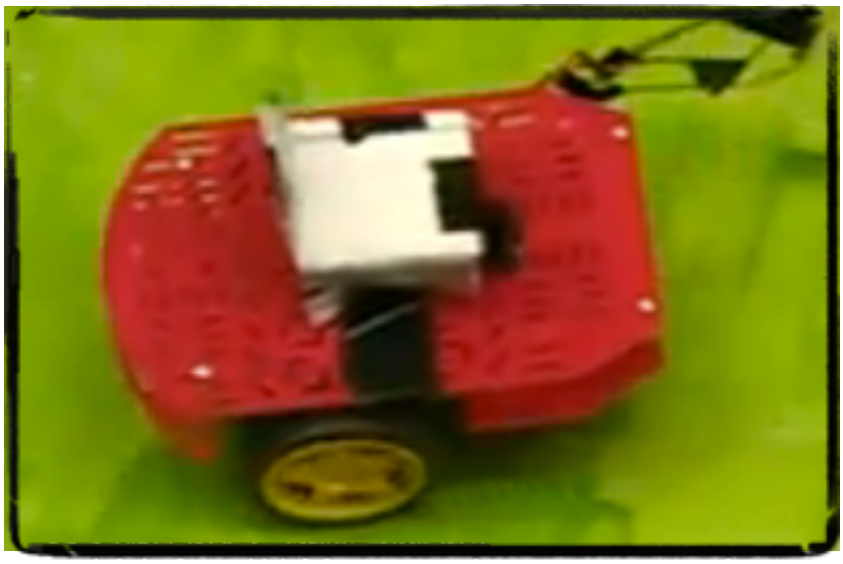
ECE 241

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING



Project Title	A controller for wheel chair prototype
Tutorial Section	108
Teaching Assistant	Mohamed Abdelfattah
Prepared By (Name and Student Numbers of the team)	Vaibhav Vijay 1000073029 Rohaila Zehra 0998371177

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Introduction

Our team made a controller for wheel chair prototype to help physically challenged people traverse between two points using a keyboard for input and motors as an output. The controller as in the FPGA controls the motors with respect to the keyboard readings.

For every destination there is a specific keyboard key that user pressed to reach their and an another key to return home from that specific location **(Appendix A)**.

This project took approximately 60 hours to complete. The workload was divided even among each team member **(Appendix B)**.

The Design

The keyboard part was involved figuring out and writing code for user interface with the wheelchair, allowing the user to communicate with the wheelchair via a PC keyboard. We used the PS2 controller module found on the EECG website to connect keyboard with the DE2 board. The keyboard interface was made possible using 3 modules. The PS2 controller module, the DATA_IN, and the COMMAND_OUT module. There was an additional (optional) module that enabled the hex make codes (of keys pressed) to be shown on the 7 segment displays. This was used as a debugging technique so that we knew that the key hits were being registered. The PS2 controller module utilized (instantiated) the other two modules so that they worked in conjunction to enable the keyboard as the input giver. The hex make codes of keys being hit on the keyboard were passed to the ps2 controller module that took the key press as input and produced the hexadecimal “make-code” of the key being pressed. We used this hex “make-code” for determining which key was pressed. The appropriate action was taken depending on which key was pressed (i.e. which hex-make code was produced by the PS2 controller).

The motors worked with the FPGA required extra motor-driving chip **(Appendix C)** to work since the FPGA was incapable of supplying enough power to drive two motors. The L293D acted as a bridge between the FPGA and the motors**(Appendix D)**.

A case statement was used to determine what action should be taken depending on which hex-make code was detected (i.e. which key was pressed). For example, a hex make code of 1B would correspond to S being pressed. We drew up a “map” on a large piece of cardboard; the map consists of “roads” and “destinations.” The roads were the paths that the wheelchair was supposed to follow in reaching a “destination;” the “destinations” were locations of the board to which the wheelchair was to navigate to. We did not utilize sensors in this navigation process, rather we *guessed* how much time the wheelchair was supposed to turn and move forward and in *which* direction. The wheelchair’s movements were a sequence of turns and forward movements, the sequence unique for each “destination.” We used the CLOCK_50 system clock of the FPGA as the counter for controlling the amount of time each motor ran. The decision to turn on which motor and in which direction depends on which destination was

specified by the user. The wheelchair had two motors. The logic is pretty straightforward; for turning left, only the left wheel would spin in the forward direction while for turning right, only the right wheel of the chair would spin forward while the other remained stationary. After the specified wheel turned the appropriate direction to the appropriate degree, the wheelchair would stop turning and then start moving forward. After reaching the specified destination , the wheelchair would stop moving and wait for another command from the keyboard issued by the user. If the user pressed the "reverse" key for the destination, then the wheelchair would "drive" back "home." "Home" was the original location where the wheelchair always started. For example, pressing "S" would make the wheelchair drive to the location labelled "Starbucks" on the map. Pressing "T" would make the wheelchair navigate back to "Home." Supposed "Starbucks" is located 20 cm ahead, 34 cm to the left , then 21 cm forward again. The Verilog module responsible for the wheelchair navigation would first check which key was pressed by checking which hex make-code it had received. After determining that S was pressed (for Starbucks), it would begin travelling down the path towards Starbucks. It would run both motors forward (supplying power to both motors in "positive" polarity) for about3 seconds (corresponding to a distance travelled of 20 cm), then for 1 second supply power to only the left motor so that this is only one that turns (hence "turning left"); finally it would supply power to both motors again in "positive polarity" *for a pre-determined length of time only,* in order to make the wheelchair move forward.

For navigating back home, the module simply carries out the same set of instructions, but *in reverse*. After receiving a command for "home" from the keyboard, the wheelchair would first take a U turn, then carry out a reverse set of instructions to what it originally did **(Appendix E)**. This whole mechanism depends on correct synchronization between the motors turning and the CLOCK_50 system clock.

Each destination was reached by the wheelchair carrying out a unique sequence of turns and forward driving**(Appendix F)**.

We drew up a "map" on a large piece of cardboard; the map consists of "roads" and "destinations." The roads are the paths that the wheelchair was supposed to follow in reaching a "destination;" **(Appendix G)** the "destinations" are locations on the board to which the wheelchair was to navigate to. We did not employ sensors in this navigation process, rather we *guessed* how much time the wheelchair was supposed to turn and move forward and in *which* direction.

