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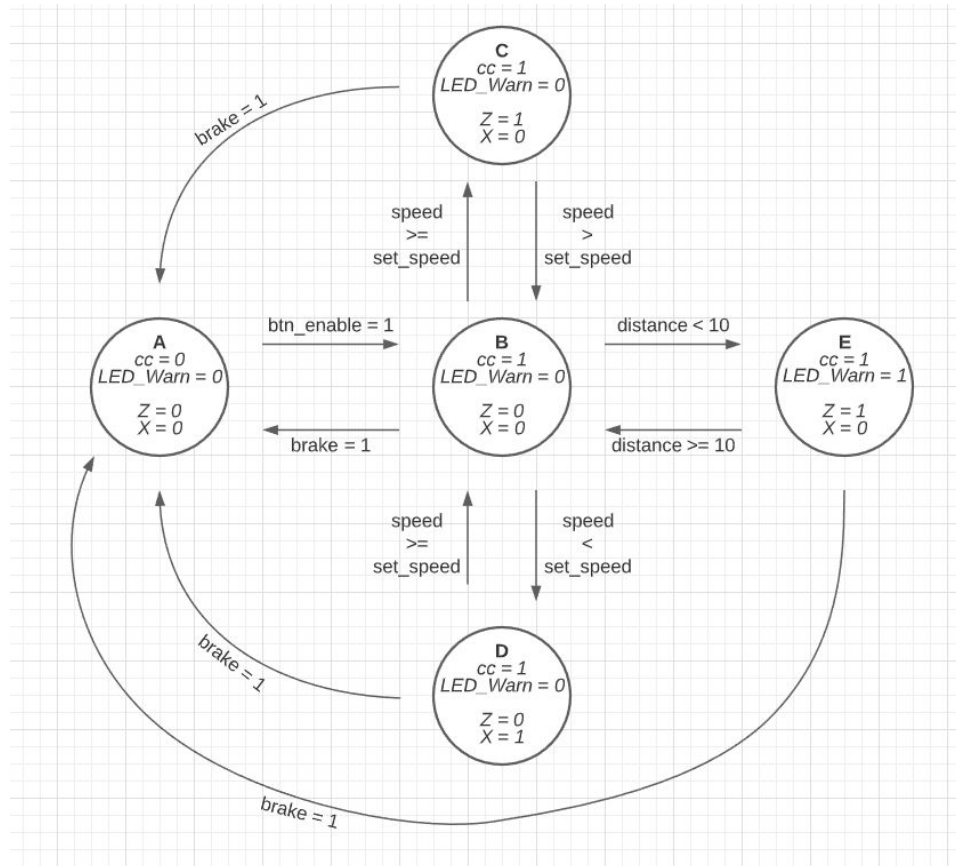
## Digital Logic Final Project

### **Abstract**

We were tasked with developing an adaptive cruise control system for a vehicle. The constraints were that

- The driver must be able to set a speed anywhere between 0 and 64 mph
- The vehicle must maintain that speed by accelerating or decelerating by 1 mph at each clock cycle until the current speed matches the set speed
- The cruise control is deactivated and needs to be re-enabled manually when the brake is pressed
- The cruise control allows the driver to press the accelerator, but when it is released, the cruise control is re-enabled automatically
- The vehicle must keep at least 10 meters behind any vehicles in front of it, as well as warning the driver and activating the brakes if the vehicle is approaching another vehicle too fast

