

به نام خدا

پروژه امتیازی طراحی سیستم های دیجیتال

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(الف)

ماژول park را درست می کنیم و ورودی و خروجی های مورد نیاز را به آن اضافه می کنیم

```
code > V park.v
1  module park (
2      input car_entered,
3      input is_uni_car_entered,
4      input car_exited,
5      input is_uni_car_exited,
6      input [4:0] hour,
7      output reg signed [9:0] uni_parked_car = 0,
8      output reg signed [9:0] parked_car = 0,
9      output signed [9:0] uni_vacated_space,
10     output signed [9:0] vacated_space,
11     output uni_is_vacated_space,
12     output is_vacated_space,
13     output parking_is_vacated_space
14 );
15
16 reg signed [9:0] free_space = 0;
17 wire signed [9:0] uni_free_space;
18
19 assign uni_vacated_space = uni_free_space - uni_parked_car;
20 assign vacated_space = free_space - parked_car;
21
22 assign uni_free_space = 700 - free_space;
23
24 assign uni_is_vacated_space = uni_vacated_space > 0;
25 assign is_vacated_space = vacated_space > 0;
26 assign parking_is_vacated_space = uni_vacated_space + vacated_space > 0;
27
28 always @(hour) begin
29     if (hour >= 8 && hour < 13)
30         free_space = 200;
31     else if (hour >= 13 && hour < 16)
32         free_space = 200 + (hour - 12) * 50;
33     else
34         free_space = 500;
35 end
```

تا اینجا کار ما سیم های مورد نیاز را تولید کرده ایم و در هر موقعی که ساعت تغییر میکند مقدار free_space را که نشان دهنده فضای خالی آزاد میباشد تنظیم میکنیم

```

36
37 ✓ always @(posedge car_entered, posedge car_exited) begin
38 ✓     if (car_entered) begin
39         if (is_uni_car_entered)
40 ✓         begin
41 ✓             if (uni_is_vacated_space)
42                 uni_parked_car <= uni_parked_car + 1;
43             end
44         else
45 ✓         begin
46 ✓             if (is_vacated_space)
47                 parked_car <= parked_car + 1;
48             end
49     end
50
51 ✓     else if (car_exited) begin
52         if (is_uni_car_exited)
53 ✓         begin
54 ✓             if (uni_parked_car > 0)
55                 uni_parked_car <= uni_parked_car - 1;
56             end
57         else
58 ✓         begin
59 ✓             if (parked_car > 0)
60                 parked_car <= parked_car - 1;
61             end
62     end
63 end
64 endmodule

```

در این مرحله منتظر ورود یا خروج ماشین می مانیم و در صورتی که سیگنال های مربوطه را دریافت کردیم بررسی می کنیم اگر از دانشگاه است متغیر های دانشگاه وگرنه متغیر های آزاد را تغییر دهیم

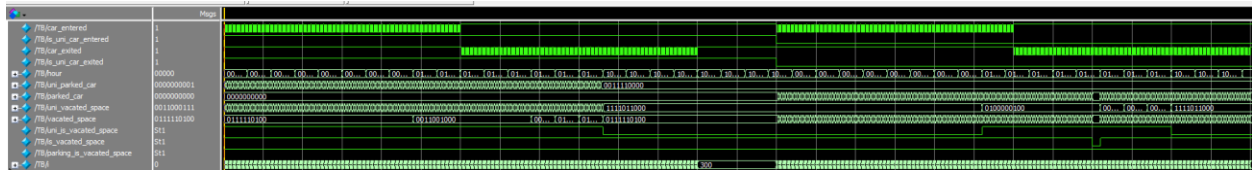
ورودی hour به ماژول اضافه شده و در لیست ورودی ها نبود و دلیل آن این است که ورود یا خروج ماشین را ما همراه با ساعت ورود و خروج او به ماژول میفرستیم تا بفهمیم فضای خالی داریم یا خیر

یک تست برای مدار نوشته ایم که به صورت زیر است

```
32  initial
33      hour = 0;
34  always begin
35      #30
36      if (hour >= 23)
37          hour = 0;
38      else
39          hour = hour + 1;
40  end
41
42  initial begin
43      car_entered <= 1;
44      is_uni_car_entered <= 1;
45      car_exited <= 1;
46      is_uni_car_exited <= 1;
47
48      for (i = 0; i < 300; i = i + 1) begin
49          #1 car_entered <= !car_entered;
50      end
51
52      for (i = 0; i < 300; i = i + 1) begin
53          #1 car_exited <= !car_exited;
54      end
55      #100
56
57      is_uni_car_entered <= 0;
58      is_uni_car_exited <= 0;
59
60      for (i = 0; i < 300; i = i + 1) begin
61          #1 car_entered <= !car_entered;
62      end
63
64      for (i = 0; i < 300; i = i + 1) begin
65          #1 car_exited <= !car_exited;
66      end
67
68      #100 $stop();
69  end
70
```

