Hacettepe University

Computer Engineering Department

BBM233 – LOGIC DESIGN LAB.

FINAL VERILOG PROJECT

“Siganfu Machine”

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Problem Definition

IN ORDER TO READ THE REST OF THIS REPORT, YOU NEED TO TRUST THE PLAN

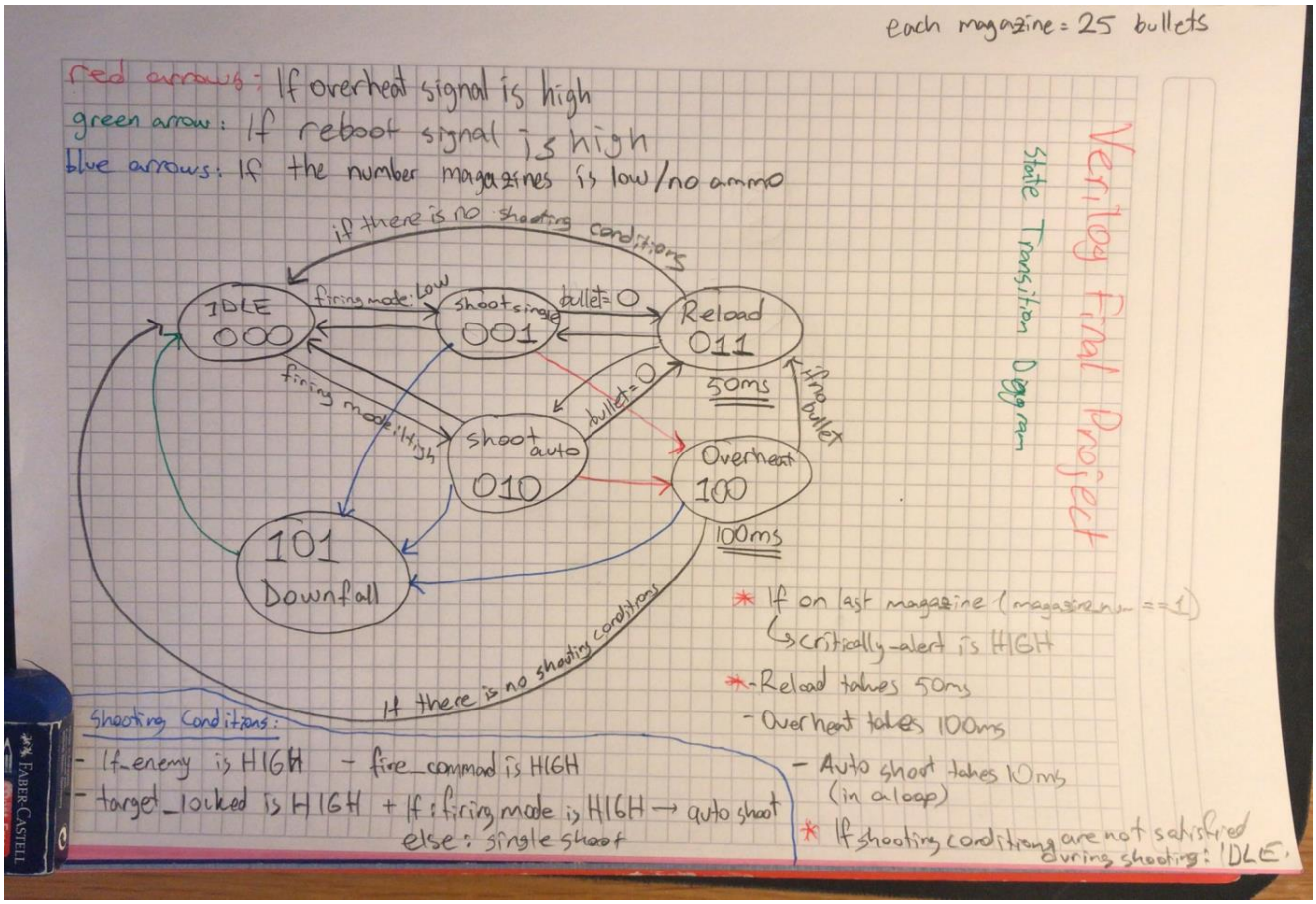
AS WELL AS I DID

At this Project we were supposed to design a controller unit for MK-LMC SIGANFU Tactical Power Armor's weapon called the SIGANFU Machine Gun. The armor's controller chip receives its inputs from the neural link and produces output at miliseconds.

