = 0;
        #100;

        // Test scenario 10: Non-university car exits
        $display("Action 10: Non-university car exits");
        is_uni_car_exited = 0;
        car_exited = 1;
        #20;
        car_exited = 0;
        is_uni_car_exited = 0;
        #100;

        // Test scenario 11: Park a university car after spot is vacated
        $display("Action 11: Park a university car after spot is vacated");
        is_uni_car_entered = 1;
        car_entered = 1;
        #20;
        car_entered = 0;
        is_uni_car_entered = 0;
        #100;

        // Test scenario 12: Park a non-university car after spot is vacated
        $display("Action 12: Park a non-university car after spot is vacated");
        is_uni_car_entered = 0;
        car_entered = 1;
        #20;
        car_entered = 0;
        is_uni_car_entered = 0;
        #100;
```

```
        // Additional test scenario 13: Multiple university car entries and exits
        $display("Action 13: Multiple university car entries and exits");
        repeat (10) begin
            is_uni_car_entered = 1;
            car_entered = 1;
            #20;
            car_entered = 0;
            is_uni_car_entered = 0;
            #20;

            is_uni_car_exited = 1;
            car_exited = 1;
            #20;
            car_exited = 0;
            is_uni_car_exited = 0;
            #20;
        end

        // Additional test scenario 14: Multiple non-university car entries and
exits
        $display("Action 14: Multiple non-university car entries and exits");
        repeat (10) begin
            is_uni_car_entered = 0;
            car_entered = 1;
            #20;
            car_entered = 0;
            is_uni_car_entered = 0;
            #20;

            is_uni_car_exited = 0;
            car_exited = 1;
            #20;
            car_exited = 0;
            is_uni_car_exited = 0;
            #20;
        end

        // Finish simulation
        #1000;
        $finish;
    end

endmodule
```

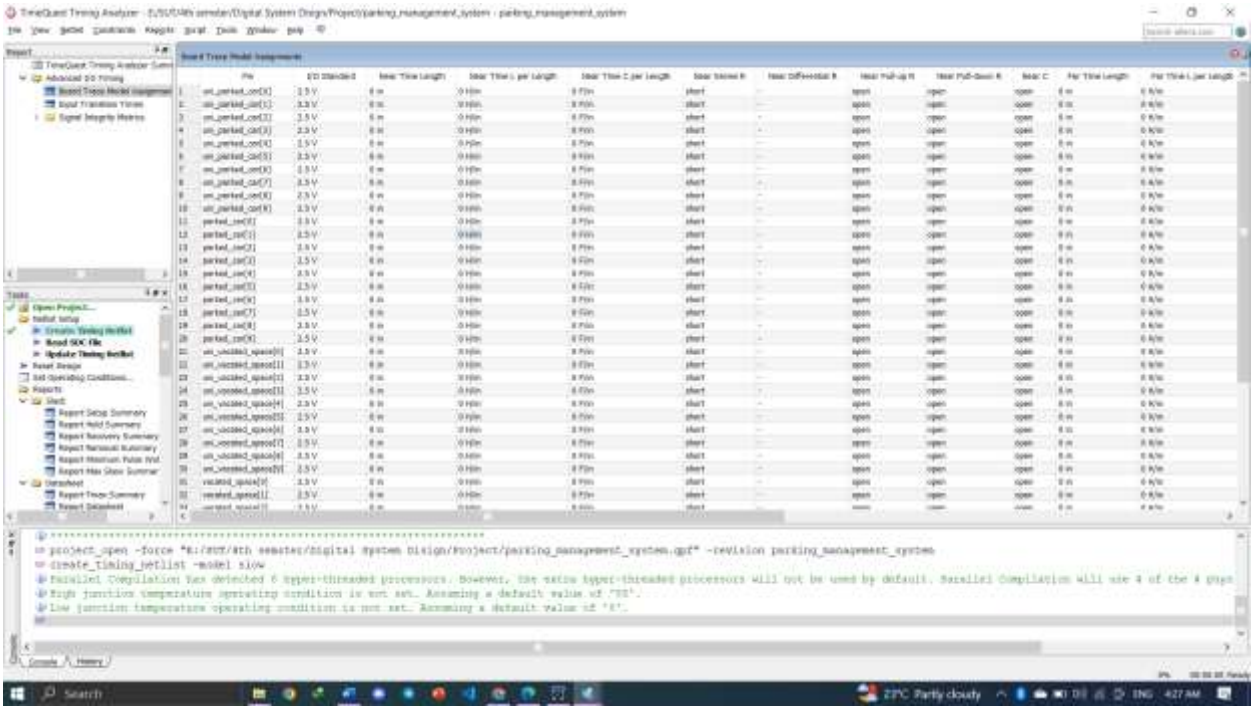
همانطور که قابل مشاهده است ۴ حالت مختلف برای پارکینگ پیش بینی و در این تست بنچ طراحی شده است که نتیجه آن به شکل زیر می شود.