این کد در ابتدا یک اینستنس از ماژول پارک ساخته است و سپس در بلاک اینیشیال مراحل بالا را انجام داده است که به ترتیب 300 بار ورود و خروج ماشین های دانشگاه اتفاق می افتد و بعد از 100 واحد توقف 300 بار ورود و خروج ماشین های آزاد اتفاق می افتد و در هر 30 واحد زمانی یک ساعت به جلو رفته ایم

خروجی این تست به صورت زیر است



که همه حالات خالی بود یا پر بودن پارکینگ برای ماشین های آزاد یا دانشگاه تست شده است

(ب)

از طریق نرم افزار quartus می توانیم خروجی ماکسیمم فرکانس را بگیریم که به صورت زیر است

	Fmax	Restricted Fmax	Clock Name	Note
1	117.15 MHz	117.15 MHz	car_entered	
2	122.7 MHz	122.7 MHz	car_exited	

در تصویر زیر میتوانیم ببینیم که مسیر ها چقدر تاخیر دارند

Removal: car_exited							
Slack	From Node	To Node	Launch Clock	Latch Clock	Relationship	Clock Skew	Data Delay
1 -0.199	car_entered	uni_parked_car[3]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.232
2 -0.199	car_entered	uni_parked_car[5]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.232
3 -0.199	car_entered	uni_parked_car[3]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.232
4 -0.199	car_entered	parked_car[3]~reg0_emulated	car_entered	car_exited	0.000	2.359	2.235
5 -0.199	car_entered	parked_car[5]~reg0_emulated	car_entered	car_exited	0.000	2.359	2.235
6 -0.198	car_entered	uni_parked_car[1]~reg0_emulated	car_entered	car_exited	0.000	2.358	2.235
7 -0.195	car_entered	uni_parked_car[4]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.236
8 -0.195	car_entered	uni_parked_car[6]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.236
Hold: car_exited							
Slack	From Node	To Node	Launch Clock	Latch Clock	Relationship	Clock Skew	Data Delay
1 -0.041	car_entered	uni_parked_car[5]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.390
2 -0.021	car_entered	uni_parked_car[3]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.410
3 -0.011	car_entered	uni_parked_car[3]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.420
4 -0.011	car_entered	uni_parked_car[5]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.420
5 -0.011	car_entered	uni_parked_car[3]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.420
6 -0.008	car_entered	uni_parked_car[0]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.423
7 -0.005	car_entered	uni_parked_car[4]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.426
8 -0.005	car_entered	uni_parked_car[6]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.426
9 -0.005	car_entered	uni_parked_car[7]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.426
10 -0.005	car_entered	uni_parked_car[3]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.426
11 -0.005	car_entered	uni_parked_car[2]~reg0_emulated	car_entered	car_exited	0.000	2.356	2.426
Hold: car_entered							
Slack	From Node	To Node	Launch Clock	Latch Clock	Relationship	Clock Skew	Data Delay
1 -0.555	car_entered	uni_parked_car[7]~29	car_entered	car_entered	0.000	2.431	1.876
2 -0.555	car_entered	uni_parked_car[7]~29	car_entered	car_entered	0.000	2.431	1.876
3 -0.549	car_entered	uni_parked_car[7]~29	car_entered	car_entered	0.000	2.431	1.882
4 -0.528	car_entered	uni_parked_car[7]~29	car_entered	car_entered	0.000	2.431	1.903
5 -0.521	car_entered	uni_parked_car[7]~29	car_entered	car_entered	0.000	2.431	1.910
6 -0.511	car_entered	uni_parked_car[7]~29	car_entered	car_entered	0.000	2.431	1.920
