

Digital Design and Computer Organization Laboratory

3rd Semester, Academic Year 2024

Date: 30/08/2024

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Week# ____ 4 ____

TITLE:

- Design 2:1 MUX
- Design 4:1 MUX using 2:1 MUX
- Design 1:2 DeMUX
- Design an Encoder
- Design a Decoder

GENERATE THE VVP OUTPUT AND SIMULATION WAVEFORM USING GTKWAVE. VERIFY THE OUTPUT AND WAVEFORM WITH THE AND GATE TRUTH TABLE

1) 2:1 MUX

i_0	i_1	j	y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	1

week 4 > ≡ mux2.v

```
1 module mux2 (input wire i0, i1, j, output wire o);
2     assign o = j ? i1 : i0;
3 endmodule
4
```

week 4 > ≡ mux2_tb.v

```
1 module TB;
2     reg A, B, S;
3     wire X;
4
5     mux2 newMUX (.i0(A), .i1(B), .j(S), .o(X));
6
7     initial
8     begin
9         #5; S = 1'b0; A = 1'b0; B = 1'b0;
10        #5; S = 1'b0; A = 1'b0; B = 1'b1;
11        #5; S = 1'b0; A = 1'b1; B = 1'b0;
12        #5; S = 1'b0; A = 1'b1; B = 1'b1;
13        #5; S = 1'b1; A = 1'b0; B = 1'b0;
14        #5; S = 1'b1; A = 1'b0; B = 1'b1;
15        #5; S = 1'b1; A = 1'b1; B = 1'b0;
16        #5; S = 1'b1; A = 1'b1; B = 1'b1;
17    end
18
19    initial
20    begin
21        $monitor($time, " A=%b, B=%b, S=%b, X=%b", A, B, S, X);
22    end
23
24    initial
25    begin
26        $dumpfile("MUX2_test.vcd");
27        $dumpvars(0, TB);
28    end
29 endmodule
30
```

```

rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4$ iverilog -o mux mux2.v mux2_tb.v
rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4$ vvp mux
VCD info: dumpfile MUX2_test.vcd opened for output.
      0 A=0, B=0, S=0, X=0
      5 A=0, B=1, S=0, X=0
     10 A=1, B=0, S=0, X=1
     15 A=1, B=1, S=0, X=1
     20 A=0, B=0, S=1, X=0
     25 A=0, B=1, S=1, X=1
     30 A=1, B=0, S=1, X=0
     35 A=1, B=1, S=1, X=1
rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4$ gtkwave MUX2_test.vcd

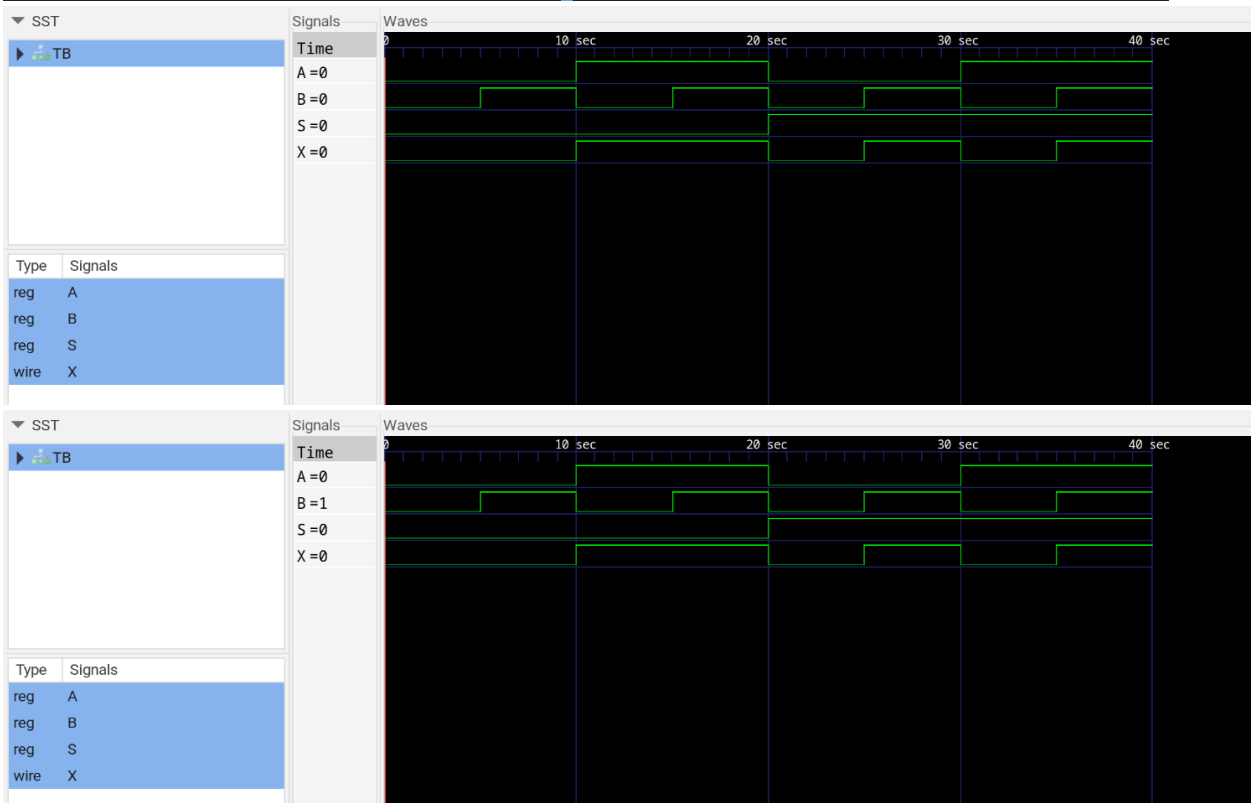
```

