CS203 - PROJECT
TIC TAC TOE GAME IMPLEMENTATION USING VERILOG

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INTRODUCTION

We have implemented Tic Tac Toe in verilog using various modules.

We have used computer as the 2nd player in the game.

1	2	3
4	5	6
7	8	9

(1,2,3), (4,5,6), (7,8,9) [HORIZONTAL]

(1,4,7), (2,5,8), (3,6,9) [VERTICAL]

(1,5,9), (3,5,7) [DIAGONAL]

The player or computer wins the game if 3 similar X/0 are put in the following rows

00 – if neither player and computer played in that position [REST STATE]

01 – represents **X**. If player played at that position [PLAYER STATE]

10 – represents **0**. If computer played at that position [COMPUTER STATE]

11-game is finished [OVER STATE]

DESIGN & FEATURES

STATES

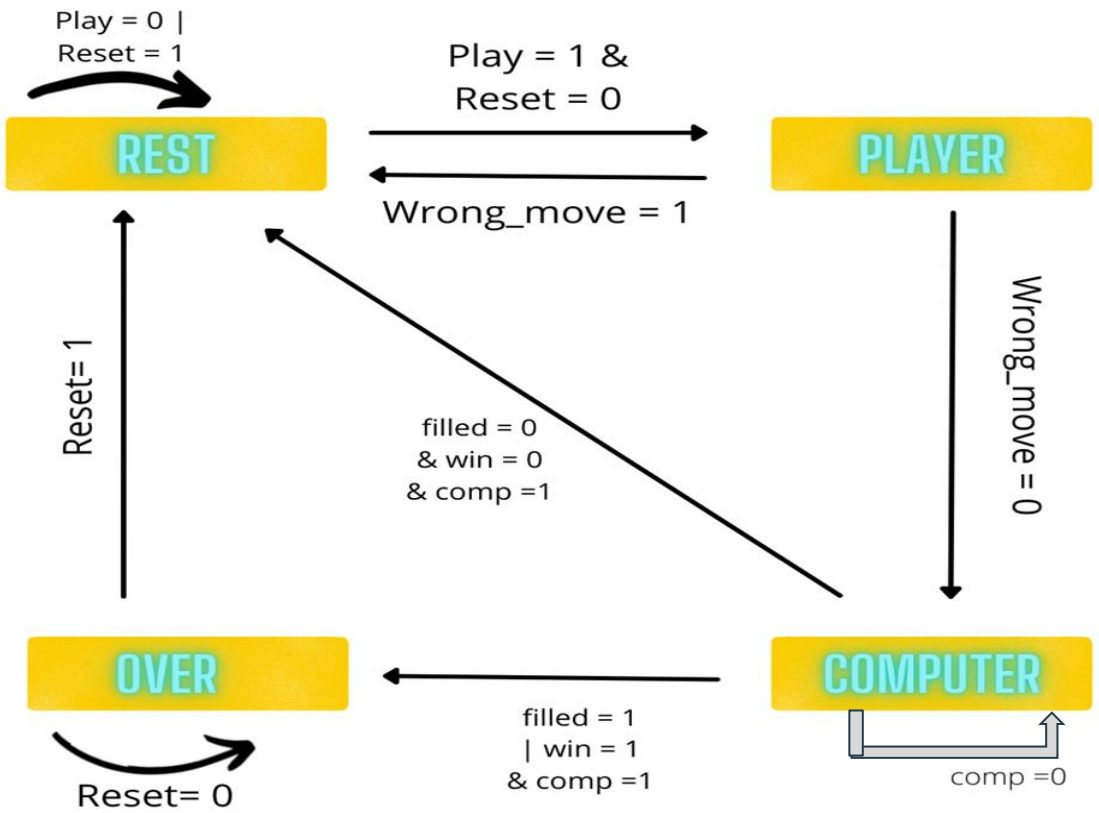
There are 4 states in our project which are as follows :

- REST state → Rest state comes when player is waiting for the computer or computer is waiting for the player to play.
- PLAYER state → Player state comes when there is player's turns to
- COMPUTER state → Computer state come when there is computer's turn to play
- OVER state → Over state come when the game is finished (one of the 2 player won the match or all spaces of the tic tac toe are filled and no spaces are left to play)