The controller modules works like a 6 state 7 input finite state machine (Finite Automata) with Mealy design schematic. In order to design in Verilog, Sequential Circuits logic which we learned and applied in the previous weeks helped a lot to define and solve the problems which i came across during the project.

Mealy State Transition Diagram

State transition diagram for this project's is shown below (hand-drawn, by me)

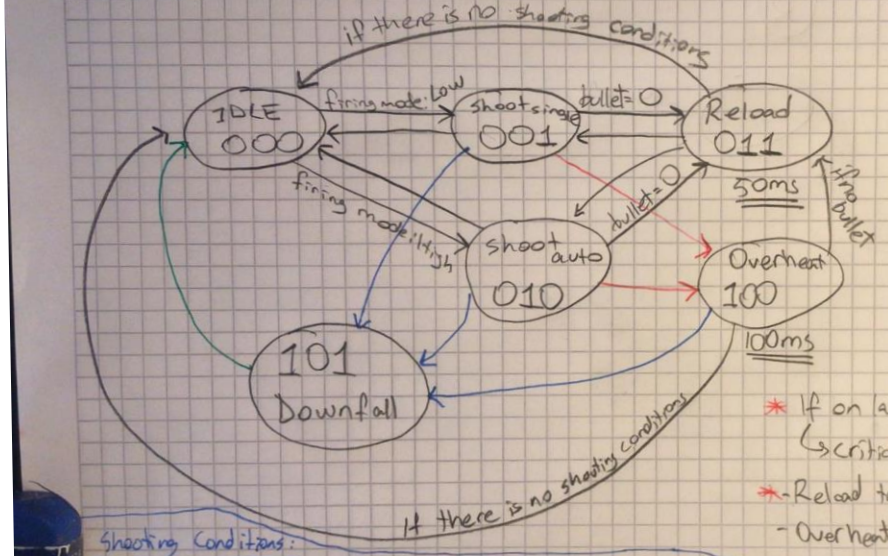


each magazine = 25 bullets

red arrows: If overheat signal is high
green arrow: If reboot signal is high
blue arrows: If the number magazines is low/no ammo

Verilog Final Project

State Transition Diagram



* If on last magazine (magazine_num == 1)
  ↳ critically_alert is HIGH
* - Reload takes 50ms
  - Overheat takes 100ms
  - Auto shoot takes 10ms (in a loop)
* If shooting conditions are not satisfied during shooting: IDLE.

Shooting Conditions:
- If_enemy is HIGH
- target_locked is HIGH
- fire_command is HIGH
+ If: firing mode is HIGH → auto shoot
  else: single shoot

Verilog Implementation

Here are the verilog adaptations of the Mealy State Transition Diagram's which I mentioned in the previous topic. I tried to comment nearly every detail or method/statement I added to the code.

- Main declarations:

```
`timescale 1ms / 100ns

module siganfu_machine_gun (
    // KARDEŞİM SEN MAKİNASIN MAKİNA <3 GÖKHAN
    input sysclk,
    input reboot,
    input target_locked,
    input is_enemy,
    input fire_command,
    input firing_mode, // 0 single, 1 auto
    input overheat_sensor,
    output reg[2:0] current_state,
    output reg criticality_alert,
    output reg fire_trigger

);
    parameter Idle = 3'b000, shoot_single =  3'b001, shoot_auto  =  3'b010, reload  =  3'b011, overheat = 3'b100, downfall = 3'b101;
    //Idle=000, shoot_single =001, shoot_auto= 010, reload= 011, overheat= 100, downfall= 101;// the states that are required for Mealy

    reg state, nextstate; //current state and the next state
    /*parameter*/ integer magazine_num = 4, bullet_num = 25;
    reg clk ;
    //toggle clock every 10 time units
    always
    #10 clk =~ clk;
```

- State transitions:

```
always@ (posedge sysclk or posedge reboot)
begin
if (reboot) // go to state zero if reboot
    state <= Idle;
else
    state <= nextstate;
    current_state =state; //deneysel oldu biraz might delete later
end
```

