

Problem 1: [12 points] Drill problem
Filename: library.sv
AndrewID: xinyew

```
1 `default_nettype none
2 module Decoder
3   (input  logic en,
4    input  logic [2:0] I,
5    output logic [7:0] D);
6
7   always_comb begin
8     unique case (I)
9       3'b000: D = 8'b00000001;
10      3'b001: D = 8'b00000010;
11      3'b010: D = 8'b00000100;
12      3'b011: D = 8'b00001000;
13      3'b100: D = 8'b00010000;
14      3'b101: D = 8'b00100000;
15      3'b110: D = 8'b01000000;
16      3'b111: D = 8'b10000000;
17    endcase
18    D = en ? D : 0;
19  end
20
21 endmodule : Decoder
22
23 module BarrelShifter
24   (input  logic [15:0] v,
25    input  logic [3:0] by,
26    output logic [15:0] s);
27
28   always_comb begin
29     s = by[3] ? v << 8 : v;
30     s = by[2] ? s << 4 : s;
31     s = by[1] ? s << 2 : s;
32     s = by[0] ? s << 1 : s;
33   end
34
35 endmodule : BarrelShifter
36
37 module Multiplexer
38   (input  logic [7:0] I,
39    input  logic [2:0] s,
40    output logic Y);
41
42   always_comb
43     case (s)
44       3'b000: Y = I[0];
45       3'b001: Y = I[1];
46       3'b010: Y = I[2];
47       3'b011: Y = I[3];
48       3'b100: Y = I[4];
49       3'b101: Y = I[5];
50       3'b110: Y = I[6];
51       3'b111: Y = I[7];
52     endcase
53
54 endmodule: Multiplexer
55
56 module Mux2to1
57   (input  logic [6:0] I0,
58    input  logic [6:0] I1,
59    input  logic S,
60    output logic [6:0] Y);
61
62   always_comb
63     case (S)
64       0: Y = I0;
65       1: Y = I1;
66     endcase
67
68 endmodule : Mux2to1
69
```

```
70 module MagComparator
71     (input  logic [7:0] A,
72      input  logic [7:0] B,
73      output logic AltB,
74      output logic AeqB,
75      output logic AgtB);
76
77     assign AltB = A < B;
78     assign AgtB = A > B;
79     assign AeqB = A == B;
80
81 endmodule : MagComparator
82
83 module Comparator
84     (input  logic [3:0] A,
85      input  logic [3:0] B,
86      output logic AeqB);
87
88     assign AeqB = A == B;
89
90 endmodule : Comparator
```