VARIABLES

- **Play** = 0 → Stay in the rest state
- Play = 1 → switches controller to the player state and player's turn comes
- **Reset** = 0 → Game starts
- Reset = 1 → It resets the game
- **Pp**=1 → player to play (player's turn)
- **Cp**=1 → computer to play (computer's turn)
- **Comp** = 0 → stay in the computer state
- Comp = 1 → switch to the Rest state and computer's turn comes
- **Wrong_move** = 0 → Player's state will switch to the Computer's state (if game is in player state).
- Wrong_move = 1 → It means the player or computer played a wrong move which is not valid in the game this will switch to the rest state once again.
- **Filled** = 0 → if the tic tac toe have enough space to play the next chance.
- Filled = 1 → if tic tac toe does not have enough space to play (all the 9 spaces are filled and no one won the game)
- **Win** = 0 → No one won the game till now
- Win = 1 → any one player won the game and game is over and the game resets

State Diagram



MODULES

1. Module Tic_Tac_Toe

It’s the main module that uses all the submodules made in the code. The use of various submodules is ordered.

```
module Tic_Tac_Toe(clock, reset, play, comp, computer, player, pos1, pos2, pos3, pos4, pos5, pos6, pos7, pos8, pos9, winner);
    input clock, reset, play, comp;
    input [3:0] computer , player;
    output wire [1:0] pos1,pos2,pos3,pos4,pos5,pos6,pos7,pos8,pos9;
    output wire[1:0] winner;

 wire [15:0] c_enable,p_enable;// enable signal for computer and the player

wire wrong_move; //whenever wrong move is played, the program will terminate

wire cp; //turn of computer
wire pp; //turn of player
wire filled;
wire win;
```

1. Module Tic_Tac_Toe

It’s the main module that uses all the submodules made in the code. The use of various submodules is ordered.

```
position p_reg(clock, reset, wrong_move, c_enable, p_enable, pos1, pos2, pos3, pos4, pos5, pos6, pos7, pos8, pos9);  // function calling 'position'

 who_wins who_pc(pos1,pos2,pos3,pos4,pos5,pos6,pos7,pos8,pos9,win,winner);   //finds out the winner
 pos_decode c_dec(computer,cp,c_enable); //returns the position of computer
 pos_decode p_dec(player,pp,p_enable); //returns the position of player
 re_block error_pc( pos1,pos2,pos3,pos4,pos5,pos6,pos7,pos8,pos9,c_enable[8:0], p_enable[8:0],wrong_move);  //checks for wrong moves

finish f_no_space(pos1,pos2,pos3,pos4,pos5,pos6,pos7,pos8,pos9,filled);  // whenever all positions are filled
FSM control(clock,reset,play,comp,wrong_move,filled,win,cp,pp);

endmodule
```

2. Module Position

This module is used to store the positions of player and computer (2nd player).

```
module position(clock, reset, wrong_move, c_enable, p_enable, pos1, pos2, pos3, pos4, pos5, pos6, pos7, pos8, pos9);
    input [15:0] c_enable,p_enable;
    input clock, reset, wrong_move;

     output reg[1:0] pos1, pos2, pos3, pos4, pos5, pos6, pos7, pos8, pos9;

//posedge checks at the edges when clock/reset changes its value
 always @(posedge clock or posedge reset)   //for the 1st position
 begin
  if(reset)
   pos1 <= 2'b00;
  else begin
   if(wrong_move==1'b1)
    pos1<=pos1;                    // stores the old position
   else if(c_enable[0]==1'b1)
    pos1<= 2'b10;                   // stores the computer's position
   else if(p_enable[0]==1'b1)
    pos1<= 2'b01;                     // stores the player's position
   else
    pos1 <= pos1;                     //stores the old position
  end
 end
```

Implemented this for all the 9 positions

3. Module FSM

We have implemented state machine in this module.

This is the main module which is used to control the overall gameplay.

```
module FSM(clock,reset,play,comp,wrong_move,filled,win,cp,pp);    //implementation of state machine, controls the overall gameplay
    input clock,reset,play,comp,wrong_move,filled,win;
    output reg cp,pp;

parameter REST=2'b00;       //rest state
parameter COMPUTER=2'b10;   //computer's turn
parameter PLAYER=2'b01;     //player's turn
parameter OVER=2'b11;       //game is over/finished
reg[1:0] old,new;           //previous and next states
```

Parameter represents constant and are often used to define variable width and delay value

3. Module FSM

We have implemented state machine in this module.

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```
REST:
begin
 if(reset==1'b0 && play == 1'b1)
  new<= PLAYER; // player's turn
 else
  new<= REST;
 pp <= 1'b0;
 cp <= 1'b0;
end
```

```
COMPUTER:
begin
 pp<= 1'b0;
 if(comp==1'b0) begin
  new <= COMPUTER;
  cp<= 1'b0;
 end
 else if(filled == 1 || win ==1'b1)
 begin
  new<=OVER;      //game over
  cp<= 1'b1;    //cp=1 gives turn to computer
 end
 else if(win==1'b0 && filled== 1'b0)
 begin
  new <= REST;
  cp <= 1'b1;      //cp=1 gives turn to computer
 end

end
```

3. Module FSM

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This is the main module which is used to control the overall gameplay.