### **Solution**



**Code:**

```

1  /*The following module is designed to be an adaptive cruise control unit. The program allows the user to toggle cruise control on any input speed
2  equal to or lower than 64 mph. The body of the code is almost entirely state based, with automated accelerate and decelerate functions for matching
3  speeds. The user may also manually accelerate or decelerate, deactivating the cruise control if brakes are applied. Sensors are also simulated in
4  the program for objects in front of the user's car. Objects/other cars cannot be closer than 10 meters from the user's car. Otherwise, brakes are
5  applied and a warning LED will flash.
6
7
8  Inputs
9
10 -----
11 initial_speed = 6-bit binary input to represent the initial speed of the user's car. Maximum speed is 64.
12 speed_otherCar = 6-bit binary input to represent the speed of the other car. Maximum speed is 64.
13 btn_enable = Button that enables/toggles cruise control
14 clk = Input clock onboard
15 brake = Button that toggles the brakes when held down
16 accel = Button that toggles the accelerator when held down
17 btn_reset = Button that enables/toggles a reset, setting all 7-segments to 00
18 distance = 3-bit binary input to represent the distance between the user's car and the car in front of it. Maximum distance is 10.
19
20 -----
21
22 Outputs
23
24 -----
25 cc_led = LED that indicates cruise control is on/off
26 LED_warning = LED that toggles when the user car is too close to the other car
27 seg1_set_speed = 7-segment display showing the set speed of the user's car (0-9)
28 seg2_set_speed = 7-segment display showing the set speed of the user's car (0-6)
29 seg1_speed = 7-segment display showing the current speed of the user's car (0-9)
30 seg2_speed = 7-segment display showing the current speed of the user's car (0-6)
31 seg1_otherCar_speed = 7-segment display showing the speed of the other car (0-9)
32 seg2_otherCar_speed = 7-segment display showing the speed of the other car (0-6)
33
34 -----
35 */
36
37 module FP_CruiseControl (input [5:0] initial_speed, speed_otherCar, input btn_enable, clk, brake, accel, btn_reset, input [3:0] distance, output reg cc_LED, LED_warning,
38
39 //Regulate a variable to be used with the clock
40 reg seg_clk;
41 //Regulate variables X and Z for the states
42 reg X, Z;
43 //Create a parameter for the maximum count of the clock
44 parameter MAX_COUNT = 10000000;
45 //Regulate a 24-bit binary variable to represent the count of the clock
46 reg [23:0] count;
47 //Regulate a 6-bit binary variable for the set speed
48 reg [5:0] set_speed;
49 //Regulate a variable for the current speed
50 reg speed;
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52 //Create local parameters for the next state
53 localparam A = 0, B = 1, C = 2, D = 3, E = 4;
54 //Regulate 2 2-bit binary variables representative of the car's state
55 reg [1:0] present_state, next_state;
56
57
58 //Next State
59
60 always @ (*) begin
61     case (present_state)
62     A: begin
63         if (btn_enable == 0) begin
64             set_speed = speed;
65             next_state = B;
66         end else begin
67             next_state = A;
68         end
69     end
70     B: begin
71         if (brake == 0) begin
72             next_state = A;
73         end else if ((distance < 10) || ((speed_otherCar < speed) && (distance < 20))) begin
74             next_state = E;
75         end else if (speed > set_speed) begin
76             next_state = C;
77         end else if (speed < set_speed) begin
78             next_state = D;
79         end else begin
80             next_state = B;
81         end
82     end
83     C: begin
84         if (brake == 0) begin
85             next_state = A;
86         end else if (speed <= set_speed || accel == 0) begin
87             next_state = B;
88         end else begin
89             next_state = C;
90         end
91     end
92     D: begin
93         if (brake == 0) begin
94             next_state = A;
95         end else if (speed >= set_speed) begin
96             next_state = B;
97         end else begin
98             next_state = D;
99         end
100     end

```

```

101  E: begin
102      if (brake == 0) begin
103          next_state = A;
104      end else if (distance >= 10 && speed_otherCar > speed) begin
105          next_state = B;
106      end else begin
107          next_state = E;
108      end
109  end
110  endcase
111
112  //Output
113
114  case (present_state)
115      A: begin
116          cc_LED = 0; LED_Warning <= 0; Z <= 0; X <= 0;
117      end
118      B: begin
119          cc_LED = 1; LED_Warning <= 0; Z <= 0; X <= 0;
120      end
121      C: begin
122          cc_LED = 1; LED_Warning <= 0; Z <= 1; X <= 0;
123      end
124      D: begin
125          cc_LED = 1; LED_Warning <= 0; Z <= 0; X <= 1;
126      end
127      E: begin
128          cc_LED = 1; LED_Warning <= 1; Z <= 1; X <= 0;
129      end
130      default: begin
131          cc_LED = 0; LED_Warning <= 0; Z <= 0; X <= 0;
132      end
133  endcase
134  end
135
136
137
138  //Maintain Speed
139
140  always @ (posedge clk) begin
141      speed = initial_speed;
142      if (Z == 1) begin
143          speed = speed - 1;
144      end else if (X == 1) begin
145          speed = speed + 1;
146      end
147      //Clk
148      if (count < MAX_COUNT) begin
149          count = count + 1;
150      end else begin
151          count <= 0;
152          seq_clk <= ~seq_clk;