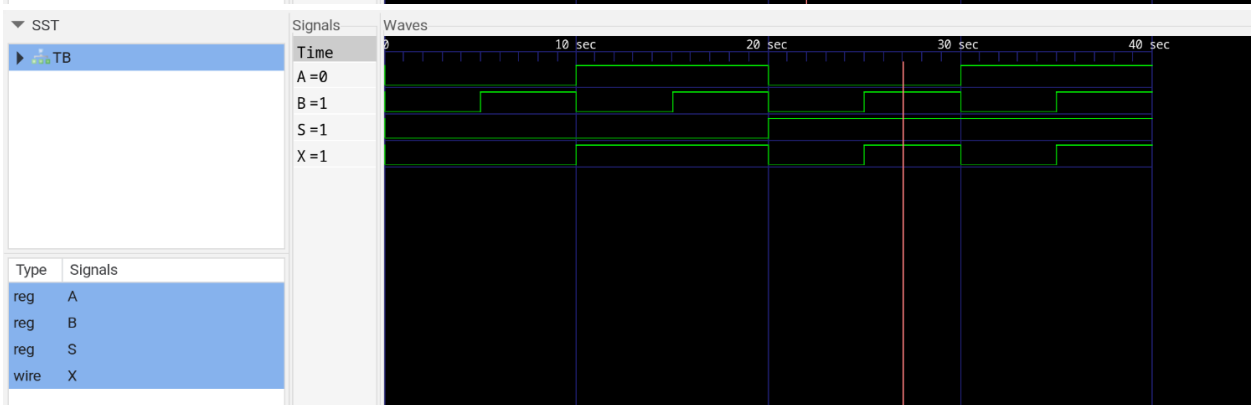
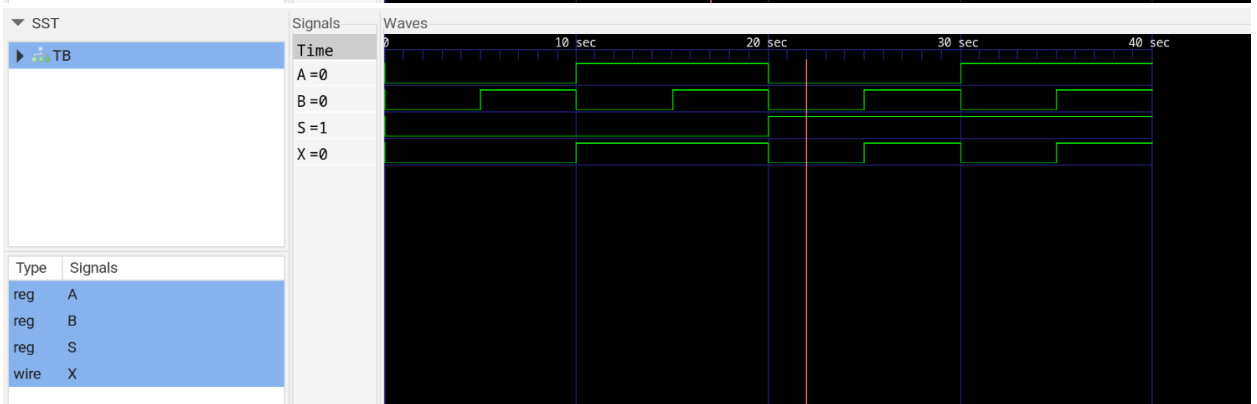
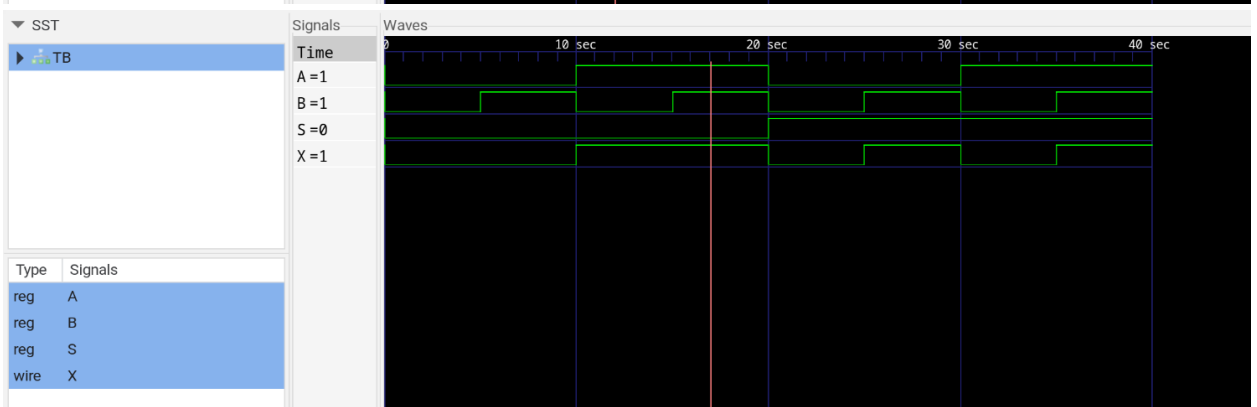
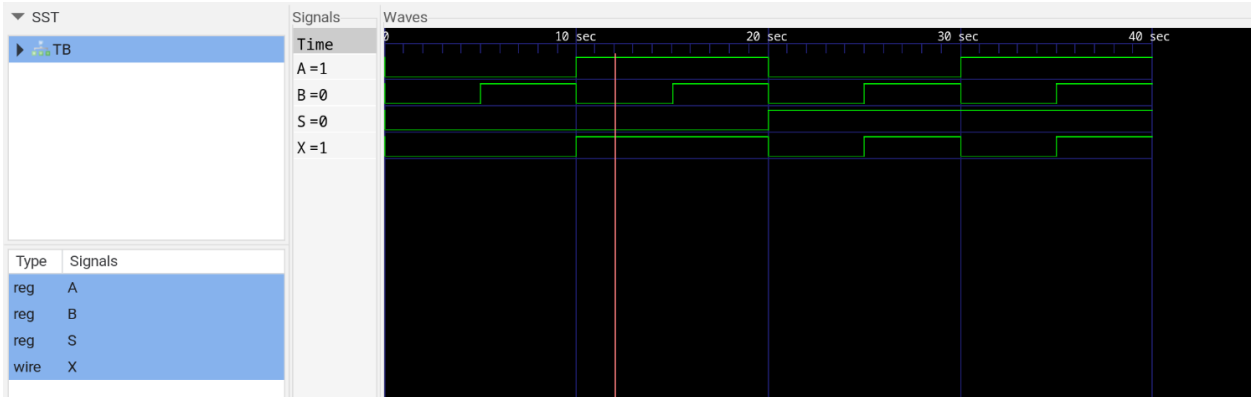
GTKWave Analyzer v3.3.118 (w)1999-2023 BSI

