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Subject: - Digital System Design (3EL42)

Branch: - Electronics (EL)

Assignment:-2

Q-1:-Design 4-bit Ripple Carry Adder with the help of 1-bit adder

VERILOG CODE:-

SV/Verilog Design

```
module full_adder(in0, in1, cin, out, cout);
    input in0, in1, cin;
    output out, cout;

    assign out = in0 ^ in1 ^ cin;
    assign cout = ((in0 ^ in1) & cin) | (in0 & in1);
endmodule
module ripple_carry_adder(in0, in1, out, cout);
    input [3:0] in0;
    input [3:0] in1;
    output [3:0] out;
    output cout;

    wire c1, c2, c3;
    full_adder fa0(in0[0], in1[0], 0, out[0], c1);
    full_adder fa1(in0[1], in1[1], c1, out[1], c2);
    full_adder fa2(in0[2], in1[2], c2, out[2], c3);
    full_adder fa3(in0[3], in1[3], c3, out[3], cout);

endmodule
```

TEST BENCH:-

```
module ripple_carry_adder_tb;

    reg [3:0] in0;
    reg [3:0] in1;
    wire [3:0] out;
    wire cout;

    ripple_carry_adder rca(.in0(in0), .in1(in1), .out(out),
.cout(cout));

    initial begin
        in0 = 4'b0000; in1 = 4'b0000; #10
        in0 = 4'b0000; in1 = 4'b0001; #10
        in0 = 4'b0000; in1 = 4'b0010; #10
        in0 = 4'b0000; in1 = 4'b0011; #10
        in0 = 4'b0001; in1 = 4'b0000; #10
        in0 = 4'b0010; in1 = 4'b0000; #10
        in0 = 4'b0010; in1 = 4'b0001; #10
        in0 = 4'b0010; in1 = 4'b0010; #10
        in0 = 4'b0010; in1 = 4'b0011; #10
        in0 = 4'b0011; in1 = 4'b0000; #10
        in0 = 4'b0011; in1 = 4'b0001; #10
        in0 = 4'b0011; in1 = 4'b0010; #10
        in0 = 4'b0011; in1 = 4'b0011; #10
        in0 = 4'b0100; in1 = 4'b0000; #10
        in0 = 4'b0100; in1 = 4'b0001; #10
        in0 = 4'b0100; in1 = 4'b0010; #10
        in0 = 4'b0100; in1 = 4'b0011; #10
        in0 = 4'b0100; in1 = 4'b0100; #10
        end

    initial begin
        $dumpfile("ripple-carry-adder.vcd");
        $dumpvars(0, ripple_carry_adder_tb);
        $monitor($time, ": %b + %b = %b, %b", in0, in1, out,
cout);
    end
endmodule
```

OUTPUT: -

0
500
1,000
1,500
2,000
cout
in0[3:0]
0 1 2 3 4 5 6 7 8 9 a b c d e f
in1[3:0]
out[3:0]
c1
c2
c3
cout

Q-2: - Design D-flipflop and reuse it to implement 4- bit Johnson Counter

```
module dflip_flop(out,d,reset,clk);
input d,clk,reset;
output  out;

reg q;

  always @(posedge reset or negedge clk)
begin

if(reset)
 out=1'b0;
 else
    begin
        out=d;
    end
 end
endmodule
module johnson_counter(q,clk,reset,q0);
  input clk,reset,q0;
  output q;
  wire q1,q2,q3;
  assign q0=~out;
  assign dflip_flop d1(q1,clk,reset,q0);
  assign dflip_flop d2(q2,clk,reset,q1);
  assign dflip_flop d3(q3,clk,reset,q2);
  assign dflip_flop d4(out,clk,reset,q3);
endmodule
```

TEST BENCH:-

SV/Verilog Testbench

```
module jc_tb;
  reg clk,reset;
  wire  out;

  johnson_counter dut (.out(out), .reset(reset), .clk(clk));

  always
    #5 clk =~clk;

  initial begin
    reset=1'b1; clk=1'b0;
   #20 reset= 1'b0;
  end

  initial
    begin
     $monitor( $time, " clk=%b, out= %b, reset=%b",
clk,out,reset);
     #105  $stop;
   end

endmodule
```