Problem 1: [12 points] Drill problem
Filename: library_tests.sv
AndrewID: xinyew

```
1 `default_nettype none
2 module Decoder_test;
3     logic en;
4     logic [2:0] I;
5     logic [7:0] D;
6
7     Decoder DUT(.en(en),
8                 .I(I),
9                 .D(D));
10
11     initial begin
12         $monitor($time,,
13                 "en = %b, I = %b, D = %b", en, I, D);
14         en = 1;
15         for (I = 3'b000; I < 3'b111; I++)
16             #1;
17         en = 0;
18         for (I = 3'b000; I < 3'b111; I++)
19             #1;
20         #1 $finish;
21     end
22
23 endmodule: Decoder_test
24
25 module BarrelShifter_test;
26     logic [15:0] v;
27     logic [3:0] by;
28     logic [15:0] s;
29
30     BarrelShifter DUT(.v(v),
31                       .by(by),
32                       .s(s));
33
34     initial begin
35         $monitor($time,,
36                 "v = %b, by = %b, s = %b", v, by, s);
37         v = 16'b0101010101010101;
38         for (by = 4'b0000; by < 4'b1111; by++)
39             #1;
40         #1 $finish;
41     end
42
43 endmodule: BarrelShifter_test
44
45 module Multiplexer_test;
46     logic [7:0] I;
47     logic [2:0] s;
48     logic Y;
49
50     Multiplexer DUT(.I(I),
51                     .s(s),
52                     .Y(Y));
53
54     initial begin
55         $monitor($time,,
56                 "I = %b, s = %b, Y = %b", I, s, Y);
57         I = 8'b01010101;
58         for (s = 3'b000; s < 3'b111; s++)
59             #1;
60         #1 $finish;
61     end
62
63 endmodule : Multiplexer_test
64
65 module Mux2to1_test;
66     logic [6:0] I0;
67     logic [6:0] I1;
68     logic S;
69     logic [6:0] Y;
```

```
70
71 Mux2to1 DUT(.I0(I0),
72             .I1(I1),
73             .S(S),
74             .Y(Y));
75
76 initial begin
77     $monitor($time,,
78             "I0 = %b, I1 = %b, S = %b, Y = %b", I0, I1, S, Y);
79     I0 = 7'b00000000;
80     I1 = 7'b11111111;
81     S = 0;
82     #1 S = 1;
83     #1 $finish;
84 end
85
86 endmodule : Mux2to1_test
87
88 module MagComparator_test;
89     logic [7:0] A;
90     logic [7:0] B;
91     logic AltB;
92     logic AgtB;
93     logic AeqB;
94
95     MagComparator DUT (.A(A),
96                       .B(B),
97                       .AltB(AltB),
98                       .AgtB(AgtB),
99                       .AeqB(AeqB));
100
101     initial begin
102         $monitor($time,,
103                 "A = %b, B = %b, AltB = %b, AgtB = %b, AeqB = %b", A, B , AltB, AgtB, AeqB);
104         A = 8'b00000000;
105         B = 8'b11111111;
106         #2 A = 8'b11111111;
107         #2 B = 8'b00000000;
108         #2 $finish;
109     end
110
111 endmodule : MagComparator_test
112
113 module Comparator_test;
114     logic [3:0] A;
115     logic [3:0] B;
116     logic AeqB;
117
118     MagComparator DUT (.A(A),
119                       .B(B),
120                       .AeqB(AeqB));
121
122     initial begin
123         $monitor($time,,
124                 "A = %b, B = %b, AeqB = %b", A, B, AeqB);
125         A = 8'b00000000;
126         B = 8'b11111111;
127         #2 A = 8'b11111111;
128         #2 $finish;
129     end
130
131 endmodule : Comparator_test
```

Problem 2: [6 points] Drill problem
Filename: hw2prob2.sv
AndrewID: xinyew

```
1 module hw2prob2
2   (input  logic a, b ,c , d,
3    output logic f, g, h);
4
5   always_comb
6     case ({a, b, c})
7       3'd1: f = 1;
8       3'd3: f = 1;
9       3'd4: f = 1;
10      default: f = 0;
11    endcase
12
13    always_comb begin
14      if ({a, b, c, d} == 4'd1 || {a, b, c, d} == 4'd3
15        || {a, b, c, d} == 4'd5 || {a, b, c, d} == 4'd12)
16        g = 0;
17      else
18        g = 1;
19    end
20
21    assign h = ({b, d} == 2'b11 || {c, d} == 2'b01 || {a, b, c} == 3'b000
22      || {a, b, c} == 3'b011 || {b, c, d} == 3'b010) | 0;
23
24  endmodule : hw2prob2
25
26  module hw2prob2_test;
27    logic [3:0] vector;
28    logic f, g, h;
29
30    hw2prob2 DUT (.a(vector[3]),
31                  .b(vector[2]),
32                  .c(vector[1]),
33                  .d(vector[0]),
34                  .f(f),
35                  .g(g),
36                  .h(h));
37
38    initial begin
39      $monitor($time,,
40        "a = %b, b = %b, c = %b, d = %b, f = %b, g = %b, h = %b",
41        vector[3], vector[2], vector[1], vector[0], f, g, h);
42      for (vector = 4'b0000; vector < 4'b1111; vector++)
43        #1;
44      #1 $finish;
45    end
46
47  endmodule : hw2prob2_test
```