Conclusion

The wheelchair's movements are a sequence of turns and forward movements; this sequence is unique for each "destination." We used the CLOCK_50 system clock of the FPGA as the counter for controlling the amount of time each motor ran. After the specified wheel turned the appropriate direction to the appropriate degree, the wheelchair would stop turning and

then start moving forward. After reaching the specified destination, the wheelchair would stop moving and wait for another command from the keyboard issued by the user. If the user pressed the “reverse” key for the destination, then the wheelchair would “drive” back “home.” “Home” was the original location where the wheelchair always started. For example, pressing “S” would make the wheelchair drive to the location labelled “Starbucks” on the map. If the user tapped “T”, then the wheelchair would navigate back to “Home.” Supposed “Starbucks” is located 20 cm ahead, 34 cm to the left , then 21 cm forward again. The Verilog module responsible for the wheelchair navigation would first check which key was pressed by checking which hex make-code it had received. After determining that S was pressed (for Starbucks), the wheelchair would begin travelling down the path towards Starbucks. It would run both motors forward for about 3 seconds (corresponding to a distance travelled of 20 cm), then for 1 second, turn the left motor clockwise and leave the right one at rest, one that turns (hence “turning left”); finally it would run both motors forward again for about 3 seconds **(Appendix H)**.

For driving back home, the wheelchair simply carries out the same set of instructions but *in reverse*. After receiving a command for “home” from the keyboard, the wheelchair would first take a U turn, and then carry out a reverse set of instructions to what it originally did. This whole mechanism depends on correct synchronization between the motors turning and the CLOCK_50 system clock**(Appendix I)**.

What would you do differently

The biggest problem was that the wheelchair didn’t drive exactly to the specified location for all destinations. The timing of the turns and the forward driving could have been a lot better. The wheelchair’s movements require more precision. We do not consider it sufficient for the wheelchair to merely move *vaguely* in the direction of a destination. We want the wheelchair’s movements to be sharper and more precise. This is the main part of this project and it could be improved a lot.

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Appendices

Appendix A

Destination	Begin Journey	Return Home
Restaurant	R	H
Supermarket	M	N
Park	A	B
Hospital	J	I
Starbucks	S	T

Appendix B

TASK	VAIBHAV VIJAY	ROHAILA ZEHRA
Working of Keyboard		✓
Hardware	✓	
Working of Motors	✓	
Game Logic	✓	
Assembling the prototype		✓
Making the image		✓
Working of VGA	✓	
Drawing the map on cardboard		✓

Appendix C

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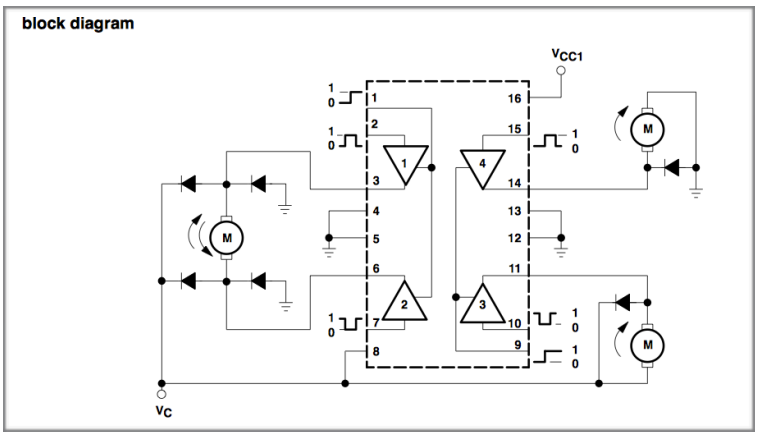
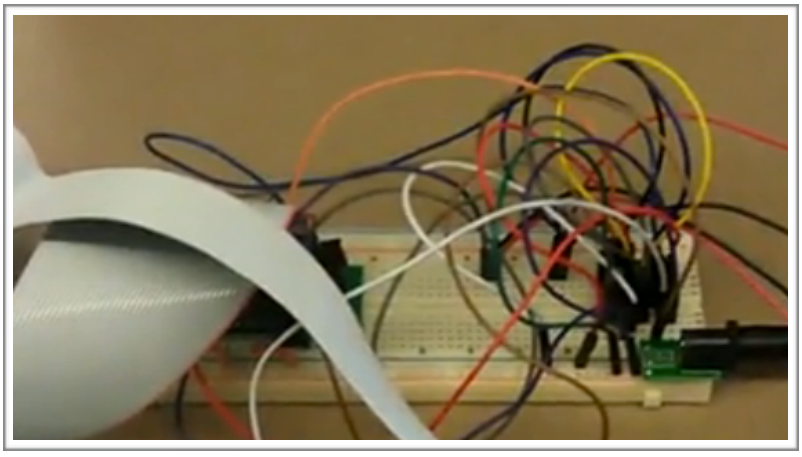
This is a block diagram of chip L293D