```
PLAYER:
begin
  pp <= 1'b1;
  cp <= 1'b0;
  if(wrong_move==1'b0)
   new <= COMPUTER; // computer's turn
  else
   new <= REST;
 end
```

```
OVER:
begin      // game over
 pp <= 1'b0;
 cp <= 1'b0;
 if(reset==1'b1)
  new <= REST;  // return to REST
 else
  new <=OVER;
end
default:new <=REST;
```

4. Module Finish

This module is used to detect if all 9 positions are filled and no one won the game.

```
module finish(pos1, pos2, pos3, pos4, pos5, pos6, pos7, pos8, pos9, filled);
   input [1:0] pos1, pos2, pos3, pos4, pos5, pos6, pos7, pos8, pos9;
   output wire filled;

wire f1,f2,f3,f4,f5,f6,f7,f8,f9;

//f's check out the spaces mentioned in their RHS are filled or not
assign f1 = (pos1[0] | pos1[1]);
assign f2 = (pos2[0] | pos2[1]);
assign f3 = (pos3[0] | pos3[1]);
assign f4 = (pos4[0] | pos4[1]);
assign f5 = (pos5[0] | pos5[1]);
assign f6 = (pos6[0] | pos6[1]);
assign f7 = (pos7[0] | pos7[1]);
assign f8 = (pos8[0] | pos8[1]);
assign f9 = (pos9[0] | pos9[1]);

assign filled =(((((((f1 & f2) & f3) & f4) & f5) & f6) & f7) & f8) & f9);
endmodule
```

f(i) = 1 → i th position is filled

When all 9 positions are filled

Filled = 1

5. Module Re_block

This module is used to check whether the player or computer played a wrong move or not.

```
module re_block (pos1, pos2, pos3, pos4, pos5, pos6, pos7, pos8, pos9, c_enable, p_enable, wrong_move); //ch
    input [1:0] pos1, pos2, pos3, pos4, pos5, pos6, pos7, pos8, pos9;
   input [8:0] c_enable, p_enable;

   output wire wrong_move;

wire rb1,rb2,rb3,rb4,rb5,rb6,rb7,rb8,rb9,rb11,rb12,rb13,rb14,rb15,rb16,rb17,rb18,rb19,rb21,rb22;

assign rb1 = (pos1[0] | pos1[1]) & p_enable[0];  //player makes the wrong move
assign rb2 = (pos2[0] | pos2[1]) & p_enable[1];
assign rb3 = (pos3[0] | pos3[1]) & p_enable[2];
assign rb4 = (pos4[0] | pos4[1]) & p_enable[3];
assign rb5 = (pos5[0] | pos5[1]) & p_enable[4];
assign rb6 = (pos6[0] | pos6[1]) & p_enable[5];
assign rb7 = (pos7[0] | pos7[1]) & p_enable[6];
assign rb8 = (pos8[0] | pos8[1]) & p_enable[7];
assign rb9 = (pos9[0] | pos9[1]) & p_enable[8];

assign rb11 = (pos1[0] | pos1[1]) & c_enable[0];    //computer makes the wrong move
assign rb11 = (pos1[0] | pos1[1]) & c_enable[0];
assign rb12 = (pos2[0] | pos2[1]) & c_enable[1];
assign rb13 = (pos3[0] | pos3[1]) & c_enable[2];
assign rb14 = (pos4[0] | pos4[1]) & c_enable[3];
assign rb15 = (pos5[0] | pos5[1]) & c_enable[4];
assign rb16 = (pos6[0] | pos6[1]) & c_enable[5];
assign rb17 = (pos7[0] | pos7[1]) & c_enable[6];
assign rb18 = (pos8[0] | pos8[1]) & c_enable[7];
assign rb19 = (pos9[0] | pos9[1]) & c_enable[8];

assign rb21 =(((((((rb11|rb12)|rb13)|rb14)|rb15)|rb16)|rb17)|rb18)|rb19);   //computer makes the wrong move
assign rb22 =(((((((rb1|rb2)|rb3)|rb4)|rb5)|rb6)|rb7)|rb8)|rb9);   //player makes the wrong move


assign wrong_move = rb21|rb22 ;  //overall wrong move by any of player

endmodule
```

for(i>=1 && i<=9)

If rb(i) = 1 → rb22 = 1
Implies Player played a wrong move

for(i>=11 && i<=19)

If rb(i) = 1 → rb21 = 1
Implies computer played a wrong move

6. Module Pos_decode

It decodes the position of player and computer at all points in a game.it is 4 to 16 bit decoder.