Problem 3: [8 points] Drill problem
Filename: hw2prob3.sv
AndrewID: xinyew

```
1 module hw2prob3
2   (input logic a, b, c, d,
3    output logic l_assign, l_assign_min, l_case, l_casez);
4
5   assign l_assign = {a, b, c, d} == 4'd0 || {a, b, c, d} == 4'd2
6                  || {a, b, c, d} == 4'd4 || {a, b, c, d} == 4'd6
7                  || {a, b, c, d} == 4'd7 || {a, b, d, d} == 4'd10
8                  || {a, b, c, d} == 4'd13 || {a, b, c, d} == 4'd5
9                  || {a, b, c, d} == 4'd8 || {a, b, c, d} == 4'd15;
10
11  assign l_assign_min = {b, d} == 2'b11 || {a, d} == 2'b00
12                  || {a, b, d} == 3'b100;
13
14  always_comb
15    unique case ({a, b, c, d})
16      4'd0: l_case = 1;
17      4'd2: l_case = 1;
18      4'd4: l_case = 1;
19      4'd6: l_case = 1;
20      4'd7: l_case = 1;
21      4'd10: l_case = 1;
22      4'd13: l_case = 1;
23      default: l_case = 0;
24    endcase
25
26  always_comb
27    unique casez ({a, b, c, d})
28      4'b?1?1: l_casez = 1;
29      4'b0??0: l_casez = 1;
30      4'b10?0: l_casez = 1;
31      default: l_casez = 0;
32    endcase
33
34 endmodule : hw2prob3
35
36 module hw2prob3_test;
37   logic [3:0] vector;
38   logic l_assign, l_assign_min, l_case, l_casez;
39
40   hw2prob3 DUT (.a(vector[3]),
41                .b(vector[2]),
42                .c(vector[1]),
43                .d(vector[0]),
44                .l_assign(l_assign),
45                .l_assign_min(l_assign_min),
46                .l_case(l_case),
47                .l_casez(l_casez));
48
49   initial begin
50     $monitor($time,,
51              "a = %b, b = %b, c = %b, d = %b, l1 = %b, l2 = %b, l3 = %b, l4 = %b",
52              vector[3], vector[2], vector[1], vector[0],
53              l_assign, l_assign_min, l_case, l_casez);
54     for (vector = 4'b0000; vector < 4'b1111; vector++)
55       #1;
56     #1 $finish;
57   end
58
59 endmodule : hw2prob3_test
```

Problem 4: [8 points]
Filename: hw2prob4.sv
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```
1 `default_nettype none
2 module hw2prob4
3   (input  logic a, b, c, d, e,
4    output logic m, n);
5
6   assign m = a ^ (b + c & (~d));
7   always_comb
8     case ({a, b, c, d, e})
9       5'd0: n = 0;
10      5'd1: n = 0;
11      5'd2: n = 0;
12      5'd3: n = 0;
13      5'd5: n = 0;
14      5'd9: n = 0;
15      5'd16: n = 0;
16      5'd17: n = 0;
17      5'd22: n = 0;
18      5'd25: n = 0;
19      5'd27: n = 0;
20      default: n = 1;
21    endcase
22
23 endmodule : hw2prob4
24
25 module hw2prob4_test;
26   logic [4:0] vector;
27   logic m, n;
28
29   hw2prob4 DUT (.a(vector[4]),
30                .b(vector[3]),
31                .c(vector[2]),
32                .d(vector[1]),
33                .e(vector[0]),
34                .m(m),
35                .n(n));
36
37   initial begin
38     $monitor($time,,
39              "a = %b, b = %b, c = %b, d = %b, e = %b, m = %b, n = %b",
40              vector[4], vector[3], vector[2], vector[1], vector[0], m, n);
41     for (vector = 5'b00000; vector < 5'b11111; vector++)
42       #1;
43     #1 $finish;
44   end
45
46 endmodule : hw2prob4_test
```

Problem 8: [6 points]
Filename: hw2prob8.sv
AndrewID: xinyew