link: http://users.ece.utexas.edu/~valvano/Datasheets/L293d.pdf

Appendix D



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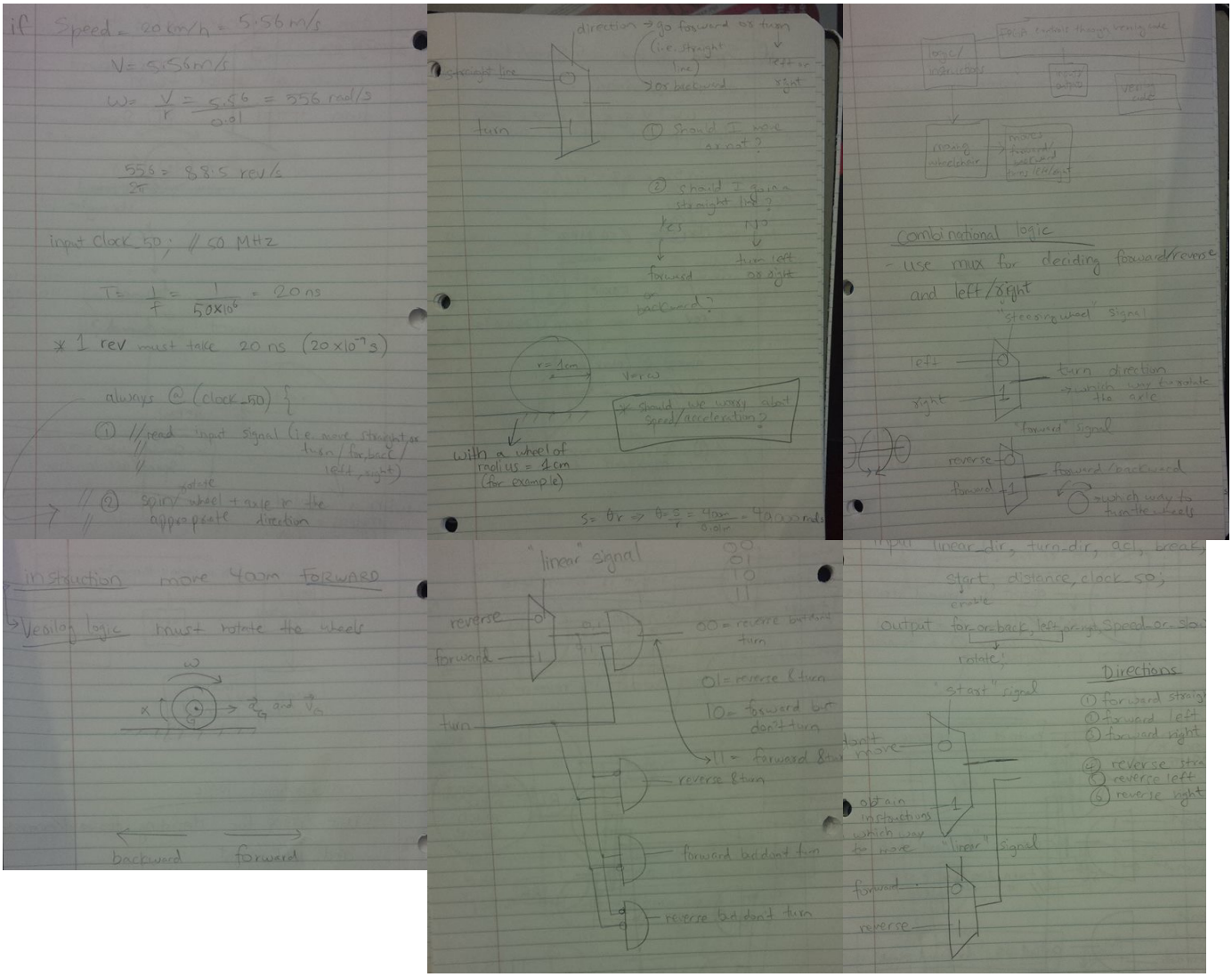
Appendix E



Appendix F

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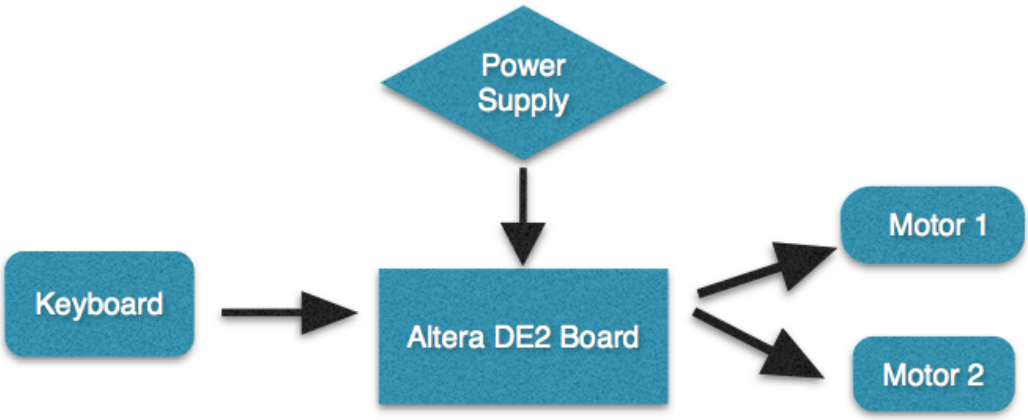

Appendix G

MOTOR 1	MOTOR 2	STATE
0	0	STOP
1	1	FORWARD
1	0	LEFT
0	1	RIGHT

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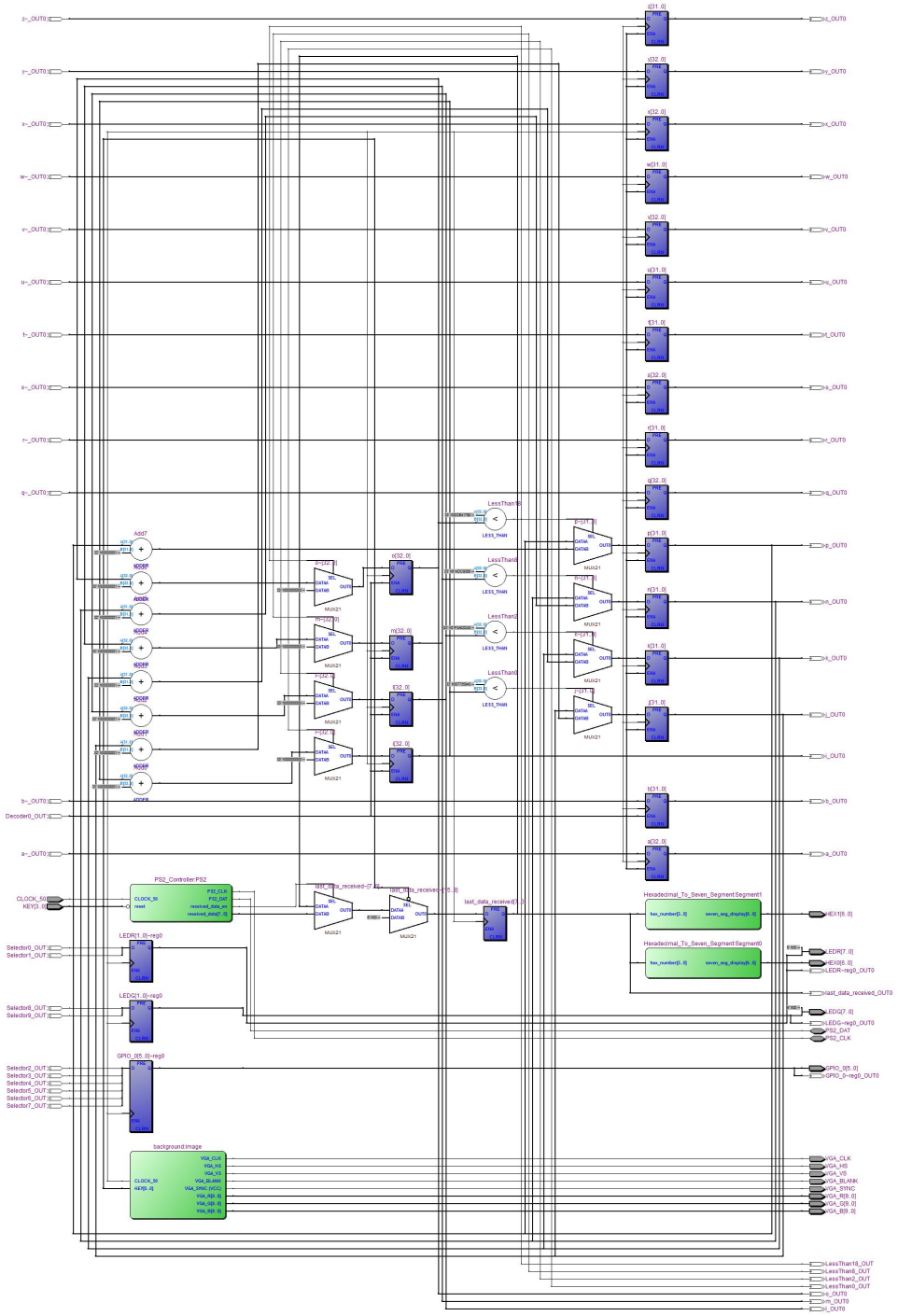
Appendix H



