CSEE W4840 Project: Shoot bubble video game

Team Name: Bubble Tea

Team Members:

Jun Dai jd2968

Shuo-Shu Tsai st2786

Weichia Chen wgc2111

Michael Shone yh2567

Fig.1 Shoot bubble Demo Figure

1. Introduction

Our project is to implement the video game called “shoot bubble”. The rules of the bubble game is to blast as many bubbles as possible. The more you pop, the higher your score is, but you must not let the bubbles touch the ground as this will end your game.

At beginning of the game, you can select one player mode or two player mode. Once the player starts the game, on the upside of the screen, there are some bubbles with different colors holding together. The only way to pop bubbles is to get 3 or more consecutive bubbles with the same color lined up and you do so by using your only weapon - the pipe which is an arrow at the bottom of your game screen.

In one player mode, you can use the key " ← " and " → " on the keyboard to point the pipe to the exact direction you choose and then with the click of the "Enter" key you shoot the next bubble. By contrast, in two player mode, players click the "Enter" key orderly to shoot the bubble. Meanwhile, player 1 use the key "<" and " > " and player 2 use " ← " and " → " to control the direction of the pipe. The pipe always show the color of the next bubble you are going to shot so you have to plan ahead before shooting to make sure you will get those 3 or more bubble lined up. You don't necessarily have to blast bubbles on each fire you make, planning ahead can be real necessity in this game, but you must be sure that you have where to shot at because the minute those bubbles touch the ground, that's it, game over.

2. System Architecture

In order to realize our design, seven major components are included: SRAM, SDRAM, JTAG/UART, PS2 keyboard, VGA, and Audio. Following figure shows the connections between each other.

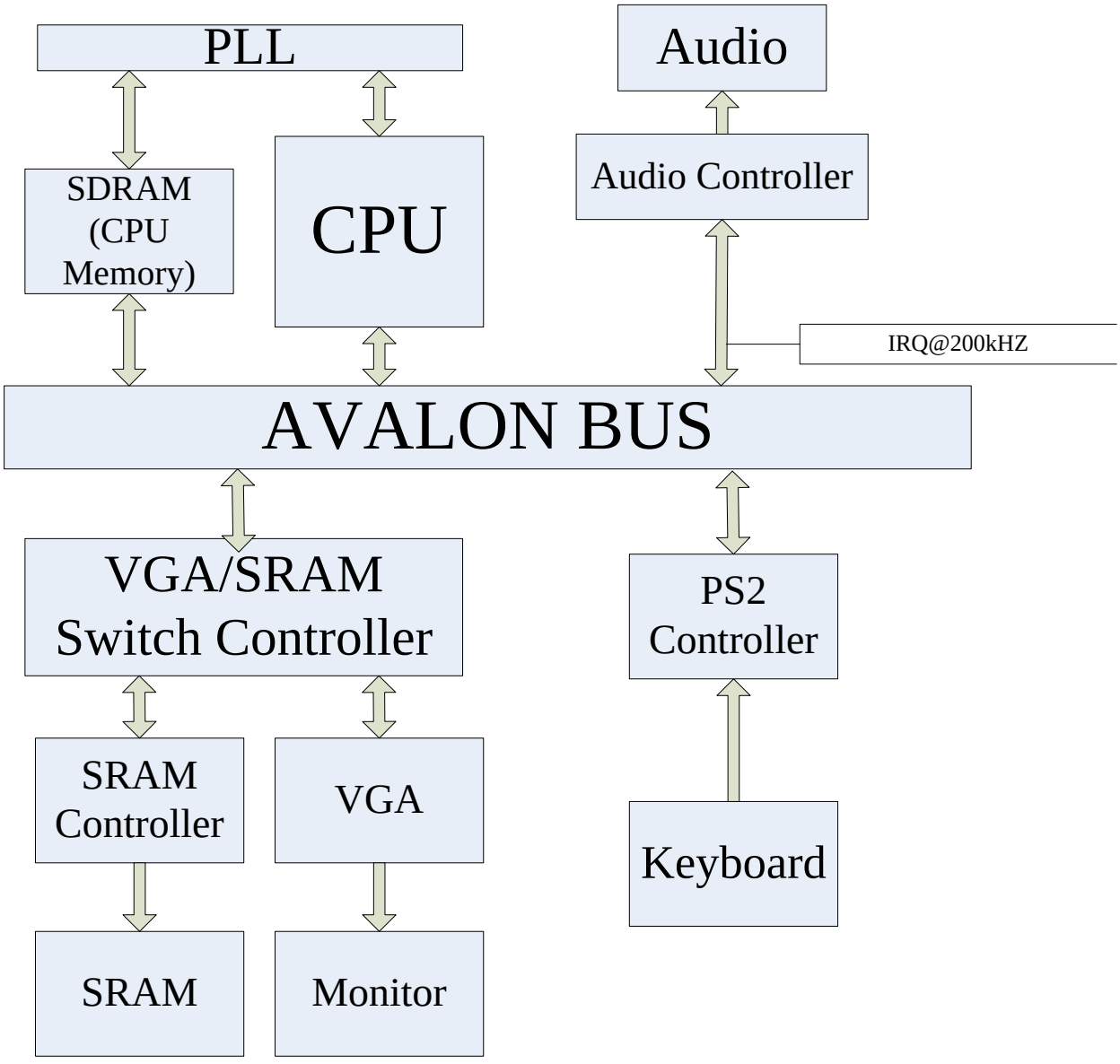


Fig. 2 Architecture diagram

3. Software and Hardware Implementation

Whole Design split into two parts: software programming and hardware setup. Software program controls the game logic: path of the bubble, logic to remove the bubbles and decision of whether

3.1 Keyboard

The keyboard in this project is where we get the input from the player to control the game. The keys and their functions show in the following figure:

KEYS	FUNCTIONs
← , →	Player 1 control: Control the arrowhead which determine the direction for shooting
Enter	Player 1 Shoot!!
<,>	Player 2 control: Control the arrowhead which determine the direction for shooting
P	Using in menu for choosing one_playermode
N	Using in menu for choosing two_playermode
ESC	Returning to menu while playing

Fig.4 Keys instruction

We have different angles for thirty different shooting directions. While pressing right or left, logic change the function from the original function to the specific one. In this way, controlling direction can be realized in the game. We also add the debounce function to prevent unnecessary duplicate signals.

3.2. Audio:

In our project, we would like to produce sound effect and background music when player is playing the game. We will use the high-quality 16-bits audio via the Wolfson WM8731 audio CODEC. The WM8731 is controlled by a serial I2C bus interface on the Cyclone II FPGA board we are using. It is designed with digital audio input word lengths ranging from 16-32 bits and sampling rates from 8kHz to 96kHz.The sampling rate in our project is 16KHZ.While we want to play a high quality background music. We used MATLAB to generate the data of audio we find on the internet in 16KHZ sampling rate and store it in the SDRAM. We create

a buffer in the music controller with 16bits*128. CPU will send 128 data to the buffer to play the music. Whenever the music controller finished playing all the data in the buffer. It will send an interrupt signal to CPU to request for the new data.

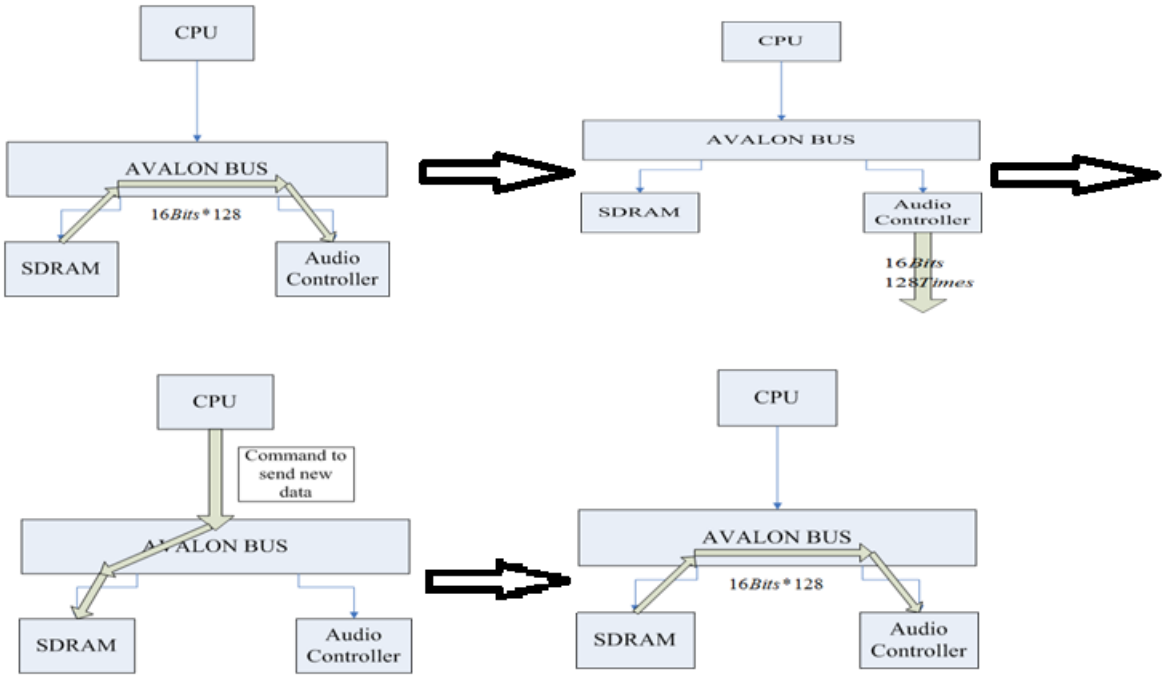


Fig.5 Audio Diagram

Sound effect will be composed of different frequency sin wave that is similar with the FM sound synthesizer of the lab3. We will make 4 kinds of the background music in the VHDL part for the software to use in the video game: “Shoot”, “Move Arrow”, “Hit Bubble”, and “Completed Bubble”. Just change the modulating frequency and the modulation depth to make the musical notes we wanted.

Background music will be preloaded in the individual ROMs, and being played when the CPU gives the audio controller commands. We will record 3 kinds of sound from the original game as .wav file: “game start music”, “game playing music”, and “game over music”.

3.3. VGA

For the playing window region, we can divide it to 180 ball regions, each column contains 18 blocks and row contains 10 blocks. We have four different types of balls for the most difficult level and one special bullet (shooting bubble) which can eliminate three columns of ball. The sizes of bullets, balls and exploding images are 32x32 pixels and eight bit depth for each pixel. We can storage thirty tube images in different angles in SRAM. We save several different background in the SDRAM at the beginning. When every we change to the different Gamemode we can load an image from SDRAM to SRAM and VGA_controll will read the data from SRAM. Because we save our data in 8 bits RGB, there will be two data in one address of SRAM. Therefore, when we read the data from SRAM. We need to read a new data in 16 bits width every two clock cycle.

Turtle Ball	Mushroom Ball	Box	Exploding Image	Pipe
				

Fig. 6 Image sample

Image processing:

Due to the memory constrain, we don't store sprites in 8-bits type. We use Matlab to covert images we search from websites to RGB type; therefore, we can save sprites in SRAM.