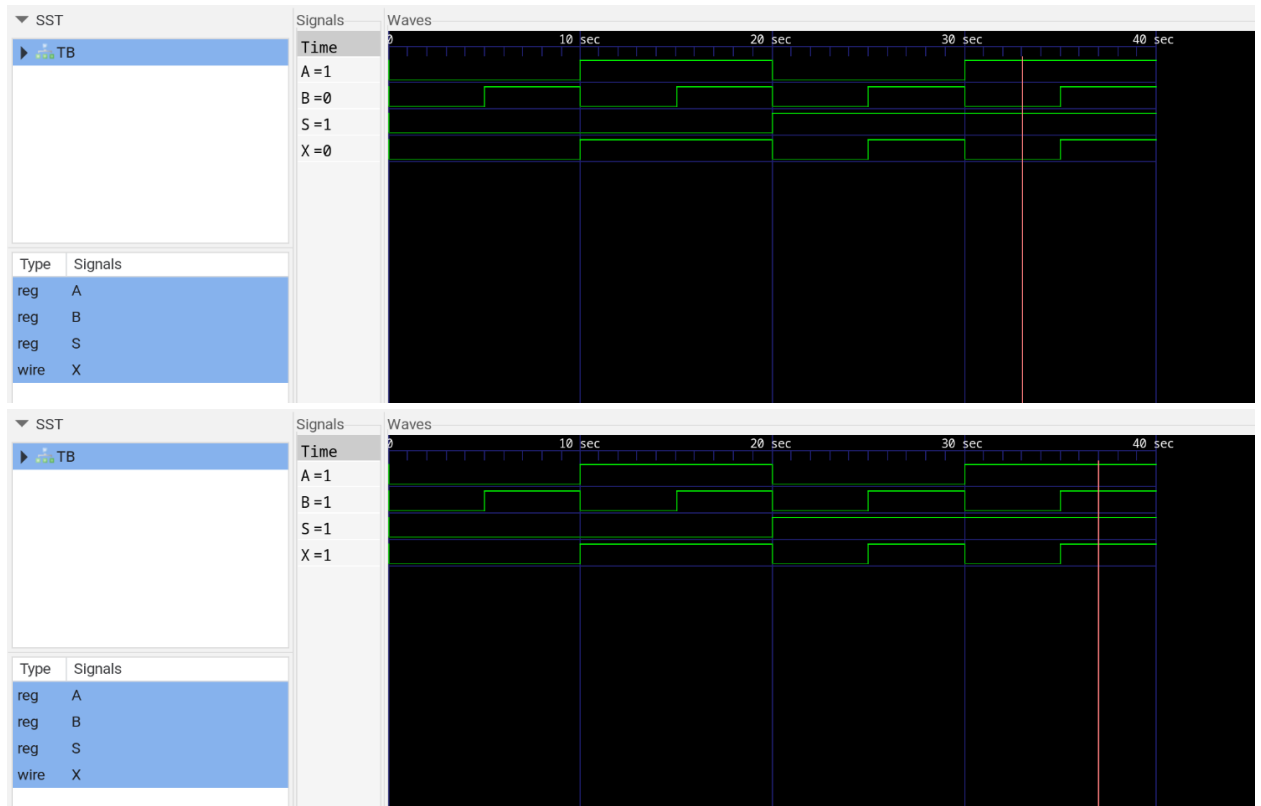
```

[0] start time.
[40] end time.
GTKWAVE | Touch screen detected, enabling gestures.
WM Destroy

```







2) 4:1 MUX

i0	i1	i2	i3	s0	s1	y
0	0	0	0	0	0	0
1	0	0	0	0	0	1
0	0	0	0	0	1	0
0	1	0	0	0	1	1
0	0	0	0	1	1	0
0	0	1	0	1	1	1
0	0	0	0	1	1	0

0	0	0	1	1	1	1
---	---	---	---	---	---	---

week 4 >  mux4.v

```
1  module mux2 (input wire i0, i1, j, output wire o);
2  assign o = j ? i1 : i0;
3  endmodule
4
5
6  module mux4 (input wire [0:3] i, input wire j1, j0, output wire o);
7  wire t0, t1;
8  mux2 mux2_0 (.i0(i[0]), .i1(i[1]), .j(j0), .o(t0));
9  mux2 mux2_1 (.i0(i[2]), .i1(i[3]), .j(j0), .o(t1));
10 mux2 mux2_2 (.i0(t0), .i1(t1), .j(j1), .o(o));
11 endmodule
12
```

week 4 >  mux4_tb.v

```
1  module TB;
2
3  reg [0:3] ii;
4  reg s0, s1;
5  wire yy;
6
7  mux4 newMUX(.i(ii), .j0(s0), .j1(s1), .o(yy));
8
9  initial begin
10 #5; ii = 4'b0000; s0 = 1'b0; s1 = 1'b0;
11 #5; ii = 4'b1000; s0 = 1'b0; s1 = 1'b0;
12 #5; ii = 4'b0000; s0 = 1'b0; s1 = 1'b1;
13 #5; ii = 4'b0100; s0 = 1'b0; s1 = 1'b1;
14 #5; ii = 4'b0000; s0 = 1'b1; s1 = 1'b0;
15 #5; ii = 4'b0010; s0 = 1'b1; s1 = 1'b0;
16 #5; ii = 4'b0000; s0 = 1'b1; s1 = 1'b1;
17 #5; ii = 4'b0001; s0 = 1'b1; s1 = 1'b1;
18 end
19
20 initial
21 begin
22 $monitor($time, " ii=%b, s0=%b, s1=%b, yy=%b", ii, s0, s1, yy);
23 end
24
25
26 initial begin
27 $dumpfile("MUX4_test.vcd");
28 $dumpvars(0, TB);
29 end
30
31 endmodule
```



```
rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4$ iverilog -o mux4 mux4.v mux4_tb.v
```

```
rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4$ vvp mux4
```

```
VCD info: dumpfile MUX4_test.vcd opened for output.
```

```
0 ii=0000, s0=0, s1=0, yy=0
5 ii=1000, s0=0, s1=0, yy=1
10 ii=0000, s0=0, s1=1, yy=0
15 ii=0100, s0=0, s1=1, yy=0
20 ii=0000, s0=1, s1=0, yy=0
25 ii=0010, s0=1, s1=0, yy=0
30 ii=0000, s0=1, s1=1, yy=0
35 ii=0001, s0=1, s1=1, yy=1
```

```
rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4$ gtkwave MUX4_test.vcd
```

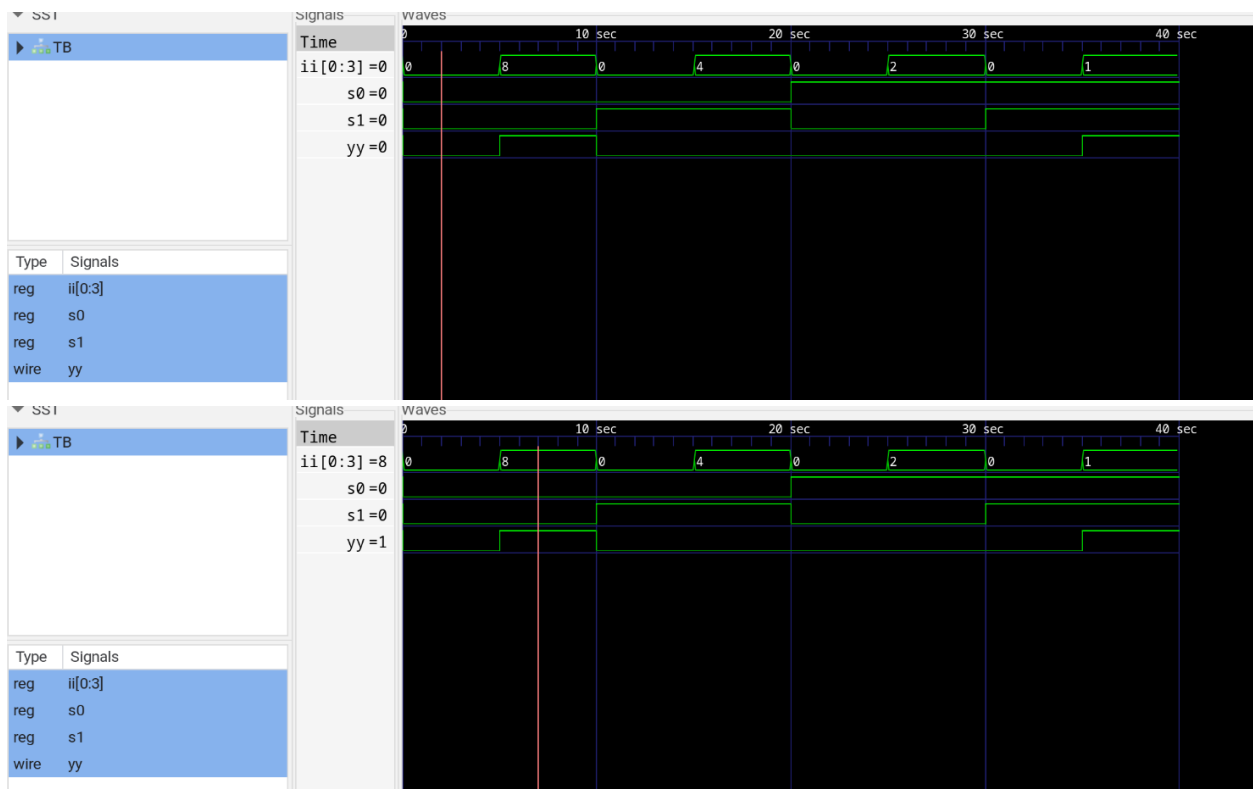
```
GTKWave Analyzer v3.3.118 (w)1999-2023 BSI
```