Appendix I

```
module GPS( //PS2_Demo
		// Inputs
		CLOCK_50,
		KEY, LEDG, LEDR, SW,
		// Bidirectionals
		PS2_CLK,
		PS2_DAT,

		GPIO_0,

		// Outputs
		HEX0,
		HEX1,
		HEX2,
		HEX3,
		HEX4,
		HEX5,
		HEX6,
		HEX7,
		VGA_CLK,   //	VGA Clock
		VGA_HS,   //	VGA H_SYNC
		VGA_VS,   //	VGA V_SYNC
		VGA_BLANK,   //	VGA BLANK
		VGA_SYNC,   //	VGA SYNC
		VGA_R,   //	VGA Red[9:0]
		VGA_G,   //	VGA Green[9:0]
		VGA_B
);
/*****************************************************************************
 *                      Parameter Declarations                               *
 *****************************************************************************/
/*****************************************************************************
 *                      Port Declarations                                    *
 *****************************************************************************/
// Inputs
input    [7:0]SW;
input                   CLOCK_50;
input           [3:0]   KEY;
// Bidirectionals
inout                   PS2_CLK;
inout                   PS2_DAT;
output reg [7:0] LEDG;
wire enable;
assign enable = KEY[1];
// Outputs
output          [6:0]   HEX0;
output          [6:0]   HEX1;
output          [6:0]   HEX2;
output          [6:0]   HEX3;
output          [6:0]   HEX4;
output          [6:0]   HEX5;
output          [6:0]   HEX6;
output          [6:0]   HEX7;
output      reg[7:0] LEDR;
output reg [5:0]GPIO_0;
```

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```
/*****************************************************************************
 *                 Internal Wires and Registers Declarations                 *
 *****************************************************************************/
// Internal Wires
wire            [7:0]   ps2_key_data;
wire                    ps2_key_pressed;
// Internal Registers
reg             [7:0]   last_data_received;
integer  j =0;
reg [32:0]i;
integer  k =0;
reg [32:0]l;
integer  n =0;
reg [32:0]m;
integer  p =0;
reg [32:0]o;
integer  r =0;
reg [32:0]q;
integer  t =0;
reg [32:0]s;
integer  u =0;
reg [32:0]y;
integer  w =0;
reg [32:0]v;
integer  z =0;
reg [32:0]x;
integer  b =0;
reg [32:0]a;
// State Machine Registers
/*****************************************************************************
 *                    Finite State Machine(s)                                *
 *****************************************************************************/
/*****************************************************************************
 *                      Sequential Logic                                     *
 *****************************************************************************/
background image
        (
                CLOCK_50,                                               //      On Board 50 MHz
                KEY,                                                    //      Push Button[0:0]
                VGA_CLK,                                                //      VGA Clock
                VGA_HS,                                                 //      VGA H_SYNC
                VGA_VS,                                                 //      VGA V_SYNC
                VGA_BLANK,                                              //      VGA BLANK
                VGA_SYNC,                                               //      VGA SYNC
                VGA_R,                                          //      VGA Red[9:0]
                VGA_G,                                                  //      VGA Green[9:0]
                VGA_B                                                   //      VGA Blue[9:0]
        );
        output  VGA_CLK;                                //      VGA Clock
        output  VGA_HS;                                 //      VGA H_SYNC
        output  VGA_VS;                                 //      VGA V_SYNC
        output  VGA_BLANK;                              //      VGA BLANK
        output  VGA_SYNC;                               //      VGA SYNC
        output  [9:0] VGA_R;                    //      VGA Red[9:0]
        output  [9:0] VGA_G;                    //      VGA Green[9:0]
        output  [9:0] VGA_B;

always @(posedge CLOCK_50)
begin
        if (KEY[0] == 1'b0)
                last_data_received <= 8'h00;
        else if (ps2_key_pressed == 1'b1)
                begin
                        last_data_received <= ps2_key_data;
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```
                    end

end
always @ (posedge CLOCK_50)
begin
                        case(last_data_received)
                                8'h2D: //R
                                        begin
                                                i <= i + 1;
                                                        if (i > 125000000)
                                                                begin
                                                                        LEDR[0] <= 0;
                                                                        LEDR[1] <= 0;
                                                                        GPIO_0[0] <= 0;//enable
for motor 1
                                                                        GPIO_0[5] <= 0;//enable
for motor 2
                                                                        i <= 0;
                                                                        j = j +1;
                                                                end
                                                        else if (i < 125000000 && j == 0) //15 move
forward
                                                                begin

GPIO_0[0] <= 1;//enable for motor 1

GPIO_0[2] <= 1;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//for moving the motor 2 clockwise