```

```

153     end
154 end
155
156 //Reset
157 always @ (posedge seg_clk) begin
158     if (btn_reset == 0) begin
159         present_state <= A; //Initial State
160     end else begin
161         present_state <= next_state;
162     end
163 end
164
165 /**Set/Input Speed
166 //7-seg 1
167
168 always @ (*) begin
169     case (set_speed)
170         0: seg1_set_speed = 7'b1000000;
171         1: seg1_set_speed = 7'b1111001;
172         2: seg1_set_speed = 7'b0100100;
173         3: seg1_set_speed = 7'b0110000;
174         4: seg1_set_speed = 7'b0011001;
175         5: seg1_set_speed = 7'b0010010;
176         6: seg1_set_speed = 7'b0000010;
177         7: seg1_set_speed = 7'b1111000;
178         8: seg1_set_speed = 7'b0000000;
179         9: seg1_set_speed = 7'b0010000;
180     default: seg1_set_speed = 7'b1000000;
181     endcase
182     case (set_speed)
183         0: seg2_set_speed = 7'b1000000;
184         1: seg2_set_speed = 7'b1111001;
185         2: seg2_set_speed = 7'b0100100;
186         3: seg2_set_speed = 7'b0110000;
187         4: seg2_set_speed = 7'b0011001;
188         5: seg2_set_speed = 7'b0010010;
189         6: seg2_set_speed = 7'b0000010;
190     default: seg2_set_speed = 7'b1000000;
191     endcase
192     case (speed)
193         0: seg1_speed = 7'b1000000;
194         1: seg1_speed = 7'b1111001;
195         2: seg1_speed = 7'b0100100;
196         3: seg1_speed = 7'b0110000;
197         4: seg1_speed = 7'b0011001;
198         5: seg1_speed = 7'b0010010;
199         6: seg1_speed = 7'b0000010;
200         7: seg1_speed = 7'b1111000;
201         8: seg1_speed = 7'b0000000;
202         9: seg1_speed = 7'b0010000;
203     default: seg1_speed = 7'b0000000;
204     endcase

```



```

205 case (speed)
206     0:seg2_speed = 7'b1000000;
207     1:seg2_speed = 7'b1111001;
208     2:seg2_speed = 7'b0100100;
209     3:seg2_speed = 7'b0110000;
210     4:seg2_speed = 7'b0011001;
211     5:seg2_speed = 7'b0010010;
212     6:seg2_speed = 7'b0000010;
213 default: seg2_speed = 7'b0000000;
214 endcase
215 case (speed_otherCar)
216     0:seg1_otherCar_speed = 7'b1000000;
217     1:seg1_otherCar_speed = 7'b1111001;
218     2:seg1_otherCar_speed = 7'b0100100;
219     3:seg1_otherCar_speed = 7'b0110000;
220     4:seg1_otherCar_speed = 7'b0011001;
221     5:seg1_otherCar_speed = 7'b0010010;
222     6:seg1_otherCar_speed = 7'b0000010;
223     7:seg1_otherCar_speed = 7'b1111000;
224     8:seg1_otherCar_speed = 7'b0000000;
225     9:seg1_otherCar_speed = 7'b0010000;
226 default: seg1_otherCar_speed = 7'b1000000;
227 endcase
228 case (speed_otherCar)
229     0:seg2_otherCar_speed = 7'b1000000;
230     1:seg2_otherCar_speed = 7'b1111001;
231     2:seg2_otherCar_speed = 7'b0100100;
232     3:seg2_otherCar_speed = 7'b0110000;
233     4:seg2_otherCar_speed = 7'b0011001;
234     5:seg2_otherCar_speed = 7'b0010010;
235     6:seg2_otherCar_speed = 7'b0000010;
236 default: seg2_otherCar_speed = 7'b1000000;
237 endcase
238 end
239
240 endmodule
241

```

## Discussion

The verilog code we wrote was able to run successfully on the digital logic board and simulate an adaptive cruise control system. We faced problems with displaying two-digit numbers on the seven-segment displays. They kept printing only one digit on each of the seven-segment displays instead of the whole two-digit number. This was corrected by assigning multiple variables to the seven-segment display outputs, which we then could change individually in the cases to output two-digit numbers properly. We also had challenges with our always blocks. Originally, we had too many always blocks, so the code would not run. We had an always block for each section of our code. This problem was solved by condensing our code to fit into less always blocks. Once we condensed our code, the error no longer showed up. This project could be worked on further by implementing algorithms to accelerate and decelerate the car based on the speed limits and the distance to the car in front. These algorithms could turn the adaptive cruise control system into a self-driving system for a vehicle.