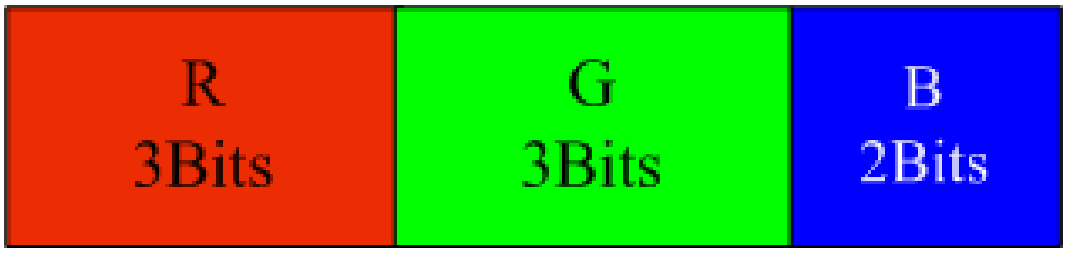


Fig.7 Bitmap of 12x20 pixels shot arrow

3.4. SRAM

We use SRAM to save the data of image that are showing on the VGA. A switch controller is connecting to both SRAM controller and VGA controller. We can control this switch controller by CPU to choose if we are to write a new data from SDRAM to SRAM in write mode, otherwise VGA controller read data from SRAM. Because we want to make sure that SRAM doesn't do read or write action at the same time, we connect the inout wire of SRAM to VGA controller when reading and connect the wire to Avalon bus when writing. Since we also need to control the VGA controller to implement our game logic. We connect the Avalon bus to VGA controller in read mode with another input of VGA controller.

3.5. SDRAM

In the SOPC builder for this project, SDRAM is connected as our CPU memory. The clock phase for the SDRAM has to be 3ns later than the other part of the Avalon bus. So we used phase locked loop to generate the clock for SDRAM. Since in our design, we need to use SRAM to store the image for VGA to display on the monitor. We put all of our image data in SDRAM. Whenever we need, we can control the switch controller and to write the data from SDRAM to SRAM.

3.5. Software

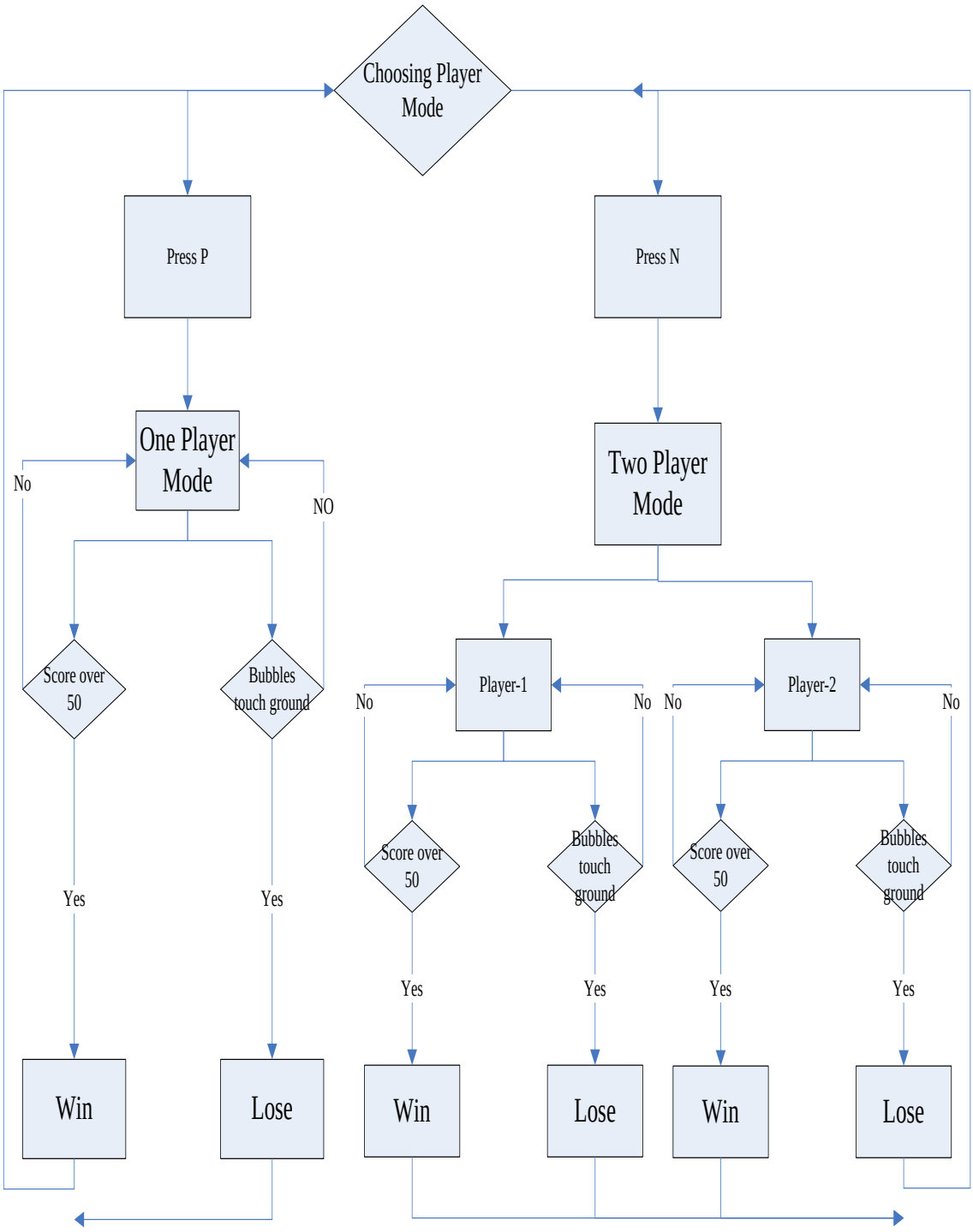
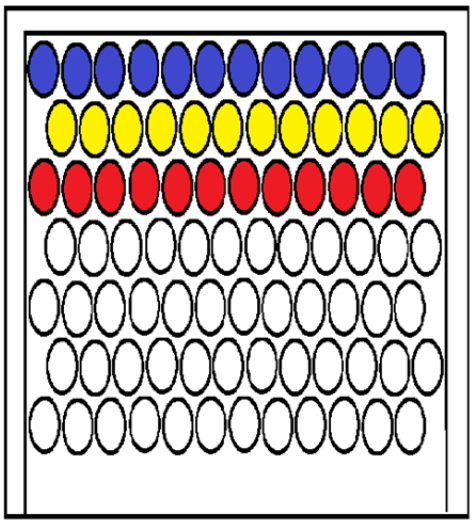


Fig.8 Game logic

It is important to implement a good structure to realize all applications. The structure of our software is based on dividing the big play region into 180 ball regions. Therefore, we can easily control the VGA_Controller to show the correct figure through a Ball_Type array transmitting by NIOS. Thus, we only need to transmit a small array when we need to change image on our displayer.



```
1 1 1 1 1 1 1 1 1 1 1 1
2 2 2 2 2 2 2 2 2 2 2 2
3 3 3 3 3 3 3 3 3 3 3 3
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
```

Fig.9 Left: 180 small ball regions on displayer Right: A Ball_Type array in NIOS

We can implement our game algorithm by this easy model. For example, the purple ball is a shooting ball. When the ball is moving (red ball), it detects whether its close ball regions exist ball or not. If it does, the moving ball is going to stop and do the clean ball functions.

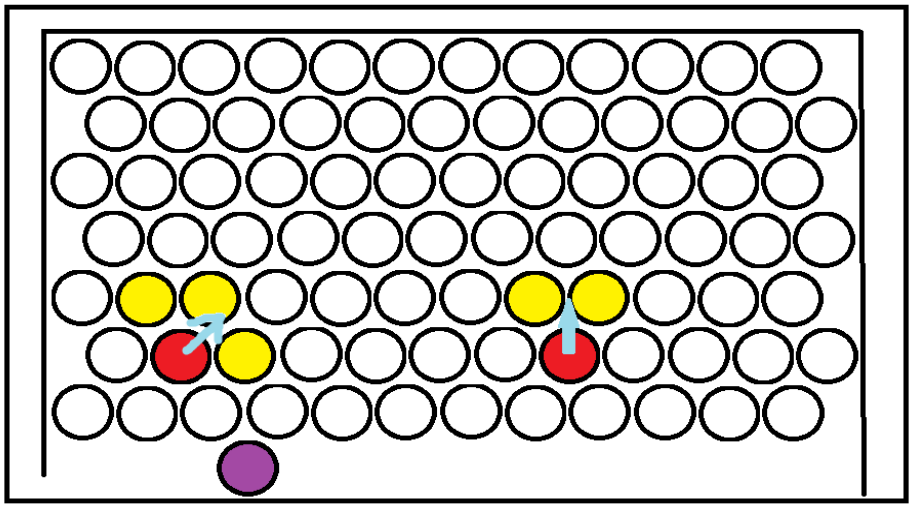


Fig.10 Game logic example.

4. Conclusion

For this project, we learned and implemented the combination of hardware and software. Meanwhile, we struggle with many difficulties especially in the hardware. One of the issue is timing, because every component have its own clock cycle. Before succeeded compiling the hardware, we took much time to realize and adjust the timing issue in hardware. Another difficulty is that hardware is hard to compile. As long as a little change in programming, it will take magnitude time for hardware to compile again. Completely thinking the whole design and understanding how each component and peripheral is much more important than writing the code first.