GPIO_0[5] <= 1;//enable for motor 2
                                                                                                LEDR[1]
<= 1;
                                                                                                LEDR[0]
<= 1;
                                                                end
                                        end
                                8'h33:    //H
                                                begin
                                                l <= l + 1;
                                                        if (l > 525000000)
                                                                begin
                                                                        LEDG[0] <= 0;
                                                                        LEDG[1] <= 0;
                                                                        GPIO_0[0] <= 0;//enable
for motor 1
                                                                        GPIO_0[5] <= 0;//enable
for motor 2
                                                                        l <= 0;
                                                                        k = k +1;
                                                                end
                                                        else if (l < 200000000 && k == 0) // uturn
                                                                begin

GPIO_0[0] <= 0;//enable for motor 1

GPIO_0[2] <= 0;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise
```

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```
GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//for moving the motor 2 clockwise

GPIO_0[5] <= 1;//enable for motor 2
                                                                    LEDG[1]
<= 0;
                                                                    LEDG[0]
<= 1;
                                                            end
                                                    else if (l > 200000000 && l < 325000000 &&
k == 0) // move forward
                                                            begin

GPIO_0[0] <= 1;//enable for motor 1

GPIO_0[2] <= 1;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//for moving the motor 2 clockwise

GPIO_0[5] <= 1;//enable for motor 2
                                                                    LEDG[1]
<= 1;
                                                                    LEDG[0]
<= 1;
                                                            end
                                                            else if (l > 325000000 && l <
525000000 && k == 0) // u turn
                                                            begin

GPIO_0[0] <= 0;//enable for motor 1

GPIO_0[2] <= 0;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//for moving the motor 2 clockwise

GPIO_0[5] <= 1;//enable for motor 2
                                                                    LEDG[1]
<= 1;
                                                                    LEDG[0]
<= 0;
                                                            end
                                                    end
                                            8'h3A:      //M
                                                    begin
                                                    m <= m + 1;
                                                            if (m > 350000000)
                                                            begin
                                                                    LEDR[0] <= 0;
                                                                    LEDR[1] <= 0;
                                                                    GPIO_0[0] <= 0;//enable
for motor 1
                                                                    GPIO_0[5] <= 0;//enable
for motor 2
                                                                    m <= 0;
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n = n +1;

end

else if (m < 25000000 && n == 0) //move

forward

begin

GPIO_0[0] <= 1;//enable for motor 1

GPIO_0[2] <= 1;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//for moving the motor 2 clockwise

GPIO_0[5] <= 1;//enable for motor 2

LEDR[1]

<= 1;

LEDR[0]

<= 1;

end

else if (m > 25000000 && m <

125000000 && n == 0) //TURN left

begin

GPIO_0[0] <= 1;//enable for motor 1

GPIO_0[2] <= 1;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 0;//for moving the motor 2 clockwise

GPIO_0[5] <= 0;//enable for motor 2

LEDR[0]

<= 0;

LEDR[1]

<= 1;

end

else if (m > 125000000 && n == 0 && m <

200000000) //move forward

begin

GPIO_0[0] <= 1;//enable for motor 1

GPIO_0[2] <= 1;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//for moving the motor 2 clockwise

GPIO_0[5] <= 1;//enable for motor 2

LEDR[1]

<= 1;

LEDR[0]

<= 1;

end

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```
                                                    else if (m > 200000000 && n == 0 && m <
300000000 ) //right
                                                        begin

GPIO_0[0] <= 0;//enable for motor 1

GPIO_0[2] <= 0;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//for moving the motor 2 clockwise

GPIO_0[5] <= 1;//enable for motor 2
                                                                                    LEDR[0]
<= 0;
                                                                                    LEDR[1]
<= 1;
                                                        end
                                                        else if (m > 300000000 && n == 0
&& m < 350000000) //forward
                                                        begin

GPIO_0[0] <= 1;//enable for motor 1

GPIO_0[2] <= 1;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//for moving the motor 2 clockwise

GPIO_0[5] <= 1;//enable for motor 2
                                                                                    LEDR[1]
<= 1;
                                                                                    LEDR[0]
<= 1;
                                                        end

                                                end

                                        8'h31:      //N
                                                begin
                                                o <= o + 1;
                                                    if (o > 750000000)
                                                        begin
                                                            LEDR[0] <= 0;
                                                            LEDR[1] <= 0;
                                                            GPIO_0[0] <= 0;//enable
for motor 1
                                                            GPIO_0[5] <= 0;//enable
for motor 2
                                                            o <= 0;
                                                            p = p +1;
                                                        end
                                                    else if (p == 0 && o < 200000000) //uturn
                                                        begin
                                                                    GPIO_0[0] <= 1;//
enable for motor 1
                                                                    GPIO_0[2] <= 1;//
for moving the motor 1 clockwise
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for moving the motor 1 anti clockwise

for moving the motor 2 anti clockwise

for moving the motor 2 clockwise

enable for motor 2

250000000)//forward

enable for motor 1

for moving the motor 1 clockwise

for moving the motor 1 anti clockwise

for moving the motor 2 anti clockwise

for moving the motor 2 clockwise

enable for motor 2

350000000) //left

enable for motor 1

GPIO_0[2] <= 1;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 0;//for moving the motor 2 clockwise

GPIO_0[5] <= 0;//enable for motor 2

<= 0;

<= 1;

425000000) //move forward

motor 1

for moving the motor 1 clockwise

for moving the motor 1 anti clockwise

for moving the motor 2 anti clockwise

GPIO_0[4] <= 0;//

GPIO_0[1] <= 0;//

GPIO_0[3] <= 0;//

GPIO_0[5] <= 0;//

LEDR[0] <= 1;
LEDR[1] <= 0;

end

else if (o > 200000000 && p == 0 && o <

begin

GPIO_0[0] <= 1;//

GPIO_0[2] <= 1;//

GPIO_0[4] <= 0;//

GPIO_0[1] <= 0;//

GPIO_0[3] <= 1;//

GPIO_0[5] <= 1;//

LEDR[0] <= 1;
LEDR[1] <= 1;

end

else if (o > 250000000 && p == 0 && o <

begin

GPIO_0[0] <= 1;//

LEDR[0]

LEDR[1]

end

else if (o > 350000000 && p == 0 && o <

begin
GPIO_0[0] <= 1;//enable for

GPIO_0[2] <= 1;//

GPIO_0[4] <= 0;//

GPIO_0[1] <= 0;//

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for moving the motor 2 clockwise

enable for motor 2

525000000) //move right

GPIO_0[0] <= 0;//enable for motor 1

GPIO_0[2] <= 0;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//for moving the motor 2 clockwise

GPIO_0[5] <= 1;//enable for motor 2

<= 0;

<= 1;

550000000) //move forward

motor 1

for moving the motor 1 clockwise

for moving the motor 1 anti clockwise

for moving the motor 2 anti clockwise

for moving the motor 2 clockwise

enable for motor 2

750000000) //u turn

enable for motor 1

for moving the motor 1 clockwise

for moving the motor 1 anti clockwise

for moving the motor 2 anti clockwise

for moving the motor 2 clockwise

enable for motor 2

GPIO_0[3] <= 1;//

GPIO_0[5] <= 1;//

LEDR[0] <= 1;
LEDR[1] <= 1;
end
else if (o > 425000000 && p == 0 && o <

begin

LEDR[0]

LEDR[1]

end
else if (o > 525000000 && p == 0 && o <

begin
GPIO_0[0] <= 1;//enable for

GPIO_0[2] <= 1;//

GPIO_0[4] <= 0;//

GPIO_0[1] <= 0;//

GPIO_0[3] <= 1;//

GPIO_0[5] <= 1;//

LEDR[0] <= 1;
LEDR[1] <= 1;
end
else if (o > 550000000 && p == 0 && o <

begin
GPIO_0[0] <= 1;//

GPIO_0[2] <= 1;//

GPIO_0[4] <= 0;//

GPIO_0[1] <= 0;//

GPIO_0[3] <= 0;//

GPIO_0[5] <= 0;//

LEDR[0] <= 1;
LEDR[1] <= 0;
end

end

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8'h1B: //S