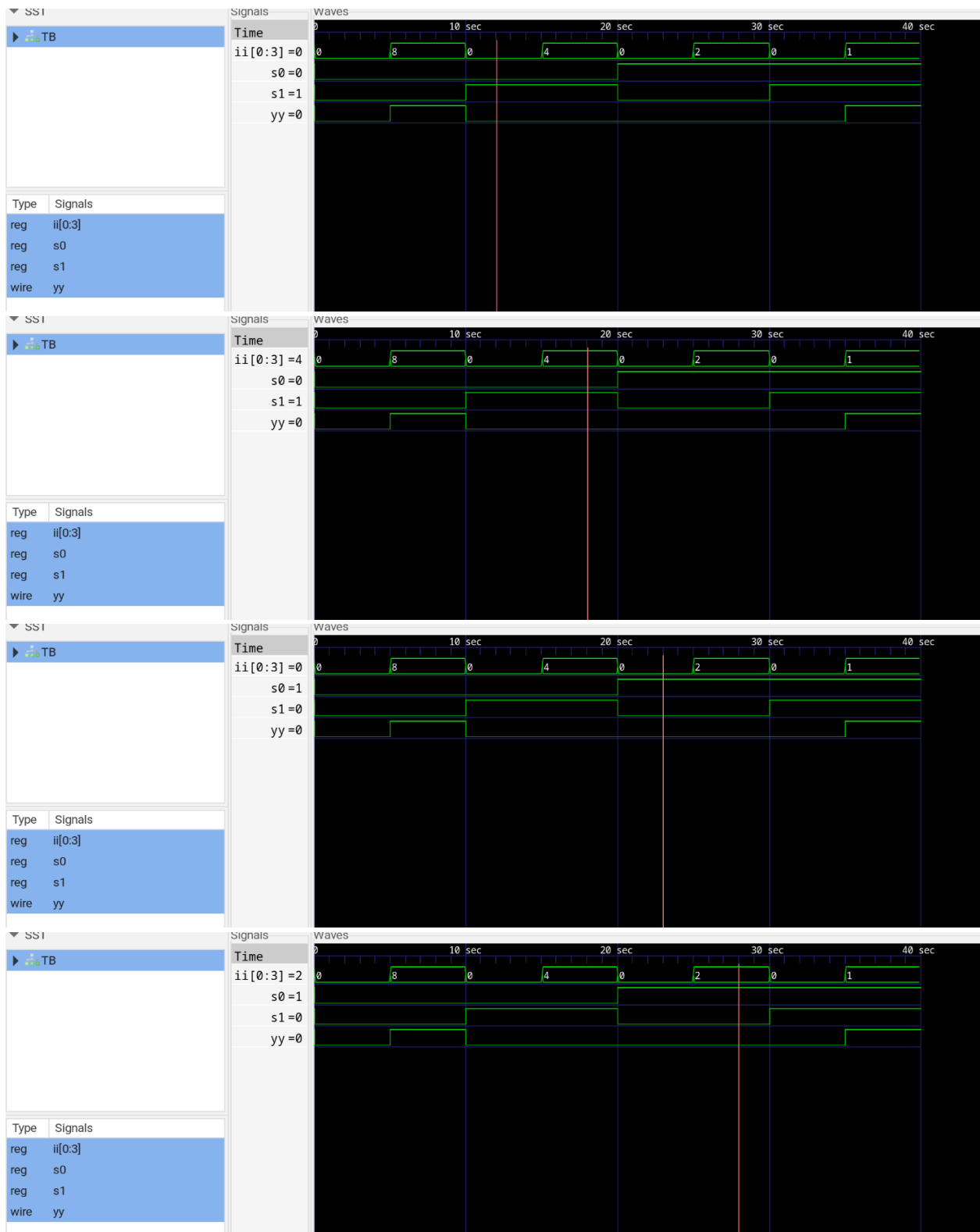
```
[0] start time.
```

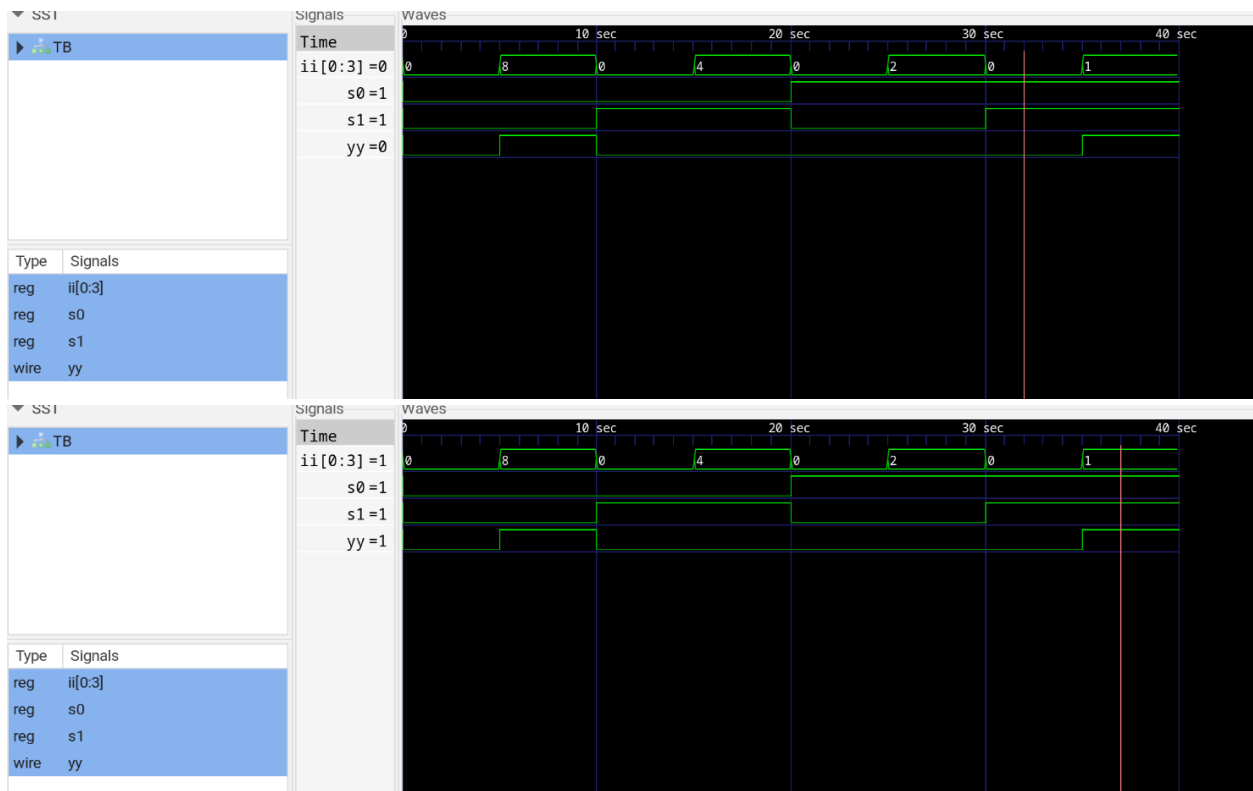
```
[40] end time.
```

```
GTKWAVE | Touch screen detected, enabling gestures.
```

```
Exiting.
```