5. Source code

```
/*
 * "Hello World" example.
 *
 */

#include <stdio.h>
#include <io.h>
#include <beach_rgb.h>
#include <system.h>
//#include "finalmario_rgb.h"
#include "pipe1.h"
//#include "mario_rgb.h"

//#include "pipe15.h"

#include "mario_game_over.h"
#include "twoplayer.h"
#include "start_background.h"
#include "pipe30.h"
#include "start.h"
#include "pipe-new1_rgb.h"
#include "Paper_Mario_Final.h"
//#include "mario_game_over2.h"
//#include <score-13sec.h>
#define IOWR_VGA_DATA(base, offset, data) \
IOWR_16DIRECT(base, (offset) * 2, data)
#define IORD_VGA_DATA(base, offset) \
IORD_16DIRECT(base, (offset) * 2)
#define IOWR_VGA_SPEED(base, data) \
IOWR_16DIRECT(base + 32, 0, data)

//int i;
```

```
//int v=0;
//static void backgroundmusic()
//{
//    i=0;
//    while(i<128)
//              {
//
IOWR_16DIRECT(MUSICCONTROLLER_0_BASE,i*2,score[v]);

//                    v++;
//                    if(v >209684)
//                    {
      //               v=0;
//                    }
//                    i++;

//              }

//}

int startgamemode=1;
int twoplayergamemode=0;
int oneplayergamemode=0;
int gameovermode=0;



int ball_type[12][18];
int nearball_type1;
int nearball_type2;
int nearball_type3;
int nearball_type4;
int column;
int row;
int startx = 210;
int starty = 360;
int shootballtype=1;
int cleanball[15][20];
int cleanfloatball[15][20];
int playmode=1;
int dcount=0;
int n1count=0;
int n2count=0;
int n3count=0;
int n4count=0;
int score=0;
int delay=0;
int a = 0;
int n = 14;
int v = 0;
int player=1;
int row14;
```

```
int column14;
int nextball_type=0;
double slope_table[29]={0.1051, 0.2126, 0.3249, 0.4452, 0.5774, 0.7265,
           0.9004, 1.1106, 1.3763, 1.7302, 2.24604, 3.07768, 4.7046,
           5, 9999, -5, -4.7046, -3.07768, -2.24604, -1.7302,
           -1.3763, -1.1106, -0.9004, -0.7265, -0.5774, -0.4452, -
0.3249,
           -0.2126, -0.1051};


int main()
{
  printf("Hello from Nios II!\n");
 // IOWR_VGA_DATA(VGA_MUX_0_BASE,125,1);
  // switch avalonbus to SRAM
  for(a=500000;a<509999;a++)
       IOWR_16DIRECT(VGA_MUX_0_BASE,a,0);

  for(a=320000;a<324095;a++)
        IOWR_8DIRECT(VGA_MUX_0_BASE,a,pipe1[a-320000]);
// write background
  for(a=0;a<307200;a++)
      IOWR_8DIRECT(VGA_MUX_0_BASE,a,startscreen[a]);

  // switch avalonbus to vga_controller
      for(a=510000;a<510003;a++)
        IOWR_16DIRECT(VGA_MUX_0_BASE,a,0);







  int i=startx;
  int j=starty;
  int wall_j=0;
  int wall_i=0;
  int count=0;
  int state=2;
  int k;
  int y;
  int p;
  int back_type = 0;

  int downcounter=0;
  int debouncecounter=0;

  unsigned char tempcode;


  unsigned char code;
```

```
  double slope;
 // alt_irq_register(   MUSICCONTROLLER_0_IRQ,
NULL,( void*)audio_irqhandler );


 for (y=0; y<12; y++)
  {
   for(k=0;k<18;k++)
   {
        ball_type[y][k] = 0;
   }
  }


 for (y=0; y<4 ;y++)
 {
  for(k=0;k<18;k++)
  {
        ball_type[y][k] = 3;

 }
 }
 for (y=0; y<12 ;y++)
 {
       for(k=7;k<11;k++)
        {
            ball_type[y][k] = 0;
        }
 }



for(;;) ///  wait people type enter
{

              downcounter++;
             if(downcounter==5000000 && (twoplayergamemode==1 ||
oneplayergamemode==1) )
             {
                  downstair();
                  downcounter=0;
                  debouncecounter=0;
             }



     if(!IORD_8DIRECT(DE2_PS2_0_BASE, 0)){/* Poll the status */
    code = IORD_8DIRECT(DE2_PS2_0_BASE, 1);
   // printf("code= %c \n", code);

     if (tempcode!=code){
          if (n >28)
```

```
    n = 28;
else if (n<1)
     n= 0;
     tempcode= code;
     slope = slope_table[n];


    if (code=='k')
     {

     int diff;
     diff = downcounter-debouncecounter;

     if (diff>18000){
          debouncecounter=downcounter;
          if(diff<21000){
                                        n=n-3;
                                   }
       n=n-1;
       IOWR_VGA_DATA(VGA_MUX_0_BASE,190,n);
       printf("left n= %d\n",n);

          }

     }
     else if(code=='t')
     {

          int diff;
          diff = downcounter-debouncecounter;

          if (diff>18000){

          debouncecounter=downcounter;
          if(diff<21000){
               n=n+3;
          }
          n=n+1;
          IOWR_VGA_DATA(VGA_MUX_0_BASE,190,n);
          printf("right n= %d\n",n);
                    }

     }

     else if(code=='1')   //press n
                    {


          oneplayergamemode=1;
          twoplayergamemode=0;
          startgamemode=0;
          gameovermode=0;
```

```
                    for(a=500000;a<509999;a++)
IOWR_16DIRECT(VGA_MUX_0_BASE,a,0);
                                                                    //
write background
for(a=0;a<307200;a++)
IOWR_8DIRECT(VGA_MUX_0_BASE,a,paper_mario_final[a]);



for(a=510000;a<510003;a++)
IOWR_16DIRECT(VGA_MUX_0_BASE,a,0);


for (y=0; y<12; y++)
                                                                    {
for(k=0;k<18;k++)
{
ball_type[y][k] = 0;
                                                                     }
                                                                    }


for (y=0; y<12; y++)
                                                                    {
for(k=0;k<12;k++)
{
ball_type[y][k] = 1;
                                                                     }
                                                                    }


for (y=0; y<10; y++)
                                                  {
                                                    for(k=0;k<18;k++)
                                                     {
```

```
IOWR_VGA_DATA(VGA_MUX_0_BASE,y*18+k+3,ball_type[y][k]);
                                                  }
                                               }

shootball();
                              }




                else if(code=='M')   //press p
                                                  {

                                     twoplayergamemode=1;
                                     oneplayergamemode=0;
                                     startgamemode=0;
                                     gameovermode=0;
                                     for(a=500000;a<509999;a++)

                 IOWR_16DIRECT(VGA_MUX_0_BASE,a,0);

            // write background

              for(a=0;a<307200;a++)

                  IOWR_8DIRECT(VGA_MUX_0_BASE,a,twoplayer[a]);



              for(a=510000;a<510003;a++)

                     IOWR_16DIRECT(VGA_MUX_0_BASE,a,0);


              for (y=0; y<12; y++)

               {

                for(k=0;k<18;k++)
```

```
  {
     ball_type[y][k] = 0;
  }
 }

for (y=0; y<4 ;y++)
{
 for(k=0;k<18;k++)
 {
     ball_type[y][k] = 3;

}
}
for (y=0; y<12 ;y++)
{
    for(k=7;k<11;k++)
     {
          ball_type[y][k] = 0;
     }
}



for (y=0; y<10; y++)
   {
     for(k=0;k<18;k++)
                                                                    {
```

```
IOWR_VGA_DATA(VGA_MUX_0_BASE,y*18+k+3,ball_type[y][k]);
                                                    }
                                                  }

                                            //shootball2();
                startx=135;
                 starty=380;
                 shootballtype=rand()%4+1;
                IOWR_VGA_DATA(VGA_MUX_0_BASE,2,shootballtype);
                IOWR_VGA_DATA(VGA_MUX_0_BASE,0,startx);
                IOWR_VGA_DATA(VGA_MUX_0_BASE,1,starty);
                v=1;


                                         }




                else if(code=='v')   //next level
                                         {

                              twoplayergamemode=0;
                              oneplayergamemode=0;
                              startgamemode=1;
                              for(a=500000;a<509999;a++)
                 IOWR_16DIRECT(VGA_MUX_0_BASE,a,0);

             // write background
               for(a=0;a<307200;a++)
                  IOWR_8DIRECT(VGA_MUX_0_BASE,a,startscreen[a]);
```

```
for(a=510000;a<510003;a++)

       IOWR_16DIRECT(VGA_MUX_0_BASE,a,0);


                                    }



   else if(code=='Z')
   {
         int diff;
         diff = downcounter-debouncecounter;

         if (diff>150){
         debouncecounter=downcounter;

                        v++;
                              player=v%2;
                        printf("player = %d\n",player);
                              int rsidewall;
                              int lsidewall;
                              int rsidewall1=254;
                              int lsidewall1=46;
                              int rsidewall2=606;
                              int lsidewall2=398;
                              int startx1=135;
                              int starty1=380;
                              int startx2=520;
                             int starty2=380;

         if (oneplayergamemode==1)
         {

               rsidewall=414;
               lsidewall=46;
               startx=210;
               starty=380;

         }


         else if(twoplayergamemode==1 && player==0)
         {
               rsidewall=rsidewall1;
               lsidewall=lsidewall1;
               startx=startx1;
               starty=starty1;
```

```
                        }
                        else if(twoplayergamemode==1 && player==1)
                        {
                              rsidewall=rsidewall2;
                              lsidewall=lsidewall2;
                              startx=startx2;
                              starty=starty2;
                        }


                         printf("startx = %d\n",startx);
                         printf("starty = %d\n",starty);


                    i=startx;
                    j=starty;

                   //     IOWR_VGA_DATA(VGA_MUX_0_BASE,125,1);
                   //     IOWR_VGA_DATA(VGA_MUX_0_BASE,2,shootballtype);
                   //     IOWR_VGA_DATA(VGA_MUX_0_BASE,0,startx);
                   //     IOWR_VGA_DATA(VGA_MUX_0_BASE,1,starty);
/// write down intial balls


                         for (y=0; y<12; y++)
                         {
                           for(k=0;k<18;k++)
                            {

IOWR_VGA_DATA(VGA_MUX_0_BASE,y*18+k+3,ball_type[y][k]);
                            }
                         }
                         count=0;



                              for(;;)
                                {

                                   if(count==200)
                                  {
                                   if(state==1)
                                          {

                                           i++;
                                           j = (int)(slope*(i-wall_i) +
wall_j);



IOWR_VGA_DATA(VGA_MUX_0_BASE,0,i);
```

```
IOWR_VGA_DATA(VGA_MUX_0_BASE,1,j);
                                        row=knowpositiony(j);
                                        column=knowpositionx(i);
                                        findnearballtype(row,column);
                                        count = 0;



                                        if(i==lsidewall && j==46)
                                        state=3;

                                        else if(i>=rsidewall)
                                        {
                                         resetncount();
                                        resetnearball();
                                         wall_i = i;
                                         wall_j = j;
                                         state=3;
                                         slope=-1*slope;
                                        }

                                        else if(j<=47 || n1count>delay
|| n2count>delay || n3count>delay || n4count>delay)
                                        {


                                              resetnearball();
                                              resetncount();



ball_type[row][column]=shootballtype;

IOWR_VGA_DATA(VGA_MUX_0_BASE,row*18+column+3,ball_type[row][column]);

                                              clean ();
                                              shootball();