```
begin
        q <= q + 1; //q and r
if (q > 500000000)
        begin
                LEDR[0] <= 0;
                LEDR[1] <= 0;
                GPIO_0[0] <= 0;//enable
```

for motor 1

```
                GPIO_0[5] <= 0;//enable
```

for motor 2

```
                q <= 0;
                r = r +1;
        end
else if (r == 0 && q < 200000000)//u turn
                begin
                  GPIO_0[0] <= 1;//enable
```

for motor 1

```
                        GPIO_0[2] <= 1;//
```

for moving the motor 1 clockwise

```
                        GPIO_0[4] <= 0;//
```

for moving the motor 1 anti clockwise

```
                        GPIO_0[1] <= 0;//
```

for moving the motor 2 anti clockwise

```
                        GPIO_0[3] <= 0;//
```

for moving the motor 2 clockwise

```
                        GPIO_0[5] <= 0;//
```

enable for motor 2

```
                        LEDR[0] <= 1;
                        LEDR[1] <= 0;
                end


        else if (q > 200000000 && r == 0
```

&& q < 325000000) //forward

```
                begin
                        GPIO_0[0] <= 1;//
```

enable for motor 1

```
                        GPIO_0[2] <= 1;//
```

for moving the motor 1 clockwise

```
                        GPIO_0[4] <= 0;//
```

for moving the motor 1 anti clockwise

```
                        GPIO_0[1] <= 0;//
```

for moving the motor 2 anti clockwise

```
                        GPIO_0[3] <= 1;//
```

for moving the motor 2 clockwise

```
                        GPIO_0[5] <= 1;//
```

enable for motor 2

```
                        LEDR[0] <= 1;
                        LEDR[1] <= 1;
                end

        else if (q > 325000000 && r == 0
```

&& q < 425000000)//left

```
                begin
                  GPIO_0[0] <= 1;//enable
```

for motor 1

GPIO_0[2] <= 1;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

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GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 0;//for moving the motor 2 clockwise

GPIO_0[5] <= 0;//enable for motor 2

LEDR[0]

<= 0;

LEDR[1]

<= 1;

end

else if (q > 425000000 && r == 0

&& q < 500000000)//forward

begin

GPIO_0[0] <= 1;//enable

for motor 1

GPIO_0[2] <= 1;//

for moving the motor 1 clockwise

GPIO_0[4] <= 0;//

for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//

for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//

for moving the motor 2 clockwise

GPIO_0[5] <= 1;//

enable for motor 2

LEDR[0] <= 1;

LEDR[1] <= 1;

end

end

8'h2C: // T

begin

s <= s + 1;

if (s > 500000000)

begin

LEDR[0] <= 0;

LEDR[1] <= 0;

GPIO_0[0] <= 0;//enable

for motor 1

GPIO_0[5] <= 0;//enable

for motor 2

s <= 0;

t = t +1;

end

else if (t == 0 && s <

200000000) //uturn

begin

GPIO_0[0] <= 1;//

enable for motor 1

GPIO_0[2] <= 1;//

for moving the motor 1 clockwise

GPIO_0[4] <= 0;//

for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//

for moving the motor 2 anti clockwise

GPIO_0[3] <= 0;//

for moving the motor 2 clockwise

GPIO_0[5] <= 0;//

enable for motor 2

LEDR[0] <= 1;

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&& s < 275000000)//forward

enable for motor 1

for moving the motor 1 clockwise

for moving the motor 1 anti clockwise

for moving the motor 2 anti clockwise

for moving the motor 2 clockwise

enable for motor 2

&& s < 375000000) //right

GPIO_0[0] <= 0;//enable for motor 1

GPIO_0[2] <= 0;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//for moving the motor 2 clockwise

GPIO_0[5] <= 1;//enable for motor 2

<= 0;

<= 1;

&& s < 500000000)//forward

enable for motor 1

for moving the motor 1 clockwise

for moving the motor 1 anti clockwise

for moving the motor 2 anti clockwise

for moving the motor 2 clockwise

enable for motor 2

LEDR[1] <= 0;
end

else if (s > 200000000 && t == 0

begin
GPIO_0[0] <= 1;//

GPIO_0[2] <= 1;//

GPIO_0[4] <= 0;//

GPIO_0[1] <= 0;//

GPIO_0[3] <= 1;//

GPIO_0[5] <= 1;//

LEDR[0] <= 1;
LEDR[1] <= 1;
end

else if (s > 275000000 && t == 0

begin

LEDR[0]

LEDR[1]

end

else if (s > 375000000 && t == 0

begin
GPIO_0[0] <= 1;//

GPIO_0[2] <= 1;//

GPIO_0[4] <= 0;//

GPIO_0[1] <= 0;//

GPIO_0[3] <= 1;//

GPIO_0[5] <= 1;//

LEDR[0] <= 1;
LEDR[1] <= 1;
end

end

8'h3B: //J

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```
                                                                    begin
                                                                        y <= y + 1;
                                                                        if (y >
625000000)
                                                                        begin
LEDR[0] <= 0;
LEDR[1] <= 0;
GPIO_0[0] <= 0;//enable for motor 1
GPIO_0[5] <= 0;//enable for motor 2
y <= 0;
u = u +1;
                                                                        end
                                                                    else if (u == 0 &&
y < 200000000)//uturn
                                                                        begin
GPIO_0[0] <= 0;//enable for motor 1
GPIO_0[2] <= 0;//for moving the motor 1 clockwise
GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise
GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise
GPIO_0[3] <= 1;//for moving the motor 2 clockwise
GPIO_0[5] <= 1;//enable for motor 2
                                                                        LEDG[1]
<= 0;
                                                                        LEDG[0]
<= 1;
                                                                        end
                                                                    else if (y >
200000000 && u == 0 && y < 250000000 ) //forward
                                                                        begin
                                                                    GPIO_0[0] <= 1;//
enable for motor 1
                                                                    GPIO_0[2] <= 1;//
for moving the motor 1 clockwise
                                                                    GPIO_0[4] <= 0;//
for moving the motor 1 anti clockwise
                                                                    GPIO_0[1] <= 0;//
for moving the motor 2 anti clockwise
                                                                    GPIO_0[3] <= 1;//
for moving the motor 2 clockwise
                                                                    GPIO_0[5] <= 1;//
enable for motor 2
                                                                    LEDR[0] <= 1;
                                                                    LEDR[1] <= 1;
                                                                        end
                                                                    else if (y >
250000000 && u == 0 && y < 350000000)//right
                                                                        begin
GPIO_0[0] <= 0;//enable for motor 1
```