3) 1:2 DEMUX

sel	in	y0	y1
0	0	0	0
0	1	1	0
1	0	0	0
1	1	0	1

week 4 >  demux.v

```
1 module demux(input wire i,sel,output wire y0,y1);
2 assign y0 = (~sel) ? i : 1'b0;
3 assign y1 = sel ? i : 1'b0;
4 endmodule
5
```

week 4 > 3) 1:2 demux >  demux_tb.v

```
1 module TB;
2 reg i;
3 reg sel;
4 wire y0;
5 wire y1;
6
7 demux uut (.i(i),.sel(sel),.y0(y0),.y1(y1));
8
9 initial begin
10 // #0; i = 1'b0; sel = 1'b0;
11 #5; i = 1'b0; sel = 1'b1;
12 #5; i = 1'b1; sel = 1'b1;
13 end
14
15 initial begin
16 $monitor($time, " i=%b, sel=%b, y0=%b, y1=%b", i, sel, y0, y1);
17 end
18
19 initial begin
20 $dumpfile("demux_test.vcd");
21 $dumpvars(0, TB);
22 end
23 endmodule
24
```

```
rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4/3) 1:2 demux$ iverilog -o demux demux.v demux_tb.v
rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4/3) 1:2 demux$ vvp demux
VCD info: dumpfile demux_test.vcd opened for output.
      0 i=0, sel=0, y0=0, y1=0
      5 i=0, sel=1, y0=0, y1=0
     10 i=1, sel=1, y0=0, y1=1
rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4/3) 1:2 demux$ gtkwave demux_test.vcd
```

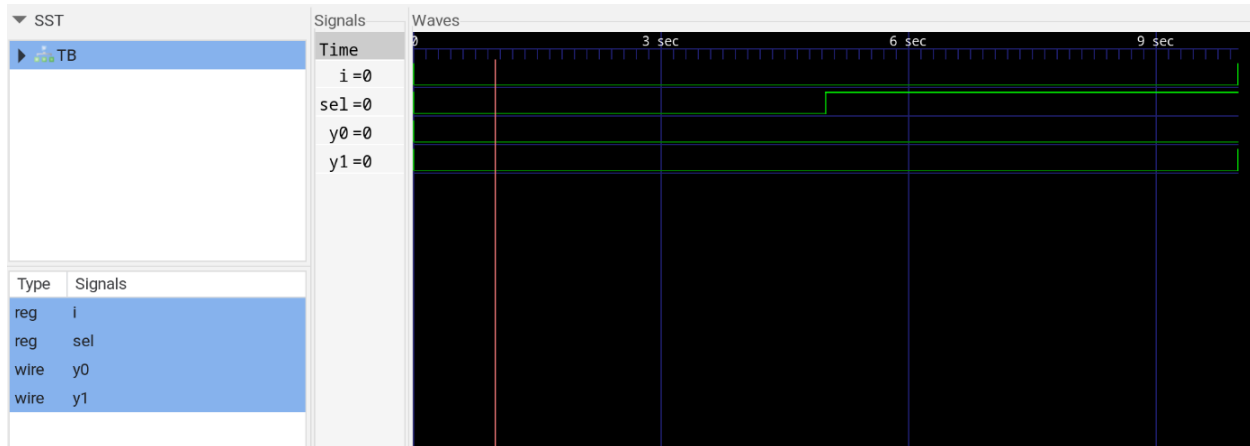
GTKWave Analyzer v3.3.118 (w)1999-2023 BSI

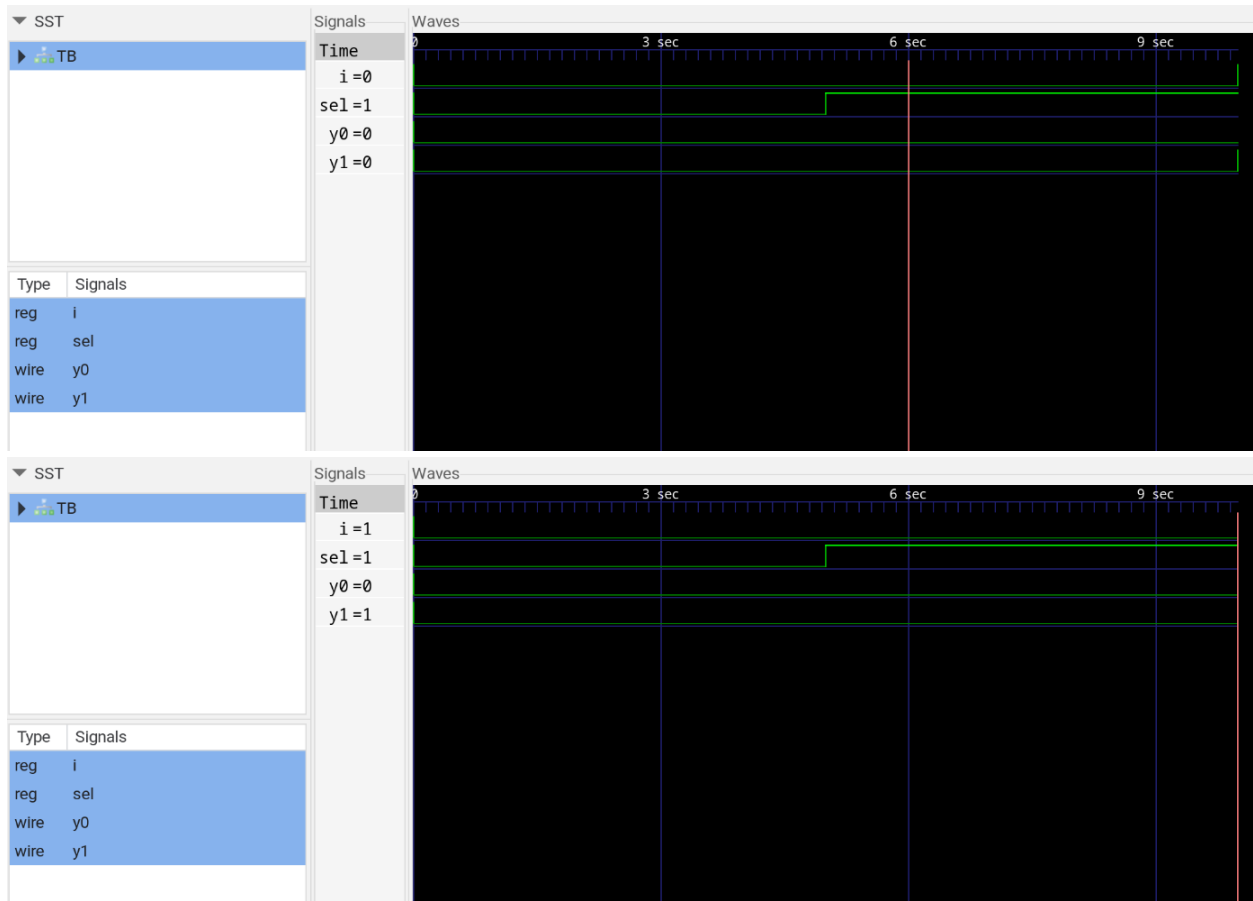
[0] start time.