                                              state = 2;
                                              i = startx;
                                              j = starty;

                                             code='p';// wait type
enter to shot ball

                                              //nextball();
```

```
                                        break;
                                    }
                                }
                                // start position left up direction
                                else if(state==2)
                                {
                              //      printf("state==2");
                                     if (n<=14.2 && n>=13.8)
                                    {

                                        j=j-1;

IOWR_VGA_DATA(VGA_MUX_0_BASE,0,i);

IOWR_VGA_DATA(VGA_MUX_0_BASE,1,j);
                                        row=knowpositiony(j);
                                        column=knowpositionx(i);

findnearballtype(row,column);
                                        count = 0;
                                    if(j<=47 || n1count>delay ||
n2count>delay || n3count>delay || n4count>delay)
                                                                {


resetncount();

resetnearball();


ball_type[row][column]=shootballtype;

IOWR_VGA_DATA(VGA_MUX_0_BASE,row*18+column+3,ball_type[row][column]);

clean ();

shootball();



state = 2;

                                                                i =
startx;
                                                                j =
starty;


code='p';   // wait type enter to shot ball
```

```
//nextball();

                                                                break;
                                                              }
                                          }

                                           else if (slope>0)
                                           {

                                   //         printf("slope>0");
                                             if (slope < 1.5)
                                                {
                                               i--;
                                               j=(int)(slope*(i-
startx)+starty);

                                                }
                                              else if(slope <2.5)
                                                {
                                                     p++;
                                                     j--;
                                                      if(p%4==0)
                                                      {
                                                        i--;
                                                      j=(int)(slope*(i-
startx)+starty);

                                                      }

                                                }
                                               else
                                                {
                                                     p++;
                                                     j--;
                                                      if(p%5==0)
                                                      {
                                                        i--;

     j=(int)(slope*(i-startx)+starty);
                                                     }


                                                }


IOWR_VGA_DATA(VGA_MUX_0_BASE,0,i);

IOWR_VGA_DATA(VGA_MUX_0_BASE,1,j);
                                            row=knowpositiony(j);
                                            column=knowpositionx(i);
                                            findnearballtype(row,column);
                                            count = 0;
/*
```

```
                                        printf("column%d\n",column);
                                        printf("nearball_type1 = %d
",nearball_type1);
                                        printf("nearball_type2 = %d
",nearball_type2);
                                        printf("nearball_type3 = %d
",nearball_type3);
                                        printf("nearball_type4 = %d
",nearball_type4);
                                        printf("i=%d\n",i);
                                        printf("j=%d\n",j);
*/
                                       if(i<=lsidewall)
                                       {
                                         resetncount();
                                        resetnearball();
                                        wall_i = i;
                                        wall_j = j;
                                        state=1;
                                        slope=-1*slope;
                                       }
                                       else if(j<=47 ||
n1count>delay || n2count>delay || n3count>delay || n4count>delay)
                                       //state=3;
                                       {
                                            resetncount();
                                            resetnearball();

ball_type[row][column]=shootballtype;

IOWR_VGA_DATA(VGA_MUX_0_BASE,row*18+column+3,ball_type[row][column]);
                                            clean ();
                                            shootball();




                                            state = 2;

                                            i = startx;
                                            j = starty;
                                            code='p';


                                            //nextball();

                                            break;
                                        }
                                       }

                                       else if (slope<0)
                                        {
```

```
                                    //          printf("slope<0");

                                                if (slope > -1.5)
                                                {
                                               i++;
                                               j=(int)(slope*(i-
startx)+starty);
                                                }
                                                else if(slope > -2.5)
                                                {
                                                       p++;
                                                       if(p%2==0)
                                                       {
                                                          i++;
                                                      }
                                                       j=(int)(slope*(i-
startx)+starty);
                                                }
                                                else
                                                {
                                                        p++;
                                                       if(p%3==0)
                                                       {
                                                          i++;
                                                      }
                                                       j=(int)(slope*(i-
startx)+starty);
                                                }


IOWR_VGA_DATA(VGA_MUX_0_BASE,0,i);

IOWR_VGA_DATA(VGA_MUX_0_BASE,1,j);
                                               row=knowpositiony(j);
                                               column=knowpositionx(i);

findnearballtype(row,column);
                                               count = 0;

                                                     if(i>=rsidewall)
                                               {
                                                  resetncount();
                                                resetnearball();
                                                wall_i = i;
                                                wall_j = j;
                                                state=3;
                                                slope=-1*slope;
                                               }
                                               else if(j<=47 ||
n1count>delay || n2count>delay || n3count>delay || n4count>delay)
                                               //state=3;
                                               {
```

```
                                        resetncount();
                                        resetnearball();

ball_type[row][column]=shootballtype;

IOWR_VGA_DATA(VGA_MUX_0_BASE,row*18+column+3,ball_type[row][column]);

                                        clean ();
                                        shootball();



                                        state = 2;

                                        i = startx;
                                        j = starty;
                                        code='p';


                                       // nextball();

                                         break;
                                       }
                                    }

                                     }



                                   // right up direction
                                   else if(state==3)
                                   {
                                //          printf("state==3");
                                     count = 0;
                                     i--;
                                     j=(int)(slope*(i-wall_i)+wall_j);
                                     IOWR_VGA_DATA(VGA_MUX_0_BASE,0,i);
                                     IOWR_VGA_DATA(VGA_MUX_0_BASE,1,j);
                                      row=knowpositiony(j);
                                      column=knowpositionx(i);
                                      findnearballtype(row,column);


                                       if(i<=lsidewall)
                                           {
                                         resetncount();
                                         resetnearball();
                                            wall_i = i;
                                            wall_j = j;
                                            state=1;
                                            slope=-1*slope;
```

```
                                                }
                                               else if(j<=47 ||
n1count>delay || n2count>delay || n3count>delay || n4count>delay)
                                              {
/*
                                                 printf("n1 = %d  ",n1count);
                                                 printf("n2 = %d  ",n2count);
                                                 printf("n3 = %d  ",n3count);
                                                     printf("n4 = %d
",n4count);
                                                       printf("left up
direction");
*/
                                                    resetncount();
                                                    resetnearball();
                                              slope=tan(3.14159/n);

ball_type[row][column]=shootballtype;

IOWR_VGA_DATA(VGA_MUX_0_BASE,row*18+column+3,ball_type[row][column]);
                                              clean ();
                                              shootball();



                                              state = 2;

                                              i = startx;
                                              j = starty;
                                              code='p';


                                              //nextball();

                                             break;
                                             }

                                          }//End if(state==3)
                                        }// Enf if(count==3000)

                                    else
                                     count++;
                                   }//End for(;;)