- **Idle State (000) :**

The default state of the Siganfu Machine Gun. For Gun to switch firing modes, first it must enter th IDLE state to switch between modes.

```
56
57  always @(state or target_locked or is_enemy or fire_command or firing_mode or overheat_sensor)
58  begin
59
60      current_state = 3'b000;
61      case(state)
62      Idle: if(target_locked==1 & is_enemy==1 & fire_command==1 & firing_mode==0)begin//conditions for idle -->> shoot single
63                nextstate = shoot_single;
64                current_state =   3'b001;
65                fire_trigger=0;
66                if(magazine_num <2)begin
67                        criticality_alert=1;
68                        end
69                    else begin
70                        criticality_alert=0;
71                    end
72            end
73            else if(target_locked==1 & is_enemy==1 & fire_command==1 & firing_mode==1)begin//conditions for idle -->> shoot auto
74                  nextstate = shoot_auto;
75                  current_state =   3'b010;
76                  fire_trigger=0;
77                  if(magazine_num <2)begin
78                          criticality_alert=1;
79                          end
80                      else begin
81                          criticality_alert=0;
82                      end
83            end
84            else begin
85                  nextstate = Idle; //otherwise stay on the IDLE state (if the shooting conds are not satisfied)
86                  current_state =3'b000;
87                  fire_trigger=0;
88                  if(magazine_num <2)begin
89                          criticality_alert=1;
90                          end
91                      else begin
92                          criticality_alert=0;
93                      end
94              end
```

- **Auto Shooting State (010)**

If all the shooting conditions are satisfied and firing mode input is 1 (which means high), the gun transitions into auto shooting state.

```
shoot_auto: if(overheat_sensor ==1)begin  //if the gun has overheated SIGANFU_MACHINE_GUN should transition to the OVERHEAT state
                current_state =3'b010;
                nextstate = overheat;
                fire_trigger=0;
                if(magazine_num <2)begin
                    criticality_alert=1;
                    end
                else begin
                    criticality_alert=0;
                end
            end
            else if (bullet_num==0) begin //check if there are any bullets left in the currently used magazine==0 yani
                    current_state =3'b010;
                    if( magazine_num==0) begin //there are no magazines left to reload yani
                        nextstate = downfall;//proceed to the DOWNFALL state
                        end
                    else begin
                        nextstate = reload;//proceed to the RELOAD state begin
                        end
          end

else if(bullet_num !==0  & target_locked==1 & is_enemy==1 & fire_command==1 & firing_mode==1) begin //auto shooting sequence if there are bullets available and the commands are 1
        current_state =3'b010;
        while (fire_command ==1 & bullet_num!==0) begin //if there is still fire_command and bullet shoot until either of them becomes 0
            fire_trigger=1;
            bullet_num = bullet_num-1;
            #5;
            fire_trigger=0;
            #5;
            if(overheat_sensor ==1)begin  //if the gun has overheated SIGANFU_MACHINE_GUN should transition to the OVERHEAT state

                nextstate = overheat;
                fire_trigger=0;
            end
        end
end
else begin
    nextstate = Idle;
    current_state =3'b010;
    end
```

- **Single Shooting State (001)**

If all the shooting conditions are satisfied and firing mode input is 0 (which means low), the gun transitions into single shooting state.

```
shoot_single: if(overheat_sensor ==1)begin  //if the gun has overheated SIGANFU_MACHINE_GUN should transition to the OVERHEAT state
                current_state =3'b001;
                nextstate = overheat;
                fire_trigger=0;
                if(magazine_num <2)begin
                    criticality_alert=1;
                    end
                else begin
                    criticality_alert=0;
                end
            end
            else if (bullet_num==0) begin //check if there are any bullets left in the currently used magazine==0 yani
                    current_state =3'b001;
                    if( magazine_num==0) begin //there are no magazines left to reload yani
                        nextstate = downfall;//proceed to the DOWNFALL state
                        end
                    else begin
                        nextstate = reload;//proceed to the RELOAD state begin
                        end
            end

else if(bullet_num !==0  & target_locked==1 & is_enemy==1 & fire_command==1 & firing_mode==0) begin //single shooting sequence if there are bullets available and conditions are satisfied
       current_state =3'b010;
       if(fire_command !==0)begin
           bullet_num = bullet_num -1;//a single shot has been fired
           fire_trigger=1; //bundan hiç emin değilim bu kadar kolay olamaz bu kısım
           if(overheat_sensor ==1)begin  //if the gun has overheated SIGANFU_MACHINE_GUN should transition to the OVERHEAT state

                   nextstate = overheat;
                   fire_trigger=0;
           end
       end
       else begin
           nextstate = Idle;
           current_state =3'b010;
```