[10] end time.

GTKWAVE | Touch screen detected, enabling gestures.

Exiting.





4) ENCODER

Y3	Y2	Y1	Y0	A1	A0
0	0	0	1	0	0
0	0	1	0	0	1
0	1	0	0	1	0
1	0	0	0	1	1

week 4 >  encoder.v

```
1  module encoder4 (  
2      input wire y3, y2, y1, y0,  
3      output wire A1, A0  
4  );  
5  
6      assign {A1, A0} = (y3 ? 2'b11 :  
7          y2 ? 2'b10 :  
8          y1 ? 2'b01 :  
9          y0 ? 2'b00 : 2'b00);  
10     endmodule  
11
```

week 4 >  encoder_tb.v

```
1  module TB;  
2  
3      reg y3, y2, y1, y0;  
4      wire A1, A0;  
5  
6      encoder4 uut (.y3(y3),.y2(y2),.y1(y1),.y0(y0),.A1(A1),.A0(A0));  
7  
8      initial begin  
9          #0; y3 = 1'b0; y2 = 1'b0; y1 = 1'b0; y0 = 1'b1;  
10         #5; y3 = 1'b0; y2 = 1'b0; y1 = 1'b1; y0 = 1'b0;  
11         #5; y3 = 1'b0; y2 = 1'b1; y1 = 1'b0; y0 = 1'b0;  
12         #5; y3 = 1'b1; y2 = 1'b0; y1 = 1'b0; y0 = 1'b0;  
13     end  
14  
15     initial begin  
16         $monitor($time, " y3=%b, y2=%b, y1=%b, y0=%b, A1=%b, A0=%b", y3, y2, y1, y0, A1, A0);  
17     end  
18  
19     initial begin  
20         $dumpfile("encoder4_test.vcd");  
21         $dumpvars(0, TB);  
22     end  
23  
24     endmodule  
25
```

```

rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4$ iverilog -o encoder encoder.v encoder_tb.v
rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4$ vvp encoder
VCD info: dumpfile encoder4_test.vcd opened for output.
    0 y3=0, y2=0, y1=0, y0=1, A1=0, A0=0
    5 y3=0, y2=0, y1=1, y0=0, A1=0, A0=1
   10 y3=0, y2=1, y1=0, y0=0, A1=1, A0=0
   15 y3=1, y2=0, y1=0, y0=0, A1=1, A0=1
rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4$ gtkwave encoder4_test.vcd

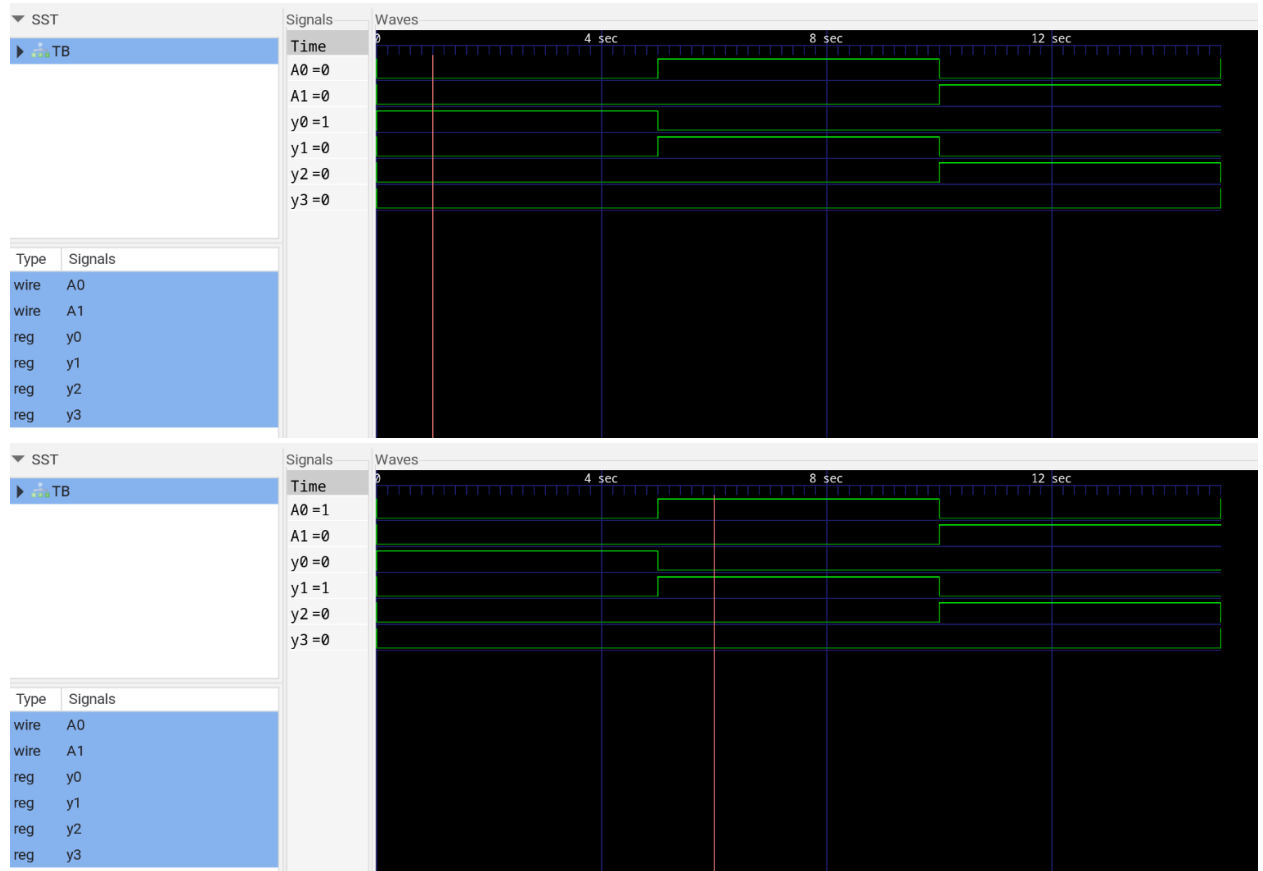
```