                                 }// End if (code=='Z' && w==1)

                                 else{
                                 }
                                 }// End for(;;)

                        }
              }
              }
```

```
  return 0;
}//End int main()




void inorder (int cleanrow, int cleancolumn, int rowtype){

  if (cleanball[cleanrow][cleancolumn]==shootballtype && cleanrow>=0
&& cleancolumn>=0){
        cleanball[cleanrow][cleancolumn]=0;
        dcount++;
//      printf("clearow= %d    cleancolumn= %d",cleanrow,cleancolumn);
//      printf("inloop dcunt = %d", dcount);
        inorder(cleanrow,cleancolumn+1,1);
        cleanball[cleanrow][cleancolumn]=0;
        inorder(cleanrow,cleancolumn-1,1);
       cleanball[cleanrow][cleancolumn]=0;
        inorder(cleanrow-1,cleancolumn,1);
       cleanball[cleanrow][cleancolumn]=0;
       inorder(cleanrow+1,cleancolumn,1);
       cleanball[cleanrow][cleancolumn]=0;
        if (cleanrow==0 || cleanrow==2 || cleanrow==4 || cleanrow==6 ||
cleanrow==8 || cleanrow==10)
            {
                  rowtype=1;
            }
        else {
                   rowtype=0;
              }
        if (rowtype==1){
        inorder(cleanrow-1,cleancolumn-1,1);
        cleanball[cleanrow][cleancolumn]=0;
        inorder(cleanrow+1,cleancolumn-1,1);
        cleanball[cleanrow][cleancolumn]=0;
        inorder(cleanrow+1,cleancolumn,1);
        cleanball[cleanrow][cleancolumn]=0;
        }
        else{
        inorder(cleanrow-1,cleancolumn+1,1);
        cleanball[cleanrow][cleancolumn]=0;
        inorder(cleanrow+1,cleancolumn+1,1);
        cleanball[cleanrow][cleancolumn]=0;
        inorder(cleanrow+1,cleancolumn,1);
        cleanball[cleanrow][cleancolumn]=0;
        }
  }
}
```

```
void clean ()
{

      if (row==9)
      {
            losegame();
      }
     dcount=0;
      int k,y;

      for (y=0; y<15; y++){
              for(k=0;k<20;k++)
                                        {
                                  cleanball[y][k]=0;
                                        }
                           }

      for (y=0; y<12; y++){
        for(k=0;k<18;k++)
                                  {
                             cleanball[y+2][k+1]=ball_type[y][k];
                                  }
                     }
      int contactball_1=cleanball[row+2][column+1+1];
     int contactball_2=cleanball[row+2][column-1+1];
      int contactball_3=cleanball[row-1+2][column+1+1];
      int contactball_4=cleanball[row-1+2][column+1];

      if (row==1 || row==3 || row==5 || row==7 || row==9 || row==11)
      {

            if (contactball_1==shootballtype ||
contactball_2==shootballtype || contactball_3==shootballtype ||
contactball_4==shootballtype){

            inorder (row+2, column+1,1);
            }
      }

      else{
            contactball_3=cleanball[row-1+2][column-1+1];

            if (contactball_1==shootballtype ||
contactball_2==shootballtype || contactball_3==shootballtype ||
contactball_4==shootballtype){

                        inorder (row+2, column+1,0);
                        }
      }
```

```
      printf("dcount =  %d", dcount);
if (dcount>=3){
      score=score+dcount;
     //printf("score= %d\n",score);
      for (y=0; y<12; y++){
             for(k=0;k<18;k++)
                                    {
                   ball_type[y][k]=cleanball[y+2][k+1];
                                    }
                          }
         for (y=0; y<12; y++){
         for(k=0;k<18;k++)
                    {

      IOWR_VGA_DATA(VGA_MUX_0_BASE,y*18+k+3,ball_type[y][k]);
                    }
        }
       cleanfloat();
}
}

int knowpositionx (int x)
{
      int column;
      int i;

      if (row==1 || row==3 || row==5 || row==7 || row==9 || row==11)
      {
            for (i=0;i<18;i++){
                  if (x>=62-16+i*32 && x<=62+i*32+15)
                        column=i;
                  }
      }
      else
      {
      for (i=0;i<18;i++){
      if (x>=46-16+i*32 && x<=46+i*32+15)
            column=i;
      }
      }
      return column;
}

int knowpositiony (int y)
{
      int row;
      int i;
      for (i=0;i<15;i++){
      if (y>=46-14+i*29 && y<=46+i*29+15)
            row=i;
      }
      return row;
```

```
}

int findnearballtype(int row,int column)
{

      if (row==1 || row==3 || row==5 || row==7 || row==9 || row==11)
            {


            if (n<=9 || n>=19){

                nearball_type1=ball_type[row-1][column];
                if (column != 0){
                  nearball_type3=ball_type[row][column-1];
                }

                if (column !=17){
                nearball_type2=ball_type[row-1][column+1];
                  nearball_type4=ball_type[row][column+1];
                }
            }
            else {
                  nearball_type1=ball_type[row-1][column];
                  if (column!=17){
                nearball_type2=ball_type[row-1][column+1];
                  }
            }
            }

      else{

            if (n<=9 || n>=19){
                  if (row!=0){
                nearball_type1=ball_type[row-1][column];
                if (column!=0){
                nearball_type2=ball_type[row-1][column-1];
                }
                  }
                  if (column!=0){
                  nearball_type3=ball_type[row][column-1];
                  }
                  if (column!=17){
                  nearball_type4=ball_type[row][column+1];
                  }
            }
            else{
                  if (row!=0){
                  nearball_type1=ball_type[row-1][column];
                  if (column!=0){
                  nearball_type2=ball_type[row-1][column-1];
                              }
                  }
```

```
            }

      }

      if (nearball_type1!=0){
            n1count++;}
      if (nearball_type2!=0){
                  n2count++;
            }
      if (nearball_type3!=0){
                  n3count++;
            }
      if (nearball_type4!=0){
                  n4count++;
            }

    return 0;

}

void resetncount()
{
      n1count=0;
      n2count=0;
      n3count=0;
      n4count=0;
}


void resetnearball()
{
      nearball_type1=0;
      nearball_type2=0;
      nearball_type3=0;
      nearball_type4=0;

}

void downstair()
{
int y;
int k;
int lose=0;
int temp[12][18];

for (k=0;k<18;k++){
if (ball_type[9][k]!=0){
      lose =1;
}
}

if (lose == 1){
```

```
      losegame();
}


else {
        for (y=0; y<8; y++)
        {
         for(k=0;k<18;k++)
         {
               temp[y+2][k]=ball_type[y][k];
         }
        }


       if (twoplayergamemode==1){
        for(k=0;k<7;k++){

                    temp[0][k]=rand()%4 + 1;
                    temp[1][k]=rand()%4 + 1;

              }

        for(k=11;k<18;k++){

                         temp[0][k]=rand()%4 + 1;
                         temp[1][k]=rand()%4 + 1;

                    }

        for(k=7;k<11;k++){

                               temp[0][k]=0;
                               temp[1][k]=0;

                         }
       }

       else if (oneplayergamemode==1){
             for(k=0;k<12;k++){

                                     temp[0][k]=rand()%4 + 1;
                                     temp[1][k]=rand()%4 + 1;

                               }

             for(k=12;k<18;k++){
                   temp[0][k]=0;
                  temp[1][k]=0;
             }

       }
```

```
        for (y=0; y<10; y++)
              {
               for(k=0;k<18;k++)
               {
                    ball_type[y][k]=temp[y][k];
               }
              }
        for (y=0; y<10; y++)
        {
          for(k=0;k<18;k++)
           {
             IOWR_VGA_DATA(VGA_MUX_0_BASE,y*18+k+3,ball_type[y][k]);
           }
        }

}
}



void cleanfloat()
{
//printf("clean float ball \n");
  int k,y;
  for (y=0; y<15; y++){
             for(k=0;k<20;k++)
                                    {
                                cleanfloatball[y][k]=0;
                                    }
                           }

  for (y=0; y<12; y++){
   for(k=0;k<18;k++)
                           {
                     cleanfloatball[y+2][k+1]=ball_type[y][k];
                           }
             }

           for (k=0;k<19;k++){
                           inorderfloat (0+2,k+1,1);
           }

           for (y=0; y<12; y++){
            for(k=0;k<18;k++)
                                 {
                     if (cleanfloatball[y+2][k+1]!=10){
                                                ball_type[y][k]=0;
                     }
                                          }
                                 }
```

```
              for (y=0; y<10; y++){
              for(k=0;k<18;k++)
                        {

      IOWR_VGA_DATA(VGA_MUX_0_BASE,y*18+k+3,ball_type[y][k]);
                        }
             }
      }



void inorderfloat (int cleanrow, int cleancolumn, int rowtype){

      //  printf("inorderfloat loop 1\n");
  if (cleanfloatball[cleanrow][cleancolumn]!=0 &&
cleanfloatball[cleanrow][cleancolumn]!=10 && cleanrow<=10 &&
cleancolumn>=0 && cleancolumn<=18){
       //  printf("cleanrow=%d  cleancolumn=%d \n",
cleanrow,cleancolumn);
        cleanfloatball[cleanrow][cleancolumn]=10;
        inorderfloat(cleanrow,cleancolumn+1,1);
        dcount++;
        cleanfloatball[cleanrow][cleancolumn]=10;
        inorderfloat(cleanrow,cleancolumn-1,1);
       cleanfloatball[cleanrow][cleancolumn]=10;
       inorderfloat(cleanrow+1,cleancolumn,1);

       cleanfloatball[cleanrow][cleancolumn]=10;
        if (cleanrow==0 || cleanrow==2 || cleanrow==4 || cleanrow==6 ||
cleanrow==8 || cleanrow==10)
            {
                 rowtype=1;
            }
        else {
                  rowtype=0;
              }
        if (rowtype==1){
        inorderfloat(cleanrow+1,cleancolumn-1,1);
        cleanfloatball[cleanrow][cleancolumn]=10;
        inorderfloat(cleanrow+1,cleancolumn,1);
        cleanfloatball[cleanrow][cleancolumn]=10;
        }
        else{
        inorderfloat(cleanrow+1,cleancolumn+1,0);
        cleanfloatball[cleanrow][cleancolumn]=10;
        inorderfloat(cleanrow+1,cleancolumn,0);
        cleanfloatball[cleanrow][cleancolumn]=10;
        }
  }
```

```
}

void nextball(){

      nextball_type = rand()%4+1;

      IOWR_VGA_DATA(VGA_MUX_0_BASE,0,160);
      IOWR_VGA_DATA(VGA_MUX_0_BASE,1,starty);

}


void shootball(){

if (oneplayergamemode==1)
{

       startx=210;
       starty=380;
       shootballtype=rand()%4+1;
     IOWR_VGA_DATA(VGA_MUX_0_BASE,2,shootballtype);
     IOWR_VGA_DATA(VGA_MUX_0_BASE,0,startx);
     IOWR_VGA_DATA(VGA_MUX_0_BASE,1,starty);
}

else if(twoplayergamemode==1)
{
        if(startx==135){
            startx=520;
                          }

        else if(startx==520){
             startx=135;
                           }

           shootballtype=rand()%4+1;
          IOWR_VGA_DATA(VGA_MUX_0_BASE,2,shootballtype);
          IOWR_VGA_DATA(VGA_MUX_0_BASE,0,startx);
          IOWR_VGA_DATA(VGA_MUX_0_BASE,1,starty);
}
}


void shootball2(){

       shootballtype=rand()%4+1;
     IOWR_VGA_DATA(VGA_MUX_0_BASE,202,shootballtype);
     IOWR_VGA_DATA(VGA_MUX_0_BASE,200,500);
     IOWR_VGA_DATA(VGA_MUX_0_BASE,201,360);
}
```

```
void losegame(){
      gameovermode=1;
      oneplayergamemode=0;
      twoplayergamemode=0;
      startgamemode=0;
      int y,k;

       IOWR_VGA_DATA(VGA_MUX_0_BASE,2,0);


       for (y=0; y<12; y++)
                         {
                          for(k=0;k<18;k++)
                          {
                               ball_type[y][k]=0;}
                         }
            for (y=0; y<12; y++)
                    {
                      for(k=0;k<18;k++)
                       {

IOWR_VGA_DATA(VGA_MUX_0_BASE,y*18+k+3,ball_type[y][k]);
                        }
                    }


              //if(back_type==0)
                                                                  {

for(a=500000;a<509999;a++)

IOWR_16DIRECT(VGA_MUX_0_BASE,a,0);