```
1 `default_nettype none
2
3 module BCDtoSevenSegment
4   (input  logic [3:0] bcd,
5    output logic [6:0] segment);
6
7   always_comb
8     case (bcd)
9       4'd0: segment = 7'b0111111;
10      4'd1: segment = 7'b0000110;
11      4'd2: segment = 7'b1011011;
12      4'd3: segment = 7'b1001111;
13      4'd4: segment = 7'b1100110;
14      4'd5: segment = 7'b1101101;
15      4'd6: segment = 7'b1111101;
16      4'd7: segment = 7'b0000111;
17      4'd8: segment = 7'b1111111;
18      4'd9: segment = 7'b1101111;
19      default: segment = 7'b0000000;
20    endcase
21
22 endmodule : BCDtoSevenSegment
```


Problem 9: [6 points]
Filename: 7SegmentDisplay.sv
AndrewID: xinyew

```
1 `default_nettype none
2
3 module SevenSegmentDisplay
4   (input  logic [3:0] BCD7, BCD6, BCD5, BCD4, BCD3, BCD2, BCD1, BCD0,
5    input  logic [7:0] blank,
6    output logic [6:0] HEX7, HEX6, HEX5, HEX4, HEX3, HEX2, HEX1, HEX0);
7
8   always_comb begin
9     HEX0 = 7'b00000000;
10    if (~blank[0])
11      case (BCD0)
12        4'd0: HEX0 = 7'b01111111;
13        4'd1: HEX0 = 7'b0000110;
14        4'd2: HEX0 = 7'b1011011;
15        4'd3: HEX0 = 7'b1001111;
16        4'd4: HEX0 = 7'b1100110;
17        4'd5: HEX0 = 7'b1101101;
18        4'd6: HEX0 = 7'b1111101;
19        4'd7: HEX0 = 7'b0000111;
20        4'd8: HEX0 = 7'b1111111;
21        4'd9: HEX0 = 7'b1101111;
22        default: HEX0 = 7'b00000000;
23      endcase
24    HEX0 = ~HEX0;
25  end
26
27  always_comb begin
28    HEX1 = 7'b00000000;
29    if (~blank[1])
30      case (BCD1)
31        4'd0: HEX1 = 7'b01111111;
32        4'd1: HEX1 = 7'b0000110;
33        4'd2: HEX1 = 7'b1011011;
34        4'd3: HEX1 = 7'b1001111;
35        4'd4: HEX1 = 7'b1100110;
36        4'd5: HEX1 = 7'b1101101;
37        4'd6: HEX1 = 7'b1111101;
38        4'd7: HEX1 = 7'b0000111;
39        4'd8: HEX1 = 7'b1111111;
40        4'd9: HEX1 = 7'b1101111;
41        default: HEX1 = 7'b00000000;
42      endcase
43    HEX1 = ~HEX1;
44  end
45
46  always_comb begin
47    HEX2 = 7'b00000000;
48    if (~blank[2])
49      case (BCD2)
50        4'd0: HEX2 = 7'b01111111;
51        4'd1: HEX2 = 7'b0000110;
52        4'd2: HEX2 = 7'b1011011;
53        4'd3: HEX2 = 7'b1001111;
54        4'd4: HEX2 = 7'b1100110;
55        4'd5: HEX2 = 7'b1101101;
56        4'd6: HEX2 = 7'b1111101;
57        4'd7: HEX2 = 7'b0000111;
58        4'd8: HEX2 = 7'b1111111;
59        4'd9: HEX2 = 7'b1101111;
60        default: HEX2 = 7'b00000000;
61      endcase
62    HEX2 = ~HEX2;
63  end
64
65  always_comb begin
66    HEX3 = 7'b00000000;
67    if (~blank[3])
68      case (BCD3)
69        4'd0: HEX3 = 7'b01111111;
```