OUTPUT:-

```
  0 clk=0, out= xxxx, reset=1
  5 clk=1, out= 0000, reset=1
 10 clk=0, out= 0000, reset=1
 15 clk=1, out= 0000, reset=1
 20 clk=0, out= 0000, reset=0
 25 clk=1, out= 0001, reset=0
 30 clk=0, out= 0001, reset=0
 35 clk=1, out= 0011, reset=0
 40 clk=0, out= 0011, reset=0
 45 clk=1, out= 0111, reset=0
 50 clk=0, out= 0111, reset=0
 55 clk=1, out= 1111, reset=0
 60 clk=0, out= 1111, reset=0
 65 clk=1, out= 1110, reset=0
 70 clk=0, out= 1110, reset=0
 75 clk=1, out= 1100, reset=0
 80 clk=0, out= 1100, reset=0
 85 clk=1, out= 1000, reset=0
 90 clk=0, out= 1000, reset=0
 95 clk=1, out= 0000, reset=0
100 clk=0, out= 0000, reset=0
```

Q-3: - Reuse 2:1 Mux code to implement 8:1 Mux

VERILOG CODE:-

```
module mux8_1(i,s,y);

input [7:0]i;

input [2:0]s;

output y;

wire w1,w2,w3,w4,w5,w6;

mux2_1 m1(.i0(i[0]),.i1(i[1]),.s(s[0]),.y(w1));

mux2_1 m2(.i0(i[2]),.i1(i[3]),.s(s[0]),.y(w2));

mux2_1 m3(.i0(i[4]),.i1(i[5]),.s(s[0]),.y(w3));

mux2_1 m4(.i0(i[6]),.i1(i[7]),.s(s[0]),.y(w4));

mux2_1 m5(.i0(w1),.i1(w2),.s(s[1]),.y(w5));

mux2_1 m6(.i0(w3),.i1(w4),.s(s[1]),.y(w6));

mux2_1 m7(.i0(w5),.i1(w6),.s(s[2]),.y(y));

endmodule

module mux2_1(input i0,i1,s,output y);
assign y=(s==0)? i0:i1;
endmodule
```

TEST BENCH:-

```
module tb;
reg [7:0]i;
reg [2:0]s;
wire y;
mux8_1   DUT(i,s,y);
initial
begin
#15 i=8'b00011100;s=3'b011;
#15 i=8'b00110000;s=3'b000;
#15 i=8'b00111000;s=3'b011;
#15 i=8'b01110000;s=3'b100;
#15 i=8'b00110000;s=3'b101;
#15 i=8'b00001110;s=3'b001;
#15 i=8'b11110010;s=3'b010;
#15 i=8'b00011111;s=3'b110;
#15 i=8'b11000000;s=3'b000;
#15 i=8'b00010000;s=3'b111;
#15 i=8'b00000011;s=3'b011;
$dumpfile("mux8_1.vcd");
  $dumpvars();
end
endmodule
```

OUTPUT:-

Q-4: - Design a Full Subtractor with Gate Level Modelling Style. (Use primitive gates)

VERILOG CODE:-

```
module full_sub(Bout,D,A,B,Bin);
output Bout,D;
input A,B,Bin;
wire w1,w4,w5,w6;
  xor (D,A,B,Bin);
  not n1(w1,A);
  and a1(w4,w1,B);
  and a2(w5,w1,Bin);
  and a3(w6,B,Bin);
  or o1(Bout,w4,w5,w6);
endmodule
```

TEST BENCH:-

```
module tb;
  reg A,B,Bin;
  wire D,Bout;
initial begin

// Add stimulus here
#100; A = 0;B = 0;Bin = 1;
#100; A = 0;B = 1;Bin = 0;
#100; A = 0;B = 1;Bin = 1;
#100; A = 1;B = 0;Bin = 0;
#100; A = 1;B = 0;Bin = 1;
#100; A = 1;B = 1;Bin = 0;
#100; A = 1;B = 1;Bin = 1;
end
  $dumpfile("full_sub.vcd);
  $dumpvars();
 endmodule
```

OUTPUT:-

Q-5: - Design a 2X4 decoder using gate level modelling

VERILOG CODE:-

```
module decoder24_gate(en,a,b,y);
     input en,a,b;
     output [3:0]y;
     wire enb,na,nb;
     not n0(enb,en);
     not n1(na,a);
     not n2(nb,b);

     nand n3(y[0],enb,na,nb);
     nand n4(y[1],enb,na,b);
     nand n5(y[2],enb,a,nb);
     nand n6(y[3],enb,a,b);

endmodule
```