                                                               // write
background

for(a=0;a<307200;a++)

IOWR_8DIRECT(VGA_MUX_0_BASE,a,mario_game_over[a]);




for(a=510000;a<510003;a++)

IOWR_16DIRECT(VGA_MUX_0_BASE,a,0);
                                                               //  back_type++;
                                                                }
```

```
}
```

```
------------------------------------------------------------------------
---------
--
-- Simple VGA raster display
--
-- Stephen A. Edwards
-- sedwards@cs.columbia.edu
--
------------------------------------------------------------------------
---------
library ieee;
use ieee.std_logic_1164.all;
use ieee.numeric_std.all;

entity de2_vga_raster is

  port (
    clk   : in std_logic;                    -- Should be 25.125 MHz
    reset : in std_logic;

    read       : in  std_logic;
    write      : in  std_logic;
    chipselect : in  std_logic;
    address    : in  std_logic_vector(18 downto 0);
    readdata   : out std_logic_vector(18 downto 0);
    writedata  : in  std_logic_vector(15 downto 0);
      write_inf  : in  std_logic_vector(15 downto 0);
      address_inf: in  std_logic_vector(18 downto 0);

    VGA_CLK,                           -- Clock
    VGA_HS,                            -- H_SYNC
    VGA_VS,                            -- V_SYNC
    VGA_BLANK,                         -- BLANK
    VGA_SYNC : out std_logic;          -- SYNC
    VGA_R,                             -- Red[9:0]
    VGA_G,                             -- Green[9:0]
    VGA_B : out std_logic_vector(9 downto 0) -- Blue[9:0]
    );

end de2_vga_raster;

architecture rtl of de2_vga_raster is

  -- Video parameters
```

```
constant HTOTAL       : integer := 800;
constant HSYNC        : integer := 96;
constant HBACK_PORCH  : integer := 48;
constant HACTIVE      : integer := 640;
constant HFRONT_PORCH : integer := 16;

constant VTOTAL       : integer := 525;
constant VSYNC        : integer := 2;
constant VBACK_PORCH  : integer := 33;
constant VACTIVE      : integer := 480;
constant VFRONT_PORCH : integer := 10;

signal Cirlce_HSTART  : integer := 200;
signal Cirlce_VSTART  : integer := 200;
signal Cirlce_VACTIVE : integer := 24;

constant RECTANGLE_HSTART : integer := 0;
constant RECTANGLE_HEND   : integer := 639;
constant RECTANGLE_VSTART : integer := 0;
constant RECTANGLE_VEND   : integer := 479;

constant tube_HSTART    : integer := 178;
constant tube_HEND      : integer := 242;
constant tube_VSTART    : integer := 384;
constant tube_VEND      : integer := 448;
constant score_VSTART   : integer := 375;
constant score_VEND     : integer := 415;
constant score_H1START  : integer := 522;
constant score_H1END    : integer := 554;
constant score_H2START  : integer := 554;
constant score_H2END    : integer := 585;
constant score_H3START  : integer := 585;
constant score_H3END    : integer := 617;

constant choose_cen_v     : integer := 335;
constant choose_cen_h     : integer := 38 ;

constant tube_first_HSTART    : integer := 103;
constant tube_first_HEND      : integer := 167;
constant tube_first_VSTART    : integer := 384;
constant tube_first_VEND      : integer := 448;

constant tube_second_HSTART    : integer := 488;
constant tube_second_HEND      : integer := 552;
constant tube_second_VSTART    : integer := 384;
constant tube_second_VEND      : integer := 448;


-- Signals for the video controller
type ram_type is array(15 downto 0) of
          std_logic_vector(15 downto 0);
```

```
  signal RAM : ram_type;
  type ram_inf_type is array(256 downto 0) of
            std_logic_vector(15 downto 0);
  signal RAM_inf : ram_inf_type;
  signal ram_address, display_address : unsigned(8 downto 0);
  signal counter : unsigned(20 downto 0);

  signal Hcount : unsigned(9 downto 0);  -- Horizontal position (0-800)
  signal Vcount : unsigned(9 downto 0);  -- Vertical position (0-524)
  signal circle_hs : unsigned(7 downto 0);
  signal circle_vs : unsigned(15 downto 0);
  signal EndOfLine, EndOfField : std_logic;
  signal vga_hblank, vga_hsync,
         vga_vblank, vga_vsync : std_logic;  -- Sync. signals
  signal VGA_R_buffer : std_logic_vector(2 downto 0);
  signal VGA_G_buffer : std_logic_vector(2 downto 0);
  signal VGA_B_buffer : std_logic_vector(1 downto 0);
  signal VGA_R_buffer_next : std_logic_vector(2 downto 0);
  signal VGA_G_buffer_next : std_logic_vector(2 downto 0);
  signal VGA_B_buffer_next : std_logic_vector(1 downto 0);
  signal circle_h, circle_v, circle : std_logic;  -- circle area
  signal VGA_buffer   : unsigned(15 downto 0);
  signal read_address : unsigned(18 downto 0);
  signal rectangle_h, rectangle_v, rectangle : std_logic;  --
rectangle area
  signal clk25 : std_logic := '0';
  signal clk_half: std_logic :='0';
  signal flag : std_logic :='0';
  signal ram_inf_address : unsigned(8 downto 0);
  signal shoot_h, shoot_v,
shoot,arrow,launch,arrow_first,arrow_second : unsigned(15 downto 0);
-- circle area
  signal shoot_h_2, shoot_v_2, shoot_2,arrow_2 : unsigned(15 downto 0);
-- circle area
  signal numberd0, numberd1, numberd2: unsigned(15 downto 0);

  signal shoot_ball_type, shoot_ball_type_2: unsigned(15 downto 0);  -
- circle area
  signal shoot_cen_h , shoot_cen_v,
arrow_n,arrow_n_first,arrow_n_second , launch_n, ball_select_n,
ball_select_a, ball_type_n, ball_select_n_2: integer;
  signal shoot_cen_h_2 , shoot_cen_v_2,
arrow_n_2,number0_type,number1_type,number2_type : integer;
  signal number0_select , number1_select, number2_select : integer;
  signal sprite_shoot_V, sprite_shoot_H, sprite_shoot_HV : std_logic;
  signal sprite_shoot_V_2, sprite_shoot_H_2, sprite_shoot_HV_2 :
std_logic;
  signal sprite_E_V, sprite_E_H, sprite_E_HV : std_logic;
  signal tube_V, tube_H,
tube_HV,score_sprite1_HV,score_sprite2_HV,score_sprite3_HV :  std_logic;
  signal tube_first_V, tube_first_H, tube_first_HV: std_logic;
  signal tube_second_V, tube_second_H, tube_second_HV: std_logic;
```

```
  signal score_H1,score_H2,score_H3,score_V : std_logic;
  signal ball_select  : integer :=0;
   type ball is array(0 to 1023) of std_logic_vector(2 downto 0);
      type number is array(0 to 1279) of std_logic_vector(2 downto 0);
      type shoot_type is array(180 downto 0) of unsigned(7 downto 0);
  signal ball_type : shoot_type;
  signal tube_sprite_control : std_logic;
   type tube_type is array(0 to 4095) of std_logic_vector(0 downto 0);
  signal tube_flag : std_logic_vector(0 downto 0);
  signal sprite_choose_HV : std_logic;
  signal option : unsigned(15 downto 0);

--  Vstart 365+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constant bang_R : ball :=("110", "110", "110", "110", "110", "110",
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--------------------------------------------------------------------
--------------------------------------------------------------------
-------------------------------------


type address_type_x is array (0 to 179) of unsigned(9 downto 0);
type address_type_y is array (0 to 11) of unsigned(9 downto 0);
                 constant address_x :
address_type_x :=("0000101110","0001001110","0001101110","0010001110",
"0010101110","0011001110","0011101110","0100001110","0100101110","0101
001110","0101101110","0110001110","0110101110","0111001110","011110111
0","1000001110","1000101110","1001001110","0000111110","0001011110","0
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10","0011101110","0100001110","0100101110","0101001110","0101101110","
```

```
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","0010111110","0011011110","0011111110","0100011110","0100111110","01
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01110","1000001110","1000101110","1001001110","0000111110","0001011110
","0001111110","0010011110","0010111110","0011011110","0011111110","01
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110","0111011110","0111111110","1000011110","1000111110","1001011110",
"0000101110","0001001110","0001101110","0010001110","0010101110","0011
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1110","0010111110","0011011110","0011111110","0100011110","0100111110"
,"0101011110","0101111110","0110011110","0110111110","0111011110","011
1111110","1000011110","1000111110","1001011110");
                  constant address_y :
address_type_y :=("0000101110","0001001011","0001101000","0010000101",
"0010100010","0010111111","0011011100","0011111001","0100010110","0100
110011","0101010000","0101101101");
--

begin

  ram_address     <= unsigned(address(8 downto 0));
  ram_inf_address <= unsigned(address_inf(8 downto 0));
--  buffer_higher <= unsigned(RAM(to_integer(display_address+1))(8
downto 6));
--  buffer_mid    <= unsigned(RAM(to_integer(display_address+1))(5
downto 3));
--  buffer_lower  <= unsigned(RAM(to_integer(display_address+1))(2
downto 0));

  process (clk)
  begin
   if rising_edge(clk) then
          clk25 <= not clk25;
     end if;
  end process;


  position : process (clk)
  begin
```

```
    if rising_edge(clk) then
      if reset = '1' then
                --readdata <= (others => read_address'0');
                display_address <= (others => '0');
                counter <= (others => '1');
      else
        if chipselect = '1' then
         if address(18) = '0' then
            if read = '1' then
                          --readdata <= RAM(to_integer(ram_address));
            elsif write = '1' then
                          RAM(to_integer(ram_address)) <= writedata;

      RAM_inf(to_integer(ram_inf_address))<=write_inf;
            end if;
                end if;
        end if;
              shoot_h <=
unsigned(RAM_inf(to_integer(display_address)));
         shoot_v <= unsigned(RAM_inf(to_integer(display_address+1)));
                shoot_ball_type <=
unsigned(RAM_inf(to_integer(display_address+2)));
                arrow <=
unsigned(RAM_inf(to_integer(display_address+190)));
                arrow_first <=
unsigned(RAM_inf(to_integer(display_address+193)));
                arrow_second <=
unsigned(RAM_inf(to_integer(display_address+194)));
                shoot_h_2 <=
unsigned(RAM_inf(to_integer(display_address+200)));
         shoot_v_2 <=
unsigned(RAM_inf(to_integer(display_address+201)));
                shoot_ball_type_2 <=
unsigned(RAM_inf(to_integer(display_address+202)));
                numberd0 <=
unsigned(RAM_inf(to_integer(display_address+203)));
                numberd1 <=
unsigned(RAM_inf(to_integer(display_address+204)));
                numberd2 <=
unsigned(RAM_inf(to_integer(display_address+205)));
                launch <=
unsigned(RAM_inf(to_integer(display_address+191)));
                option <=
unsigned(RAM_inf(to_integer(display_address+192)));
           --    if flag = '1' then
              for k in 0 to 180 loop
              ball_type(k) <=
unsigned(RAM_inf(to_integer(display_address+k+3))(7 downto 0));
                end loop;
           --    else
           --    for k in 91 to 180 loop
```

```
          --   ball_type(k) <=
unsigned(RAM_inf(to_integer(display_address+k+3))(7 downto 0));
          --    end loop;
       --    end if;

     end if;
   end if;
 end process position;


   shoot_cen_h <= to_integer(shoot_h);
   shoot_cen_v <= to_integer(shoot_v);
     arrow_n <= to_integer(arrow);
     arrow_n_first <= to_integer(arrow_first);
     arrow_n_second <= to_integer(arrow_second);

     shoot_cen_h_2 <= to_integer(shoot_h_2);
   shoot_cen_v_2 <= to_integer(shoot_v_2);
     arrow_n_2 <= to_integer(arrow);

     number0_type <= to_integer(numberd0);
   number1_type <= to_integer(numberd1);
     number2_type <= to_integer(numberd2);

   launch_n<= to_integer(launch);

 process(clk25)
 begin
     if rising_edge(clk25) then
                flag <= not flag;
          end if;
 end process;


  vga_split : process (clk25)
  begin
   if rising_edge(clk25) then
        VGA_buffer <=unsigned(RAM(to_integer(display_address)));

   end if;
  end process vga_split;


 process(clk)
 begin
     if rising_edge(clk) then
       VGA_B_buffer <= std_logic_vector(VGA_buffer(15 downto 14));
       VGA_R_buffer <= std_logic_vector(VGA_buffer(13 downto 11));
       VGA_G_buffer <= std_logic_vector(VGA_buffer(10 downto 8));