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GPIO_0[2] <= 0;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//for moving the motor 2 clockwise

GPIO_0[5] <= 1;//enable for motor 2

<= 0;

<= 1;

350000000 && u == 0 && y < 450000000)//forward

enable for motor 1

for moving the motor 1 clockwise

for moving the motor 1 anti clockwise

for moving the motor 2 anti clockwise

for moving the motor 2 clockwise

enable for motor 2

450000000 && u == 0 && y < 550000000)//left

GPIO_0[0] <= 1;//enable for motor 1

GPIO_0[2] <= 1;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 0;//for moving the motor 2 clockwise

GPIO_0[5] <= 0;//enable for motor 2

<= 0;

<= 1;

550000000 && u == 0 && y < 625000000)//forward

enable for motor 1

for moving the motor 1 clockwise

for moving the motor 1 anti clockwise

LEDR[0]

LEDR[1]

end

else if (y >

begin

GPIO_0[0] <= 1;//

GPIO_0[2] <= 1;//

GPIO_0[4] <= 0;//

GPIO_0[1] <= 0;//

GPIO_0[3] <= 1;//

GPIO_0[5] <= 1;//

LEDR[0] <= 1;

LEDR[1] <= 1;

end

else if (y >

begin

LEDR[0]

LEDR[1]

end

else if (y >

begin

GPIO_0[0] <= 1;//

GPIO_0[2] <= 1;//

GPIO_0[4] <= 0;//

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GPIO_0[1] <= 0;//

for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//

for moving the motor 2 clockwise

GPIO_0[5] <= 1;//

enable for motor 2

LEDR[0] <= 1;
LEDR[1] <= 1;
end
end
8'h43: // I
begin
v <= v + 1;
if (v >

625000000)

begin

LEDR[0] <= 0;

LEDR[1] <= 0;

GPIO_0[0] <= 0;//enable for motor 1

GPIO_0[5] <= 0;//enable for motor 2

v <= 0;

w = w + 1;

end
if (w ==

0 && v < 200000000) //uturn

begin

GPIO_0[0] <= 0;//enable for motor 1

GPIO_0[2] <= 0;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//for moving the motor 2 clockwise

GPIO_0[5] <= 1;//enable for motor 2

LEDG[1]

<= 0;

LEDG[0]

<= 1;

end

else if (v

> 200000000 && w == 0 && v < 275000000)//forward

begin

GPIO_0[0] <= 1;//

enable for motor 1

GPIO_0[2] <= 1;//

for moving the motor 1 clockwise

GPIO_0[4] <= 0;//

for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//

for moving the motor 2 anti clockwise

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for moving the motor 2 clockwise

enable for motor 2

end

> 275000000 && w == 0 && v < 375000000)//right

GPIO_0[0] <= 0;//enable for motor 1

GPIO_0[2] <= 0;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//for moving the motor 2 clockwise

GPIO_0[5] <= 1;//enable for motor 2

<= 0;

<= 1;

> 375000000 && w == 0 && v < 475000000)//forward

begin

enable for motor 1

for moving the motor 1 clockwise

for moving the motor 1 anti clockwise

for moving the motor 2 anti clockwise

for moving the motor 2 clockwise

enable for motor 2

end

> 475000000 && w == 0 && v < 575000000)//left

GPIO_0[0] <= 1;//enable for motor 1

GPIO_0[2] <= 1;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 0;//for moving the motor 2 clockwise

GPIO_0[3] <= 1;//

GPIO_0[5] <= 1;//

LEDR[0] <= 1;
LEDR[1] <= 1;

else if (v

begin

LEDR[0]

LEDR[1]

end

else if (v

GPIO_0[0] <= 1;//

GPIO_0[2] <= 1;//

GPIO_0[4] <= 0;//

GPIO_0[1] <= 0;//

GPIO_0[3] <= 1;//

GPIO_0[5] <= 1;//

LEDR[0] <= 1;
LEDR[1] <= 1;

else if (v

begin

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GPIO_0[5] <= 0;//enable for motor 2

LEDR[0]

<= 0;

LEDR[1]

<= 1;

end

else if (v

> 575000000 && w == 0 && v < 625000000)//forward

begin

GPIO_0[0] <= 1;//

enable for motor 1

GPIO_0[2] <= 1;//

for moving the motor 1 clockwise

GPIO_0[4] <= 0;//

for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//

for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//

for moving the motor 2 clockwise

GPIO_0[5] <= 1;//

enable for motor 2

LEDR[0] <= 1;
LEDR[1] <= 1;

end

end

8'h1C: //A

begin

x <= x + 1;

if (x >

200000000)

begin

LEDR[0] <= 0;