```
/* always @(*) begin
if ((en)==(1'b1))
assign out_enable=pd;
else
assign out_enable=16'd0;
end*/                    //this didn't work out

assign out_enable=(en==1'b1)?pd:16'd0;  //enable signal

always @(*)
begin

case(in)                          //switch between cases of input
4'd0: pd <= 16'b0000000000000001;    //d stands for decimal
4'd1: pd <= 16'b0000000000000010;
4'd2: pd <= 16'b0000000000000100;
4'd3: pd <= 16'b0000000000001000;
4'd4: pd <= 16'b0000000000010000;
4'd5: pd <= 16'b0000000000100000;
4'd6: pd <= 16'b0000000001000000;
4'd7: pd <= 16'b0000000010000000;
4'd8: pd <= 16'b0000000100000000;
4'd9: pd <= 16'b0000001000000000;
4'd10: pd <= 16'b0000010000000000;
4'd11: pd <= 16'b0000100000000000;
4'd12: pd <= 16'b0001000000000000;
4'd13: pd <= 16'b0010000000000000;
4'd14: pd <= 16'b0100000000000000;
4'd15: pd <= 16'b1000000000000000;

default: pd<=16'b0000000000000001;

endcase
```

7. Module Who_wins3

In this module, we check if 3 positions (of a side or diagonal) is filled first by the same player.

```
module who_wins3(input [1:0] pos0,pos1,pos2, output wire won, output wire [1:0]winner);  //used in

wire [1:0] wd0,wd1,wd2;
wire wd3;


assign wd0[0] = !(pos0[0]^pos1[0]);
assign wd0[1] = !(pos0[1]^pos1[1]);
assign wd1[0] = !(pos1[0]^pos2[0]);
assign wd1[1] = !(pos1[1]^pos2[1]);
assign wd2[1] = wd0[1] & wd1[1];
assign wd2[0] = wd0[0] & wd1[0];
assign wd3 = pos0[1] | pos0[0];

assign won = wd2[0]&wd2[1]&wd3 ;  //when the 3 positions in a side/diagonal are by the same player

assign winner[0] = pos0[0]&won;
assign winner[1] = pos0[1]&won;

endmodule
```

8. Module Who_wins

This module checks the three rows, three columns and two diagonals are filled by the same player. It does so by repeatedly calling “who_wins3”. It keeps a check if any of them has won the match or not.

```
module who_wins(input[1:0] pos1,pos2,pos3,pos4,pos5,pos6,pos7,pos8,pos9,output wire won,output wire[1:0]winner); //finding out the winner
wire [1:0] winner1,winner2,winner3,winner4,winner5,winner6,winner7,winner8;
wire win_1,win_2,win_3,win_4,win_5,win_6,win_7,win_8;

//when the same symbol fills up a side or a diagonal
who_wins3 a1(pos1,pos2,pos3,win_1,winner1);
who_wins3 a2(pos4,pos5,pos6,win_2,winner2);
who_wins3 a3(pos7,pos8,pos9,win_3,winner3);
who_wins3 a4(pos1,pos4,pos7,win_4,winner4);
who_wins3 a5(pos2,pos5,pos8,win_5,winner5);
who_wins3 a6(pos3,pos6,pos9,win_6,winner6);
who_wins3 a7(pos1,pos5,pos9,win_7,winner7);
who_wins3 a8(pos3,pos5,pos6,win_8,winner8);

assign won = (((((((win_1|win_2) | win_3) | win_4) | win_5) | win_6) | win_7) | win_8);
assign winner = (((((((winner1 | winner2) | winner3) | winner4) | winner5) | winner6) | winner7) | winner8);

endmodule
```

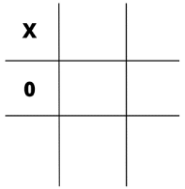
RESULTS

Test_Benc

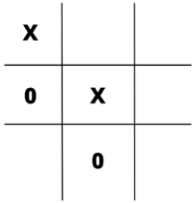
```
initial
 begin