       VGA_B_buffer_next <= std_logic_vector(VGA_buffer(7 downto 6));
       VGA_R_buffer_next <= std_logic_vector(VGA_buffer(5 downto 3));
       VGA_G_buffer_next <= std_logic_vector(VGA_buffer(2 downto 0));
```

```
          end if;
  end process;
  -- Horizontal and vertical counters

  address_count: process(clk25)
  begin
      if rising_edge(clk25) then
                if flag ='0' then
                    if tube_HV = '1' then
                        read_address <=
to_unsigned(((to_integer(Hcount) - HSYNC - HBACK_PORCH - tube_HSTART)
+ (to_integer(Vcount) - VSYNC - VBACK_PORCH - tube_VSTART)*64 +
64*64*arrow_n+320000)/2,19);
                    elsif tube_first_HV = '1' then
                        read_address <=
to_unsigned(((to_integer(Hcount) - HSYNC - HBACK_PORCH -
tube_first_HSTART) + (to_integer(Vcount) - VSYNC - VBACK_PORCH -
tube_first_VSTART)*64 + 64*64*arrow_n_first+320000)/2,19);
                     elsif tube_second_HV = '1' then
                        read_address <=
to_unsigned(((to_integer(Hcount) - HSYNC - HBACK_PORCH -
tube_second_HSTART) + (to_integer(Vcount) - VSYNC - VBACK_PORCH -
tube_second_VSTART)*64 + 64*64*arrow_n_second+320000)/2,19);
                     elsif score_sprite1_HV = '1' then
                        read_address <=
to_unsigned(((to_integer(Hcount) - HSYNC - HBACK_PORCH - score_H1START)
+ (to_integer(Vcount) - VSYNC - VBACK_PORCH - score_VSTART)*32 +
32*40*number0_type+450000)/2,19);
             elsif score_sprite2_HV = '1' then
                        read_address <=
to_unsigned(((to_integer(Hcount) - HSYNC - HBACK_PORCH - score_H2START)
+ (to_integer(Vcount) - VSYNC - VBACK_PORCH - score_VSTART)*32 +
32*40*number1_type+450000)/2,19);
                     elsif score_sprite3_HV = '1' then
                        read_address <=
to_unsigned(((to_integer(Hcount) - HSYNC - HBACK_PORCH - score_H3START)
+ (to_integer(Vcount) - VSYNC - VBACK_PORCH - score_VSTART)*32 +
32*40*number2_type+450000)/2,19);

                     else
                    read_address <= to_unsigned((to_integer(Hcount)
- HSYNC - HBACK_PORCH - RECTANGLE_HSTART)/2 + (to_integer(Vcount) -
VSYNC - VBACK_PORCH - RECTANGLE_VSTART)*320,19);
                end if;
                 end if;
          end if;
  end process;

  readdata<=std_logic_vector(read_address);
```

```
 RectangleHGen : process (clk25)
  begin
    if rising_edge(clk25) then
      if reset = '1' or Hcount = HSYNC + HBACK_PORCH +
RECTANGLE_HSTART then
        rectangle_h <= '1';
      elsif Hcount = HSYNC + HBACK_PORCH + RECTANGLE_HEND then
        rectangle_h <= '0';
      end if;
    end if;
  end process RectangleHGen;

    RectangleVGen : process (clk25)
  begin
    if rising_edge(clk25) then
      if reset = '1' then
        rectangle_v <= '0';
      elsif EndOfLine = '1' then
        if Vcount = VSYNC + VBACK_PORCH - 1 + RECTANGLE_VSTART then
          rectangle_v <= '1';
        elsif Vcount = VSYNC + VBACK_PORCH - 1 + RECTANGLE_VEND then
          rectangle_v <= '0';
        end if;
      end if;
    end if;
  end process RectangleVGen;
  ------------------------------------------------------------------------
---------------------
  score_spriteV: process (clk25)

   begin
        if rising_edge(clk25) then
          if launch = "0000000000000001" then
           if Vcount = VSYNC + VBACK_PORCH + score_VSTART then
                 score_V <= '1';
           elsif Vcount = VSYNC + VBACK_PORCH + score_VEND or reset =
'1' then
                 score_V <= '0';
           end if;
            end if;
        end if;
  end process score_spriteV;

  score_spriteH1: process (clk25)

   begin
        if rising_edge(clk25) then
          if launch = "0000000000000001" then
          if Hcount = HSYNC + HBACK_PORCH + score_H1START then
                 score_H1 <= '1';
           elsif Hcount = HSYNC + HBACK_PORCH + score_H1END or reset =
'1' then
```

```
                score_H1 <= '0';
            end if;
           end if;
       end if;
  end process score_spriteH1;

  score_spriteH2: process (clk25)

   begin
       if rising_edge(clk25) then
         if launch = "0000000000000001" then
        if Hcount = HSYNC + HBACK_PORCH + score_H2START then
                score_H2 <= '1';
          elsif Hcount = HSYNC + HBACK_PORCH + score_H2END or reset =
'1' then
                score_H2 <= '0';
          end if;
           end if;
       end if;
  end process score_spriteH2;

  score_spriteH3: process (clk25)

   begin
       if rising_edge(clk25) then
         if launch = "0000000000000001" then
         if Hcount = HSYNC + HBACK_PORCH + score_H3START then
                score_H3 <= '1';
          elsif Hcount = HSYNC + HBACK_PORCH + score_H3END or reset =
'1' then
                score_H3 <= '0';
          end if;
           end if;
       end if;
  end process score_spriteH3;


  score_sprite1_HV <= score_H1 and score_V;
  score_sprite2_HV <= score_H2 and score_V;
  score_sprite3_HV <= score_H3 and score_V;


  tube_spriteV: process (clk25)
  begin
       if rising_edge(clk25) then
         if launch = "0000000000000001" then
          if Vcount = VSYNC + VBACK_PORCH + tube_VSTART then
                tube_V <= '1';
          elsif Vcount = VSYNC + VBACK_PORCH + tube_VEND or reset =
'1' then
                tube_V <= '0';
          end if;
```

```
            end if;
        end if;
  end process tube_spriteV;

  tube_spriteH: process (clk25)
  begin
        if rising_edge(clk25) then
         if launch = "0000000000000001" then
           if Hcount = HSYNC + HBACK_PORCH + tube_HSTART then
                 tube_H <= '1';
           elsif Hcount = HSYNC + HBACK_PORCH + tube_HEND or reset =
'1' then
                 tube_H <= '0';
           end if;
            end if;
        end if;
  end process tube_spriteH;


     ---------------------------------two player-----------------------
-------------------------------------------
        tube_first_spriteV: process (clk25)
  begin
        if rising_edge(clk25) then
          if launch = "0000000000000011" then
           if Vcount = VSYNC + VBACK_PORCH + tube_first_VSTART then
                 tube_first_V <= '1';
           elsif Vcount = VSYNC + VBACK_PORCH + tube_first_VEND or
reset = '1' then
                 tube_first_V <= '0';
           end if;
            end if;
        end if;
  end process tube_first_spriteV;

  tube_first_spriteH: process (clk25)
  begin
        if rising_edge(clk25) then
         if launch = "0000000000000011" then
           if Hcount = HSYNC + HBACK_PORCH + tube_first_HSTART then
                 tube_first_H <= '1';
           elsif Hcount = HSYNC + HBACK_PORCH + tube_first_HEND or
reset = '1' then
                 tube_first_H <= '0';
           end if;
            end if;
        end if;
  end process tube_first_spriteH;

        tube_second_spriteV: process (clk25)
  begin
        if rising_edge(clk25) then
```

```
          if launch = "0000000000000011" then
           if Vcount = VSYNC + VBACK_PORCH + tube_second_VSTART then
                 tube_second_V <= '1';
           elsif Vcount = VSYNC + VBACK_PORCH + tube_second_VEND or
reset = '1' then
                 tube_second_V <= '0';
           end if;
            end if;
        end if;
  end process tube_second_spriteV;

  tube_second_spriteH: process (clk25)
  begin
       if rising_edge(clk25) then
        if launch = "0000000000000011" then
          if Hcount = HSYNC + HBACK_PORCH + tube_second_HSTART then
                 tube_second_H <= '1';
           elsif Hcount = HSYNC + HBACK_PORCH + tube_second_HEND or
reset = '1' then
                 tube_second_H <= '0';
           end if;
            end if;
       end if;
  end process tube_second_spriteH;
     ------------------------------------------------------------------
----------------------------------




     tube_HV <= tube_H and tube_V;
     tube_first_HV <= tube_first_V and tube_first_H;
     tube_second_HV <= tube_second_V and tube_second_H;
   rectangle <= rectangle_h and rectangle_v;
  ------------------------------------------------------------------
----------------------

--  tube_sprite_detect: process(clk25)
--  begin
--      if rising_edge(clk25) then
--            if tube_HV = '1' then
--                 if tube_sprite(to_integer(Hcount) - HSYNC -
HBACK_PORCH - tube_HSTART + (to_integer(Vcount) - VSYNC - VBACK_PORCH
- tube_VSTART)*64) = "1" then
--                tube_sprite_control <= '1';
--                   else
--                    tube_sprite_control <= '0';
--                   end if;
--              end if;
--         end if;
--  end process tube_sprite_detect;
```

```
  ------------------------------------------------------------------------
----------------------



  HCounter : process (clk25)
  begin
    if rising_edge(clk25) then
      if reset = '1' then
        Hcount <= (others => '0');
      elsif EndOfLine = '1' then
        Hcount <= (others => '0');
      else
        Hcount <= Hcount + 1;
      end if;
    end if;
  end process HCounter;

  EndOfLine <= '1' when Hcount = HTOTAL - 1 else '0';

  VCounter: process (clk25)
  begin
    if rising_edge(clk25) then
      if reset = '1' then
        Vcount <= (others => '0');
      elsif EndOfLine = '1' then
        if EndOfField = '1' then
          Vcount <= (others => '0');
        else
          Vcount <= Vcount + 1;
        end if;
      end if;
    end if;
  end process VCounter;

  EndOfField <= '1' when Vcount = VTOTAL - 1 else '0';

  -- State machines to generate HSYNC, VSYNC, HBLANK, and VBLANK

  HSyncGen : process (clk25)
  begin
    if rising_edge(clk25) then
      if reset = '1' or EndOfLine = '1' then
        vga_hsync <= '1';
      elsif Hcount = HSYNC - 1 then
        vga_hsync <= '0';
      end if;
    end if;
  end process HSyncGen;

  HBlankGen : process (clk25)
```

```
  begin
    if rising_edge(clk25) then
      if reset = '1' then
        vga_hblank <= '1';
      elsif Hcount = HSYNC + HBACK_PORCH then
        vga_hblank <= '0';
      elsif Hcount = HSYNC + HBACK_PORCH + HACTIVE then
        vga_hblank <= '1';
      end if;
    end if;
  end process HBlankGen;

  VSyncGen : process (clk25)
  begin
    if rising_edge(clk25) then
      if reset = '1' then
        vga_vsync <= '1';
      elsif EndOfLine ='1' then
        if EndOfField = '1' then
          vga_vsync <= '1';
        elsif Vcount = VSYNC - 1 then
          vga_vsync <= '0';
        end if;
      end if;
    end if;
  end process VSyncGen;

  VBlankGen : process (clk25)
  begin
    if rising_edge(clk25) then
      if reset = '1' then
        vga_vblank <= '1';
      elsif EndOfLine = '1' then
        if Vcount = VSYNC + VBACK_PORCH - 1 then
          vga_vblank <= '0';
        elsif Vcount = VSYNC + VBACK_PORCH + VACTIVE - 1 then
          vga_vblank <= '1';
        end if;
      end if;
    end if;
  end process VBlankGen;

  -- Circle generator

    shoot_ball: process(clk25)
   begin
        if rising_edge(clk25) then
           if (((to_integer(Vcount)-VSYNC-VBACK_PORCH-
shoot_cen_v)*(to_integer(Vcount)-VSYNC-VBACK_PORCH-
shoot_cen_v)+(to_integer(Hcount)-HSYNC-HBACK_PORCH-
shoot_cen_h)*(to_integer(Hcount)-HSYNC-HBACK_PORCH-shoot_cen_h))<16*15)
then
```

```
                sprite_shoot_HV <= '1';
            elsif(((to_integer(Vcount)-VSYNC-VBACK_PORCH-
shoot_cen_v)*(to_integer(Vcount)-VSYNC-VBACK_PORCH-
shoot_cen_v)+(to_integer(Hcount)-HSYNC-HBACK_PORCH-
shoot_cen_h)*(to_integer(Hcount)-HSYNC-HBACK_PORCH-
shoot_cen_h))>=16*15) then
                sprite_shoot_HV <= '0';
            end if;
       end if;
  end process shoot_ball;
  ------------------------------------------------------------------------
----------------------------------------
  choose: process(clk25)
   begin
        if rising_edge(clk25) then
           if (((to_integer(Vcount)-VSYNC-VBACK_PORCH-
choose_cen_v)*(to_integer(Vcount)-VSYNC-VBACK_PORCH-
choose_cen_v)+(to_integer(Hcount)-HSYNC-HBACK_PORCH-
choose_cen_h)*(to_integer(Hcount)-HSYNC-HBACK_PORCH-choose_cen_h-
option*47))<8*8) then
                sprite_choose_HV <= '1';
            elsif(((to_integer(Vcount)-VSYNC-VBACK_PORCH-