```
VSIM 8> run -all
# Action 1: University car enters
# Action 2: Non-university car enters
# Action 3: University car exits
# Action 4: Non-university car exits
# Action 5: Fill all university parking spaces
# Action 6: Fill all non-university parking spaces
# Action 7: Attempt to park another university car (should fail)
# Action 8: Attempt to park another non-university car (should fail)
# Action 9: University car exits
# Action 10: Non-university car exits
# Action 11: Park a university car after spot is vacated
# Action 12: Park a non-university car after spot is vacated
# Action 13: Multiple university car entries and exits
# Action 14: Multiple non-university car entries and exits
# ** Note: $finish    : E:/SUT/4th semster/Digital System Disign/Project/TB.v(209)
```

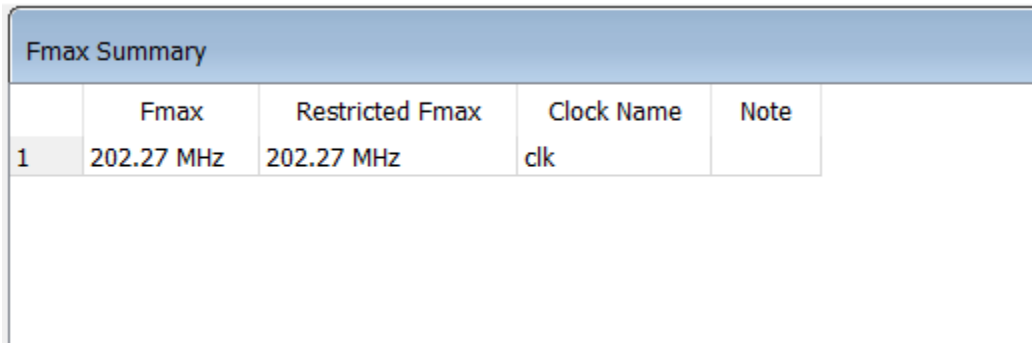
ب)

برای سنتز کردن ابتدا فایل وریلاگ ماژول درست شده رو در کوارتوس باز می کنیم و سپس در لیست دیوایس ها، **Cydone IV GX** را انتخاب می کنیم و سپس کامپایل می کنیم.

بعد ار آن باید ابزار **Time Quest Analyzer** را باز کنیم و در آن یک **Timing Netlist** بسازیم و پس از ساخته شدن به نتیجه زیر میرسیم:



پس از این مرحله، باید Read STC File و بعد از آن، Update Timing Netlist را انجام دهیم و سپس در بین گزارش ها Report Fmax Summary را باز می کنیم که به فرکانس ماکس ایجاد شده را خروجی می دهد:



Fmax Summary

	Fmax	Restricted Fmax	Clock Name	Note
1	202.27 MHz	202.27 MHz	clk	