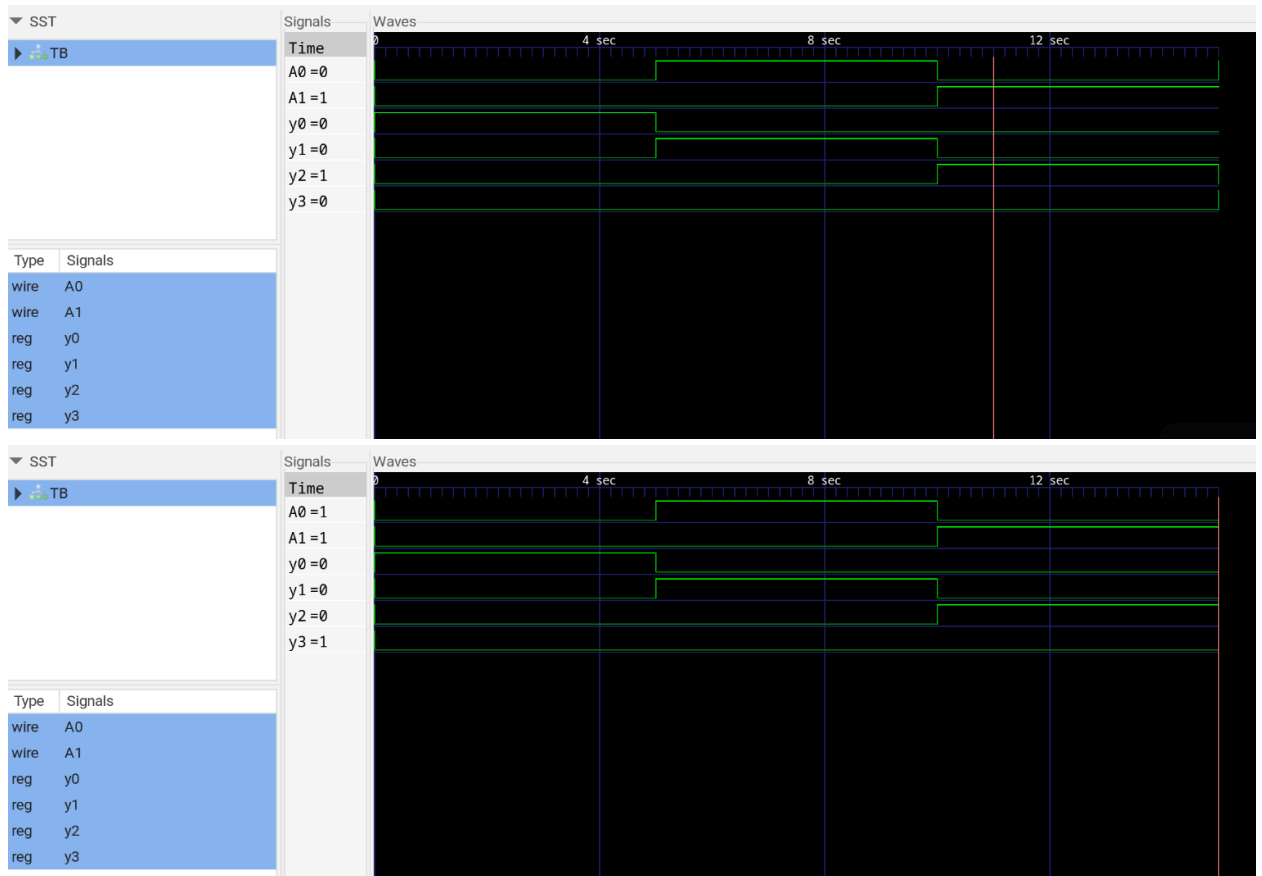
GTKWave Analyzer v3.3.118 (w)1999-2023 BSI

```

[0] start time.
[15] end time.
GTKWAVE | Touch screen detected, enabling gestures.
Exiting.

```






5) DECODER

A	B	Y0	Y1	Y2	Y3
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

week 4 >  decoder.v

```
1  module decoder2to4 [(
2      input wire A, B,
3      output wire Y0, Y1, Y2, Y3 |
4  );
5      assign Y0 = ~A & ~B;    // Y0 is active when A = 0, B = 0
6      assign Y1 = ~A & B;     // Y1 is active when A = 0, B = 1
7      assign Y2 = A & ~B;     // Y2 is active when A = 1, B = 0
8      assign Y3 = A & B;      // Y3 is active when A = 1, B = 1
9  endmodule
10
```