LEDR[1] <= 0;

GPIO_0[0] <= 0;//enable for motor 1

GPIO_0[5] <= 0;//enable for motor 2

x <= 0;

z = z +1;

end

else if (x <

25000000 && z == 0) //forward

begin

GPIO_0[0] <= 1;//

enable for motor 1

GPIO_0[2] <= 1;//

for moving the motor 1 clockwise

GPIO_0[4] <= 0;//

for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//

for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//

for moving the motor 2 clockwise

GPIO_0[5] <= 1;//

enable for motor 2

LEDR[0] <= 1;

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```
LEDR[1] <= 1;
end
else if (x >
25000000 && z == 0 && x < 125000000) //right
begin
GPIO_0[0] <= 0;//enable for motor 1
GPIO_0[2] <= 0;//for moving the motor 1 clockwise
GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise
GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise
GPIO_0[3] <= 1;//for moving the motor 2 clockwise
GPIO_0[5] <= 1;//enable for motor 2
LEDR[0]
<= 0;
LEDR[1]
<= 1;
end
else if (x <
125000000 && z == 0 && x < 200000000) //forward
begin
GPIO_0[0] <= 1;//
enable for motor 1
GPIO_0[2] <= 1;//
for moving the motor 1 clockwise
GPIO_0[4] <= 0;//
for moving the motor 1 anti clockwise
GPIO_0[1] <= 0;//
for moving the motor 2 anti clockwise
GPIO_0[3] <= 1;//
for moving the motor 2 clockwise
GPIO_0[5] <= 1;//
enable for motor 2
LEDR[0] <= 1;
LEDR[1] <= 1;
end
end
8'h32: //B
begin
a <= a + 1;
if (a >
600000000)
begin
LEDG[0] <= 0;
LEDG[1] <= 0;
GPIO_0[0] <= 0;//enable for motor 1
GPIO_0[5] <= 0;//enable for motor 2
a <= 0;
b = b +1;
end
else if (a <
200000000 && b == 0) //u turn
begin
```

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GPIO_0[0] <= 0;//enable for motor 1

GPIO_0[2] <= 0;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//for moving the motor 2 clockwise

GPIO_0[5] <= 1;//enable for motor 2

<= 0;

<= 1;

200000000 && a < 275000000 && b == 0) // forward

enable for motor 1

for moving the motor 1 clockwise

for moving the motor 1 anti clockwise

for moving the motor 2 anti clockwise

for moving the motor 2 clockwise

enable for motor 2

275000000 && a < 375000000 && b == 0) // right

GPIO_0[0] <= 0;//enable for motor 1

GPIO_0[2] <= 0;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 1;//for moving the motor 2 clockwise

GPIO_0[5] <= 1;//enable for motor 2

<= 0;

<= 1;

375000000 && a < 475000000 && b == 0) // forward

enable for motor 1

for moving the motor 1 clockwise

for moving the motor 1 anti clockwise

LEDG[1]

LEDG[0]

end
else if (a >

begin
GPIO_0[0] <= 1;//

GPIO_0[2] <= 1;//

GPIO_0[4] <= 0;//

GPIO_0[1] <= 0;//

GPIO_0[3] <= 1;//

GPIO_0[5] <= 1;//

LEDR[0] <= 1;
LEDR[1] <= 1;
end
else if (a >

begin

LEDR[0]

LEDR[1]

end
else if (a >

begin
GPIO_0[0] <= 1;//

GPIO_0[2] <= 1;//

GPIO_0[4] <= 0;//

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for moving the motor 2 anti clockwise

for moving the motor 2 clockwise

enable for motor 2

475000000 && a < 575000000 && b == 0) // left

GPIO_0[0] <= 1;//enable for motor 1

GPIO_0[2] <= 1;//for moving the motor 1 clockwise

GPIO_0[4] <= 0;//for moving the motor 1 anti clockwise

GPIO_0[1] <= 0;//for moving the motor 2 anti clockwise

GPIO_0[3] <= 0;//for moving the motor 2 clockwise

GPIO_0[5] <= 0;//enable for motor 2

<= 0;

<= 1;

575000000 && a < 625000000 && b == 0) // forward

enable for motor 1

for moving the motor 1 clockwise

for moving the motor 1 anti clockwise

for moving the motor 2 anti clockwise

for moving the motor 2 clockwise

enable for motor 2

```
                                                                    end
                                        endcase
end
/*****************************************************************************
 *                    Combinational Logic                        *
 *****************************************************************************/
assign HEX2 = 7'h7F;
assign HEX3 = 7'h7F;
assign HEX4 = 7'h7F;
assign HEX5 = 7'h7F;
assign HEX6 = 7'h7F;
assign HEX7 = 7'h7F;
/*****************************************************************************
 *                    Internal Modules                        *
 *****************************************************************************/
PS2_Controller PS2 (
          // Inputs
```

```
GPIO_0[1] <= 0;//

GPIO_0[3] <= 1;//

GPIO_0[5] <= 1;//

LEDR[0] <= 1;
LEDR[1] <= 1;
          end
else if (a >

          begin

          LEDR[0]

          LEDR[1]

          end
else if (a >

          begin
GPIO_0[0] <= 1;//

GPIO_0[2] <= 1;//

GPIO_0[4] <= 0;//

GPIO_0[1] <= 0;//

GPIO_0[3] <= 1;//

GPIO_0[5] <= 1;//

LEDR[0] <= 1;
LEDR[1] <= 1;
          end
```

```
        .CLOCK_50                                   (CLOCK_50),
        .reset                              (~KEY[0]),
        // Bidirectionals
        .PS2_CLK                    (PS2_CLK),
        .PS2_DAT                            (PS2_DAT),
        // Outputs
        .received_data              (ps2_key_data),
        .received_data_en (ps2_key_pressed)
);
//assign LEDR = last_data_received;
Hexadecimal_To_Seven_Segment Segment0 (
        // Inputs
        .hex_number                         (last_data_received[3:0]),
        // Bidirectional
        // Outputs
        .seven_seg_display          (HEX0)
);
Hexadecimal_To_Seven_Segment Segment1 (
        // Inputs
        .hex_number                         (last_data_received[7:4]),
        // Bidirectional
        // Outputs
        .seven_seg_display          (HEX1)
);
endmodule
```