- **Reload State (011)**

If the Siganfu Machine Gun runs out of bullets during one of the shooting sequences and there is or are available magazine(s) the gun enters “reload state”. At this state bullet number becomes 25 again and total magazine number decreases by 1.

```
reload: if (magazine_num !==0)begin //if there are available magazines bullet number becomes 25
            current_state=3'b011;
            #50; //bunun yerinden hiç emin değilim
            magazine_num = magazine_num-1;
            bullet_num=25;
            if(magazine_num==0)begin
                criticality_alert=1;
            end
            else begin
                criticality_alert=0;
            end
            if(bullet_num !==0  & target_locked==1 & is_enemy==1 & fire_command==1 & firing_mode==0)begin //proceed to single shooting mode
                nextstate = shoot_single;
            end
            else if (bullet_num !==0  & target_locked==1 & is_enemy==1 & fire_command==1 & firing_mode==1)begin //proceed to auto shooting mode
                nextstate= shoot_auto;
            end
        end
```

- **Overheat State (100)**

The Siganfu Machine Gun's temperature sensor becomes HIGH when the gun overheats. If the overheat sensor input becomes HIGH(especially during the shooting sequences) , the gun proceeds to "Overheat State" to wait 100ms to cooldown.

```
overheat: if(overheat_sensor==1)begin //must wait for 100 milliseconds for the cooling process to complete
              #100;
              if(target_locked==1 & is_enemy==1 & fire_command==1 & firing_mode==1)begin//conditions for idle -->> shoot auto
                  if(bullet_num==0)begin
                    if(magazine_num==0)begin
                         nextstate=downfall;
                    end
                    else if(magazine_num!==0)begin
                          nextstate=reload;
                    end
                end
                else begin
                   nextstate = shoot_auto;
                   current_state =   3'b010;
                   if(magazine_num <2)begin
                      criticality_alert=1;
                   end
                   else begin
                      criticality_alert=0;
                   end
                end
            end

  else if(target_locked==1 & is_enemy==1 & fire_command==1 & firing_mode==0)begin//conditions for idle -->> shoot single
     if(bullet_num==0)begin
        if(magazine_num==0)begin
             nextstate=downfall;
        end
        else if(magazine_num!==0)begin
             nextstate=reload;
        end
     else begin
         nextstate = shoot_single;
         current_state =   3'b001;
         if(magazine_num <2)begin
             criticality_alert=1;
         end
         else begin
             criticality_alert=0;
         end
     end
  end
  else begin
  nextstate=Idle;
  end
```

- **Downfall State (101)**

When the gun runs out of bullets and magazines, the machine gun goes into this state, at which it cannot shoot anymore until the system has been rebooted.

```
downfall:  if(bullet_num == 0 & magazine_num == 0)begin //the machine gun enters this state when
               while(reboot==0)begin                    //it runs out of bullets and magazines
                   #1;
                   continue;

               end
               if(reboot==1)begin
                   nextstate=Idle;
               end
           end

default:
       nextstate=Idle;
```

Before the resources part

I just wanted to thank you for this semester and last year's fall semester (yeah, this is my second time at this class due to my laziness). I had great time and learned a lot of stuff this semester about this lecture. Hope that you open another new technical elective classes at 4th grade. Sorry that I couldn't completed the project because I couldn't managed the time schedule for the finals week. I even have a final at 9.00 am tomorrow (10th of January) morning. Please don't treat that harsh. <3

Resources

Here are the resources I used during this project:

- BBM 231 Lecture Notes
- BBM233 Verilog Intro lecture notes
- https://brilliant.org/wiki/finite-state-machines/
- https://www.xilinx.com/support/documentation/university/ISE-Teaching/HDL-Design/14x/Nexys3/Verilog/docs-pdf/lab10.pdf
- https://verilogguide.readthedocs.io/en/latest/verilog/fsm.html
- https://www.nandland.com/verilog/examples/example-while-loop-verilog.html
- https://en.wikipedia.org/wiki/Finite-state_machine
- https://verilogguide.readthedocs.io/en/latest/verilog/datatype.html