week 4 >  decoder_tb.v

```
1  module TB;
2
3  reg A, B;
4  wire Y0, Y1, Y2, Y3;
5
6  decoder2to4 uut (.A(A),.B(B),.Y0(Y0),.Y1(Y1),.Y2(Y2),.Y3(Y3));
7
8  initial begin
9      #0; A = 1'b0; B = 1'b0;
10     #5; A = 1'b0; B = 1'b1;
11     #5; A = 1'b1; B = 1'b0;
12     #5; A = 1'b1; B = 1'b1;|
13 end
14
15 initial begin
16     $monitor($time, " A=%b, B=%b, Y0=%b, Y1=%b, Y2=%b, Y3=%b", A, B, Y0, Y1, Y2, Y3);
17 end
18
19 initial begin
20     $dumpfile("decoder2to4_test.vcd");
21     $dumpvars(0, TB);
22 end
23
24 endmodule
25
```

```

rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4$ iverilog -o decoder decoder.v decoder_tb.v
rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4$ vvp decoder
VCD info: dumpfile decoder2to4_test.vcd opened for output.
      0 A=0, B=0, Y0=1, Y1=0, Y2=0, Y3=0
      5 A=0, B=1, Y0=0, Y1=1, Y2=0, Y3=0
     10 A=1, B=0, Y0=0, Y1=0, Y2=1, Y3=0
     15 A=1, B=1, Y0=0, Y1=0, Y2=0, Y3=1
rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4$ gtkwave decoder2to4_test.vcd

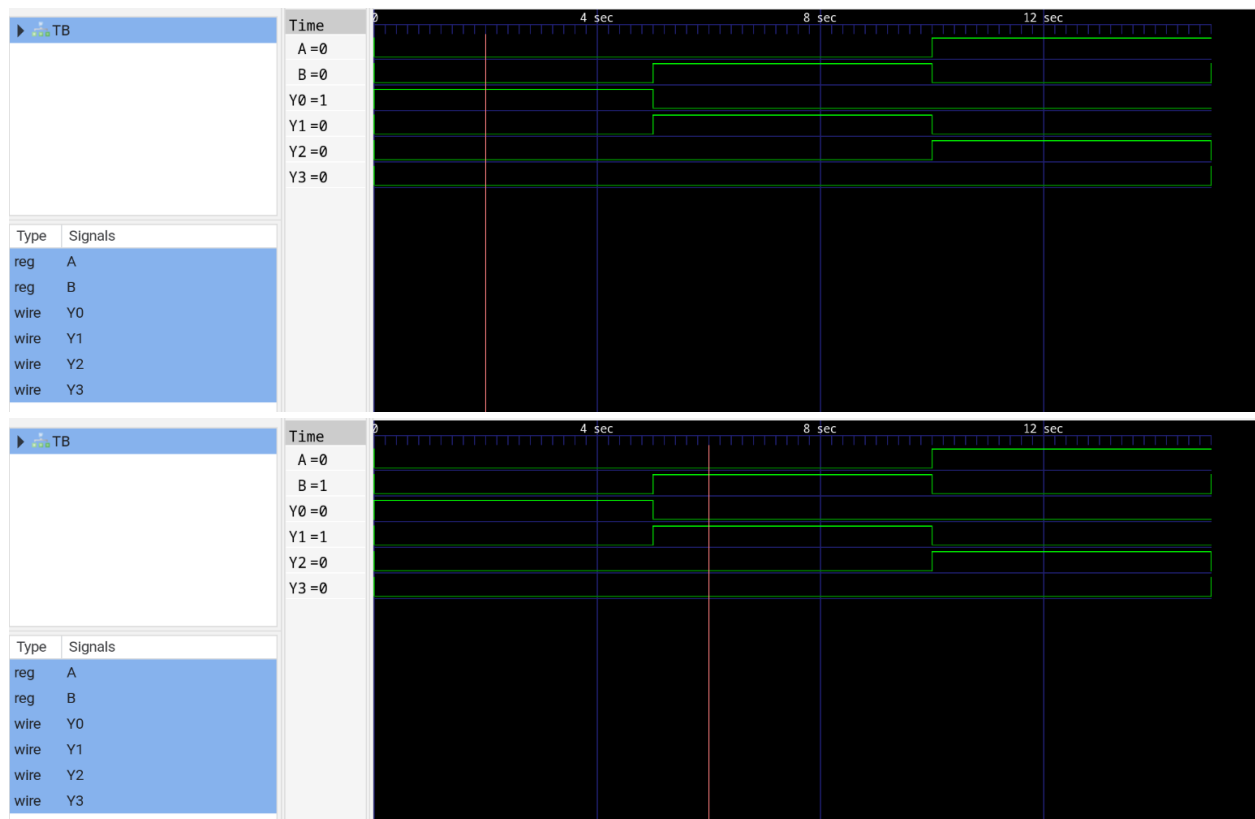
```

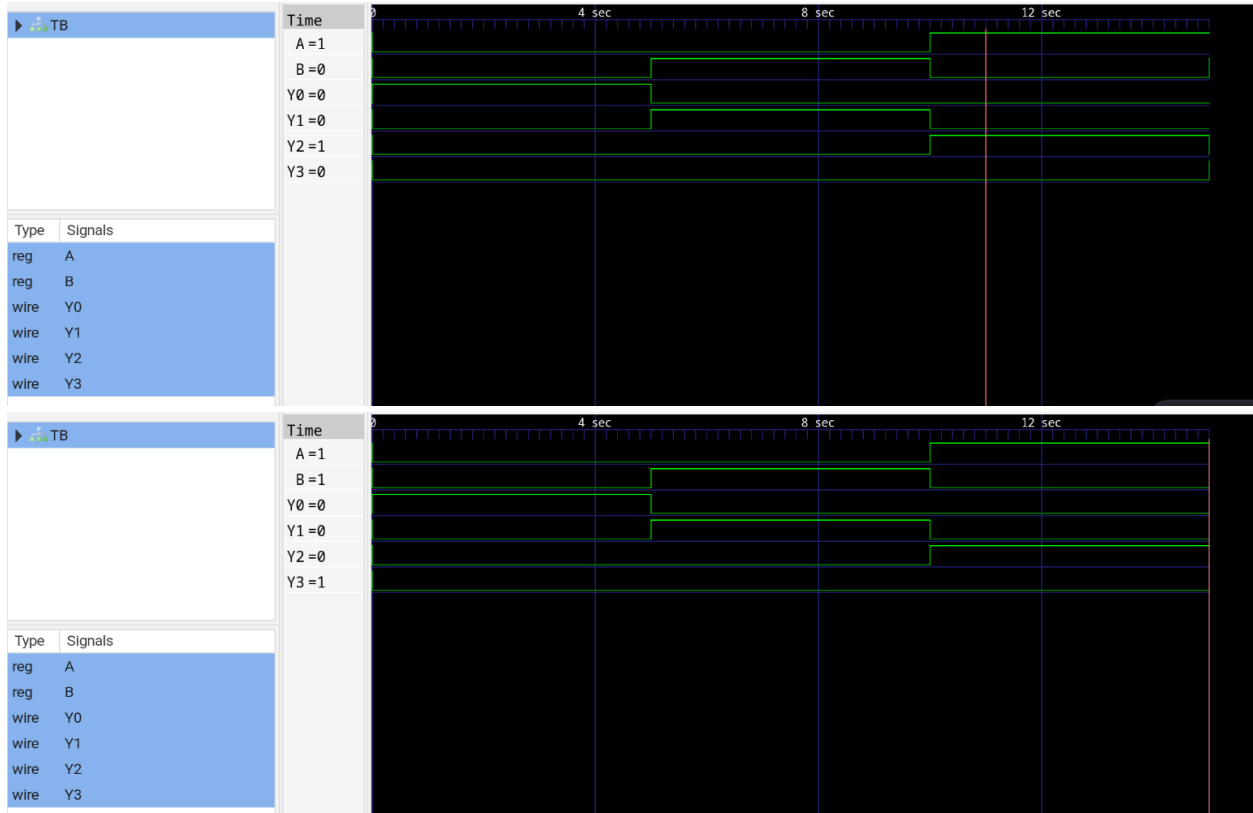
GTKWave Analyzer v3.3.118 (w)1999-2023 BSI

```

[0] start time.
[15] end time.
GTKWAVE | Touch screen detected, enabling gestures.
Exiting.
rithvikmatta@penguin:~/PES/DDCO-sem-3/week 4$

```





If found plagiarized, I will abide with the disciplinary action of the University.

Signature:

Name: Rithvik Rajesh Matta

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Section: H

Date: 30/08/2024