 play = 0;
 reset = 1;
 computer = 0;          //reset
 player = 0;
 comp= 0;
 #10;
 reset = 0;             //game
 #10;
 play = 1;
 comp= 0;
 computer= 3;           // comp
 player= 0;             // play
 #5;
 comp= 1;
 play = 0;
 #10;
 reset = 0;
 play = 1;
 comp= 0;
 computer= 7;           //comp
 player= 4;             // pla
 #5;
 comp= 1;
 play = 0;
 #10;
 reset = 0;
 play = 1;
 comp= 0;
 computer= 5;       //computer
 player= 8;         //player_at
 #5;
 comp= 1;
 play = 0;
 #5
 comp= 0;
 play = 0;
 end

 initial
 begin
     $dumpfile("design.vcd");
     $dumpvars;
 end

endmodule
```

Game starts

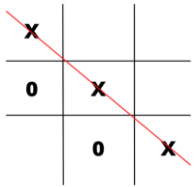
Player → 1
Computer → 4



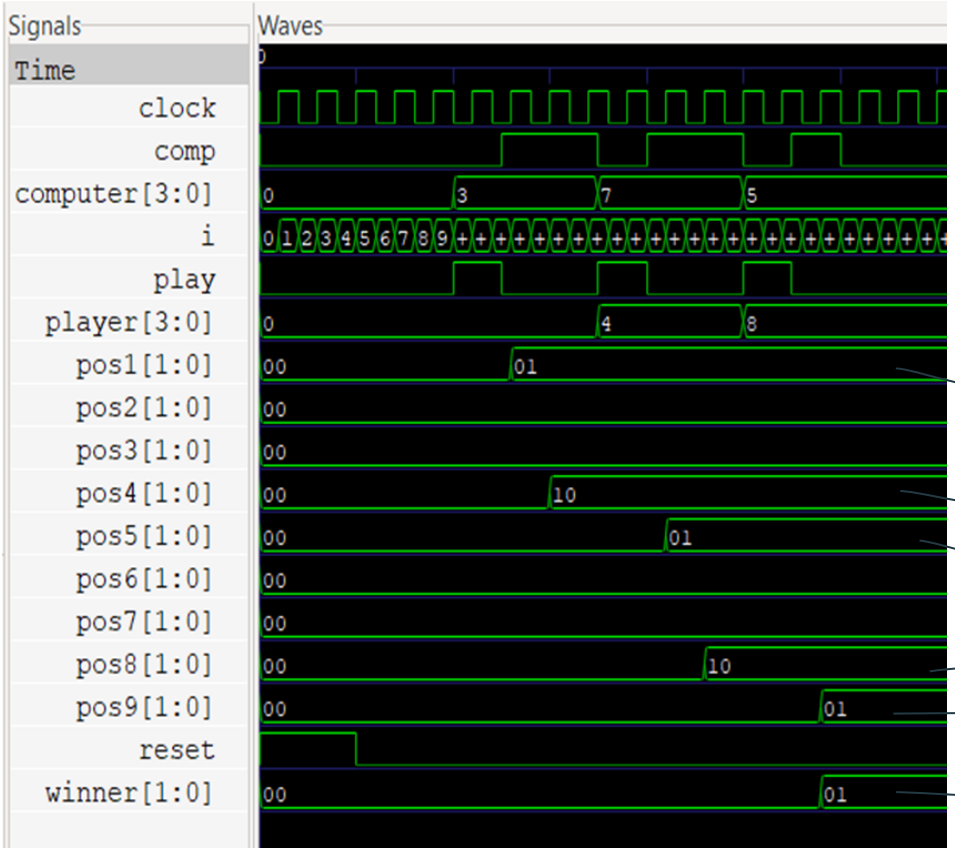
Player → 5
Computer → 8

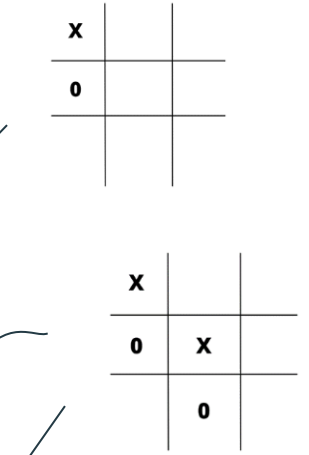


Player → 9
Computer → 6



EP_Wave


Signals
Waves
Time
clock
comp
computer[3:0]
i
play
player[3:0]
pos1[1:0]
pos2[1:0]
pos3[1:0]
pos4[1:0]
pos5[1:0]
pos6[1:0]
pos7[1:0]
pos8[1:0]
pos9[1:0]
reset
winner[1:0]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WE THANK NEERAJ SIR FOR GIVING US THIS OPPORTUNITY TO WORK AND COLLABORATE ON PROJECT.