TEST BENCH:-

```
module tb;
  reg a,b,en;
  wire [3:0]y;
  decoder24_gate dut(en,a,b,y);

  initial begin
      $monitor("en=%b a=%b b=%b y=%b",en,a,b,y);
      en=1;a=1'bx;b=1'bx;#5
      en=0;a=0;b=0;#5
      en=0;a=0;b=1;#5
      en=0;a=1;b=0;#5
      en=0;a=1;b=1;#5
      $finish;
    end
endmodule
```

OUTPUT:-

```
# KERNEL: en=0 a=x b=x y=xxxx
# KERNEL: en=1 a=0 b=0 y=1111
# KERNEL: en=1 a=0 b=1 y=1111
# KERNEL: en=1 a=1 b=0 y=1111
# KERNEL: en=1 a=1 b=1 y=1111
```

Q-6: - Design a 4x1 mux using operators. (Use data flow)

VERILOG CODE: -

```
module mux4_1(y, i0,i1,i2,i3,[1;0]sel);
     input i0, i1, i2, i3;
  input [1:0]sel;
     output y;
  assign out = sel[1]? (sel[0]?i3:i2) : (sel[0]?i1:i0);
endmodule
```

TEST BENCH: -

```
module tb;
  reg i0,i1,i2,i3,[1:0]sel;
  wire y;
  mux4_1 dut(i0,i1,i2,i3,[1:0]sel,y);

  initial begin
    $monitor("sel=%b ->i3=%b,i2=%b,i1=%b,i0=%b->y=%b"
sel,i3,i2,i1,i0,y);
      sel=2'b00;
    i0=1;i1=0;i2=1;i3=0;
    sel=2'b01;
    i0=1;i1=0;i2=1;i3=0;
    sel=2'b10;
    i0=1;i1=0;i2=1;i3=0;
    sel=2'b11;
    i0=1;i1=0;i2=1;i3=0;
      $finish;
    end
endmodule
```

OUTPUT: -

```
sel = 00 -> i3 = 0, i2 = 1 ,i1 = 0, i0 = 1 -> y = 1
sel = 01 -> i3 = 0, i2 = 1 ,i1 = 0, i0 = 1 -> y = 0
sel = 11 -> i3 = 0, i2 = 1 ,i1 = 0, i0 = 1 -> y = 0
sel = 01 -> i3 = 0, i2 = 1 ,i1 = 0, i0 = 1 -> y = 0
```

Q-7: - Design a Full adder using half adder.

VERILOG CODE:-

```
module half_addr(input a, b, output s, c);
  assign s = a^b;
  assign c = a & b;
endmodule

module full_adder(input a, b, cin, output s_out, c_out);
  wire s, c0, c1;
  half_addr HA1 (a, b, s, c0);
  half_addr HA2 (s, cin, s_out, c1);

  assign c_out = c0 | c1;
endmodule
```

TEST BENCH: -

SV/Verilog Testbench

```
module tb_top;
  reg a, b, c;
  wire s, c_out;

  full_adder fa(a, b, c, s, c_out);

  initial begin
    $monitor("At time %0t: a=%b b=%b, cin=%b, sum=%b,
carry=%b",$time, a,b,c,s,c_out);
    a = 0; b = 0; c = 0; #1;
    a = 0; b = 0; c = 1; #1;
    a = 0; b = 1; c = 0; #1;
    a = 0; b = 1; c = 1; #1;
    a = 1; b = 0; c = 0; #1;
    a = 1; b = 0; c = 1; #1;
    a = 1; b = 1; c = 0; #1;
    a = 1; b = 1; c = 1;
  end
endmodule
```

OUTPUT: -

```
At time 0: a=0 b=0, cin=0, sum=0, carry=0
At time 1: a=0 b=0, cin=1, sum=1, carry=0
At time 2: a=0 b=1, cin=0, sum=1, carry=0
At time 3: a=0 b=1, cin=1, sum=0, carry=1
At time 4: a=1 b=0, cin=0, sum=1, carry=0
At time 5: a=1 b=0, cin=1, sum=0, carry=1
At time 6: a=1 b=1, cin=0, sum=0, carry=1
At time 7: a=1 b=1, cin=1, sum=1, carry=1
```