```
70      4'd1: HEX3 = 7'b00000110;
71      4'd2: HEX3 = 7'b1011011;
72      4'd3: HEX3 = 7'b1001111;
73      4'd4: HEX3 = 7'b1100110;
74      4'd5: HEX3 = 7'b1101101;
75      4'd6: HEX3 = 7'b1111101;
76      4'd7: HEX3 = 7'b0000011;
77      4'd8: HEX3 = 7'b1111111;
78      4'd9: HEX3 = 7'b1101111;
79      default: HEX3 = 7'b00000000;
80  endcase
81  HEX3 = ~HEX3;
82  end
83
84  always_comb begin
85      HEX4 = 7'b00000000;
86      if (~blank[4])
87          case (BCD4)
88              4'd0: HEX4 = 7'b0111111;
89              4'd1: HEX4 = 7'b00000110;
90              4'd2: HEX4 = 7'b1011011;
91              4'd3: HEX4 = 7'b1001111;
92              4'd4: HEX4 = 7'b1100110;
93              4'd5: HEX4 = 7'b1101101;
94              4'd6: HEX4 = 7'b1111101;
95              4'd7: HEX4 = 7'b0000011;
96              4'd8: HEX4 = 7'b1111111;
97              4'd9: HEX4 = 7'b1101111;
98              default: HEX4 = 7'b00000000;
99          endcase
100     HEX4 = ~HEX4;
101 end
102
103 always_comb begin
104     HEX5 = 7'b00000000;
105     if (~blank[5])
106         case (BCD5)
107             4'd0: HEX5 = 7'b0111111;
108             4'd1: HEX5 = 7'b00000110;
109             4'd2: HEX5 = 7'b1011011;
110             4'd3: HEX5 = 7'b1001111;
111             4'd4: HEX5 = 7'b1100110;
112             4'd5: HEX5 = 7'b1101101;
113             4'd6: HEX5 = 7'b1111101;
114             4'd7: HEX5 = 7'b0000011;
115             4'd8: HEX5 = 7'b1111111;
116             4'd9: HEX5 = 7'b1101111;
117             default: HEX5 = 7'b00000000;
118         endcase
119     HEX5 = ~HEX5;
120 end
121
122 always_comb begin
123     HEX6 = 7'b00000000;
124     if (~blank[6])
125         case (BCD6)
126             4'd0: HEX6 = 7'b0111111;
127             4'd1: HEX6 = 7'b00000110;
128             4'd2: HEX6 = 7'b1011011;
129             4'd3: HEX6 = 7'b1001111;
130             4'd4: HEX6 = 7'b1100110;
131             4'd5: HEX6 = 7'b1101101;
132             4'd6: HEX6 = 7'b1111101;
133             4'd7: HEX6 = 7'b0000011;
134             4'd8: HEX6 = 7'b1111111;
135             4'd9: HEX6 = 7'b1101111;
136             default: HEX6 = 7'b00000000;
137         endcase
138     HEX6 = ~HEX6;
139 end
140
```

```
141 always_comb begin
142     HEX7 = 7'b1111111;
143     if (~blank[7])
144         case (BCD7)
145             4'd0: HEX7 = 7'b0111111;
146             4'd1: HEX7 = 7'b0000110;
147             4'd2: HEX7 = 7'b1011011;
148             4'd3: HEX7 = 7'b1001111;
149             4'd4: HEX7 = 7'b1100110;
150             4'd5: HEX7 = 7'b1101101;
151             4'd6: HEX7 = 7'b1111101;
152             4'd7: HEX7 = 7'b0000111;
153             4'd8: HEX7 = 7'b1111111;
154             4'd9: HEX7 = 7'b1101111;
155             default: HEX7 = 7'b0000000;
156         endcase
157     HEX7 = ~HEX7;
158 end
159
160 endmodule : SevenSegmentDisplay
```