7 -0.497	car_entered	uni_parked_car[7]~29	car_entered	car_entered	0.000	2.431	1.934
8 -0.493	car_entered	uni_parked_car[8]~33	car_entered	car_entered	0.000	2.534	2.041
9 -0.493	car_entered	uni_parked_car[8]~33	car_entered	car_entered	0.000	2.534	2.041
10 -0.491	car_entered	uni_parked_car[7]~29	car_entered	car_entered	0.000	2.431	1.940
11 -0.487	car_entered	uni_parked_car[8]~33	car_entered	car_entered	0.000	2.534	2.047
Setup: car_entered							
ack	From Node	To Node	Launch Clock	Latch Clock	Relationship	Clock Skew	Data Delay
95	uni_parked_car[0]~reg0_emulated	uni_parked_car[3]~13	car_exited	car_entered	0.500	-0.126	5.080
35	uni_parked_car[9]~reg0_emulated	uni_parked_car[3]~13	car_exited	car_entered	0.500	-0.126	4.920
21	uni_parked_car[5]~reg0_emulated	uni_parked_car[3]~13	car_exited	car_entered	0.500	-0.126	4.906
19	uni_parked_car[4]~reg0_emulated	uni_parked_car[3]~13	car_exited	car_entered	0.500	-0.126	4.894
102	uni_parked_car[7]~reg0_emulated	uni_parked_car[3]~13	car_exited	car_entered	0.500	-0.126	4.887
88	uni_parked_car[6]~reg0_emulated	uni_parked_car[3]~13	car_exited	car_entered	0.500	-0.126	4.873
84	uni_parked_car[8]~reg0_emulated	uni_parked_car[3]~13	car_exited	car_entered	0.500	-0.126	4.869
72	uni_parked_car[2]~reg0_emulated	uni_parked_car[3]~13	car_exited	car_entered	0.500	-0.126	4.857
67	uni_parked_car[0]~reg0_emulated	uni_parked_car[9]~37	car_exited	car_entered	0.500	0.069	4.858
64	uni_parked_car[1]~reg0_emulated	uni_parked_car[3]~13	car_exited	car_entered	0.500	-0.128	4.847
57	uni_parked_car[3]~reg0_emulated	uni_parked_car[3]~13	car_exited	car_entered	0.500	-0.126	4.842
45	uni_parked_car[9]~reg0_emulated	uni_parked_car[1]~5	car_exited	car_entered	0.500	-0.094	4.768
42	uni_parked_car[6]~reg0_emulated	uni_parked_car[5]~21	car_exited	car_entered	0.500	-0.112	4.776
Setup: car_exited							
k	From Node	To Node	Launch Clock	Latch Clock	Relationship	Clock Skew	Data Delay
2	uni_parked_car[8]~33	uni_parked_car[1]~reg0_emulated	car_entered	car_exited	0.500	-0.252	8.053
8	uni_parked_car[6]~25	uni_parked_car[1]~reg0_emulated	car_entered	car_exited	0.500	-0.249	8.049
4	uni_parked_car[6]~33	uni_parked_car[3]~reg0_emulated	car_entered	car_exited	0.500	-0.254	8.033
7	uni_parked_car[6]~25	uni_parked_car[5]~reg0_emulated	car_entered	car_exited	0.500	-0.251	8.029
0	uni_parked_car[6]~33	uni_parked_car[3]~reg0_emulated	car_entered	car_exited	0.500	-0.254	8.019
3	uni_parked_car[6]~25	uni_parked_car[3]~reg0_emulated	car_entered	car_exited	0.500	-0.251	8.015
8	uni_parked_car[6]~33	uni_parked_car[4]~reg0_emulated	car_entered	car_exited	0.500	-0.254	7.977
1	uni_parked_car[6]~25	uni_parked_car[4]~reg0_emulated	car_entered	car_exited	0.500	-0.251	7.973
7	uni_parked_car[8]~33	uni_parked_car[2]~reg0_emulated	car_entered	car_exited	0.500	-0.254	7.966
5	uni_parked_car[7]~29	uni_parked_car[1]~reg0_emulated	car_entered	car_exited	0.500	-0.149	8.070
0	uni_parked_car[6]~25	uni_parked_car[2]~reg0_emulated	car_entered	car_exited	0.500	-0.251	7.962
8	uni_parked_car[6]~33	uni_parked_car[7]~reg0_emulated	car_entered	car_exited	0.500	-0.254	7.957
1	uni_parked_car[6]~25	uni_parked_car[7]~reg0_emulated	car_entered	car_exited	0.500	-0.251	7.953

و اگر مقدار تاخیر دیتای انها را معکوس کنیم با تقریب دهگان فرکانس ما را میدهد