choose_cen_v)*(to_integer(Vcount)-VSYNC-VBACK_PORCH-
choose_cen_v)+(to_integer(Hcount)-HSYNC-HBACK_PORCH-
choose_cen_h)*(to_integer(Hcount)-HSYNC-HBACK_PORCH-
choose_cen_h))>=8*8) then
                sprite_choose_HV <= '0';
            end if;
       end if;
  end process choose;
 ------------------------------------------------------------------------
----------------------------------------

    shoot_ball_2: process(clk25)
   begin
        if rising_edge(clk25) then
           if (((to_integer(Vcount)-VSYNC-VBACK_PORCH-
shoot_cen_v_2)*(to_integer(Vcount)-VSYNC-VBACK_PORCH-
shoot_cen_v_2)+(to_integer(Hcount)-HSYNC-HBACK_PORCH-
shoot_cen_h_2)*(to_integer(Hcount)-HSYNC-HBACK_PORCH-
shoot_cen_h_2))<16*15) then
                sprite_shoot_HV_2 <= '1';
            elsif(((to_integer(Vcount)-VSYNC-VBACK_PORCH-
shoot_cen_v_2)*(to_integer(Vcount)-VSYNC-VBACK_PORCH-
shoot_cen_v_2)+(to_integer(Hcount)-HSYNC-HBACK_PORCH-
shoot_cen_h_2)*(to_integer(Hcount)-HSYNC-HBACK_PORCH-
shoot_cen_h_2))>=16*15) then
                sprite_shoot_HV_2 <= '0';
            end if;
       end if;
  end process shoot_ball_2;
```

```
 ---------------------------------------------------------------------
---------------------------------

---------------------------------------------------------------------
---------------------------------
  ball_V: process (clk25)
  variable yy           : integer :=0;
  begin
       if rising_edge(clk25) then
-----------------------------------------ball 1
yy :=0;
L1: for y in 0 to 9 loop
     L2: for x in 0 to 17 loop
           if ((to_integer(Vcount)-VSYNC-VBACK_PORCH-
to_integer(address_y(y)))*(to_integer(Vcount)-VSYNC-VBACK_PORCH-
to_integer(address_y(y)))+(to_integer(Hcount)-HSYNC-HBACK_PORCH-
to_integer(address_x(x+18*y)))*(to_integer(Hcount)-HSYNC-HBACK_PORCH-
to_integer(address_x(x+18*y)))<16*15) then
                  sprite_E_HV <= '1';
                       ball_select <= (x+18*y);
                       yy := 1;

        else
                  sprite_E_HV <= '0';
                  ball_select <= 0;
             end if;
             exit L1 when yy = 1;
             end loop;
            end loop;
       end if;
  end process ball_V;




  VideoOut: process (clk25, reset)
  begin
    if reset = '1' then
      VGA_R <= "0000000000";
      VGA_G <= "0000000000";
      VGA_B <= "0000000000";
    elsif clk25'event and clk25 = '1' then
        if sprite_shoot_HV = '1' then
           ball_select_n <= to_integer(unsigned((Hcount-HSYNC-
HBACK_PORCH-shoot_cen_h-16)*32+(Vcount-VSYNC-VBACK_PORCH-shoot_cen_v-
16)));

         if shoot_ball_type = "00000001" then
                      VGA_R <= ball_R(ball_select_n)& "0000000";
               VGA_G <= ball_G(ball_select_n)& "0000000";
                           VGA_B <= ball_B(ball_select_n)& "0000000";
```

```
                elsif  shoot_ball_type= "00000010" then
                      VGA_R <= turtle_R(ball_select_n)& "0000000";
                          VGA_G <= turtle_G(ball_select_n)& "0000000";
                          VGA_B <= turtle_B(ball_select_n)& "0000000";
                elsif  shoot_ball_type= "00000011" then
                      VGA_R <= goomba_R(ball_select_n)& "0000000";
                          VGA_G <= goomba_G(ball_select_n)& "0000000";
                          VGA_B <= goomba_B(ball_select_n)& "0000000";
                elsif  shoot_ball_type= "00000100" then
                      VGA_R <= star_R(ball_select_n)& "0000000";
                           VGA_G <= star_G(ball_select_n)& "0000000";
                           VGA_B <= star_B(ball_select_n)& "0000000";
                elsif  shoot_ball_type= "00000101" then
                      VGA_R <= special_ball_R(ball_select_n)&
"0000000";
                           VGA_G <= special_ball_G(ball_select_n)&
"0000000";
                           VGA_B <= special_ball_B(ball_select_n)&
"0000000";

                elsif  shoot_ball_type= "00000110" then
                      VGA_R <= bang_R(ball_select_n)& "0000000";
                           VGA_G <= bang_G(ball_select_n)& "0000000";
                           VGA_B <= bang_B(ball_select_n)& "0000000";

                else
                if flag = '1' then
                VGA_R <= VGA_R_buffer&"0000000";
            VGA_G <= VGA_G_buffer&"0000000";
            VGA_B <= VGA_B_buffer&"00000000";
                elsif flag = '0' then
                VGA_R <= VGA_R_buffer_next&"0000000";
            VGA_G <= VGA_G_buffer_next&"0000000";
            VGA_B <= VGA_B_buffer_next&"00000000";
                   end if;
               end if;
   ------------------------------------------------------------------------
----------------------------------------
       elsif sprite_shoot_HV_2 = '1' then
          ball_select_n_2 <= to_integer(unsigned((Hcount-HSYNC-
HBACK_PORCH-shoot_cen_h_2-16)*32+(Vcount-VSYNC-VBACK_PORCH-
shoot_cen_v_2-16)));

         if shoot_ball_type_2 = "00000001" then
                      VGA_R <= ball_R(ball_select_n_2)& "0000000";
              VGA_G <= ball_G(ball_select_n_2)& "0000000";
                        VGA_B <= ball_B(ball_select_n_2)& "0000000";

                elsif  shoot_ball_type_2= "00000010" then
                      VGA_R <= turtle_R(ball_select_n_2)& "0000000";
                           VGA_G <= turtle_G(ball_select_n_2)&
"0000000";
```

```
                          VGA_B <= turtle_B(ball_select_n_2)&
"0000000";
                elsif  shoot_ball_type_2= "00000011" then
                      VGA_R <= goomba_R(ball_select_n_2)& "0000000";
                           VGA_G <= goomba_G(ball_select_n_2)&
"0000000";
                           VGA_B <= goomba_B(ball_select_n_2)&
"0000000";
                elsif  shoot_ball_type_2= "00000100" then
                      VGA_R <= star_R(ball_select_n_2)& "0000000";
                          VGA_G <= star_G(ball_select_n_2)& "0000000";
                          VGA_B <= star_B(ball_select_n_2)& "0000000";
                elsif ball_type(ball_select) = "00000101" then
                 VGA_R <= special_ball_R(ball_select_n_2)& "0000000";
                           VGA_G <= special_ball_G(ball_select_n_2)&
"0000000";
               VGA_B <= special_ball_B(ball_select_n_2)& "0000000";
                elsif ball_type(ball_select)= "00000110" then
                      VGA_R <= bang_R(ball_select_n_2)& "0000000";
                          VGA_G <= bang_G(ball_select_n_2)& "0000000";
                          VGA_B <= bang_B(ball_select_n_2)& "0000000";


                else
               if flag = '1' then
               VGA_R <= VGA_R_buffer&"0000000";
           VGA_G <= VGA_G_buffer&"0000000";
           VGA_B <= VGA_B_buffer&"00000000";
                elsif flag = '0' then
                VGA_R <= VGA_R_buffer_next&"0000000";
           VGA_G <= VGA_G_buffer_next&"0000000";
           VGA_B <= VGA_B_buffer_next&"00000000";
                  end if;
              end if;

     ------------------------------------------------------------------
-----------------------------------------
           elsif sprite_choose_HV = '1' and launch =
"0000000000000010" then
                VGA_R <= "1111111111";
           VGA_G <= "1111111111";
           VGA_B <= "1111111111";
       elsif tube_HV = '1'  then
        if flag = '1' then
                VGA_R <= VGA_R_buffer&"0000000";
           VGA_G <= VGA_G_buffer&"0000000";
           VGA_B <= VGA_B_buffer&"00000000";
             elsif flag = '0' then
                VGA_R <= VGA_R_buffer_next&"0000000";
           VGA_G <= VGA_G_buffer_next&"0000000";
           VGA_B <= VGA_B_buffer_next&"00000000";
             end if;
```

```
            elsif tube_first_HV = '1'  then
        if flag = '1' then
                VGA_R <= VGA_R_buffer&"0000000";
           VGA_G <= VGA_G_buffer&"0000000";
           VGA_B <= VGA_B_buffer&"00000000";
             elsif flag = '0' then
                VGA_R <= VGA_R_buffer_next&"0000000";
           VGA_G <= VGA_G_buffer_next&"0000000";
           VGA_B <= VGA_B_buffer_next&"00000000";
             end if;
            elsif tube_second_HV = '1'  then
        if flag = '1' then
                VGA_R <= VGA_R_buffer&"0000000";
           VGA_G <= VGA_G_buffer&"0000000";
           VGA_B <= VGA_B_buffer&"00000000";
             elsif flag = '0' then
                VGA_R <= VGA_R_buffer_next&"0000000";
           VGA_G <= VGA_G_buffer_next&"0000000";
           VGA_B <= VGA_B_buffer_next&"00000000";
             end if;
-------------------------------------------------------------------------
-----------------------------------
     elsif sprite_E_HV = '1' then
   for y in 0 to 9 loop
     for x in 0 to 17 loop
     -- ball_type_n <= (x+12*y);

     if ball_select = (x+18*y) then
        ball_select_a <= to_integer(unsigned((Hcount-HSYNC-
HBACK_PORCH-address_x(ball_select)-16)*32+(Vcount-VSYNC-VBACK_PORCH-
address_y(y)-16)));

              if ball_type(ball_select) = "00000001" then
                     VGA_R <= ball_R(ball_select_a)& "0000000";
                          VGA_G <= ball_G(ball_select_a)& "0000000";
                          VGA_B <= ball_B(ball_select_a)& "0000000";
                elsif ball_type(ball_select) = "00000010" then
                     VGA_R <= turtle_R(ball_select_a)& "0000000";
                         VGA_G <= turtle_G(ball_select_a)& "0000000";
                         VGA_B <= turtle_B(ball_select_a)& "0000000";

                elsif ball_type(ball_select) = "00000011" then
                     VGA_R <= goomba_R(ball_select_a)& "0000000";
                         VGA_G <= goomba_G(ball_select_a)& "0000000";
                         VGA_B <= goomba_B(ball_select_a)& "0000000";
                elsif ball_type(ball_select) = "00000100" then
                     VGA_R <= star_R(ball_select_a)& "0000000";
                          VGA_G <= star_G(ball_select_a)& "0000000";
               VGA_B <= star_B(ball_select_a)& "0000000";
              elsif ball_type(ball_select) = "00000101" then
                 VGA_R <= special_ball_R(ball_select_a)& "0000000";
```

```
                            VGA_G <= special_ball_G(ball_select_a)&
"0000000";
               VGA_B <= special_ball_B(ball_select_a)& "0000000";
                elsif ball_type(ball_select)= "00000110" then
                      VGA_R <= bang_R(ball_select_a)& "0000000";
                           VGA_G <= bang_G(ball_select_a)& "0000000";
                           VGA_B <= bang_B(ball_select_a)& "0000000";
                else
                if flag = '1' then
                VGA_R <= VGA_R_buffer&"0000000";
           VGA_G <= VGA_G_buffer&"0000000";
           VGA_B <= VGA_B_buffer&"00000000";
                elsif flag = '0' then
                VGA_R <= VGA_R_buffer_next&"0000000";
           VGA_G <= VGA_G_buffer_next&"0000000";
           VGA_B <= VGA_B_buffer_next&"00000000";

                 end if;
                end if;
           end if;
     end loop;
end loop;

              elsif score_sprite1_HV ='1' and launch =
"0000000000000001" then
                        if flag = '1' then
                         VGA_R <= VGA_R_buffer&"0000000";
                    VGA_G <= VGA_G_buffer&"0000000";
                    VGA_B <= VGA_B_buffer&"00000000";
                      elsif flag = '0' then
                         VGA_R <= VGA_R_buffer_next&"0000000";
                    VGA_G <= VGA_G_buffer_next&"0000000";
                    VGA_B <= VGA_B_buffer_next&"00000000";
                             end if;
                elsif score_sprite2_HV ='1' and launch =
"0000000000000001" then
                        if flag = '1' then
                         VGA_R <= VGA_R_buffer&"0000000";
                    VGA_G <= VGA_G_buffer&"0000000";
                    VGA_B <= VGA_B_buffer&"00000000";
                      elsif flag = '0' then
                         VGA_R <= VGA_R_buffer_next&"0000000";
                    VGA_G <= VGA_G_buffer_next&"0000000";
                    VGA_B <= VGA_B_buffer_next&"00000000";
                             end if;
                elsif score_sprite3_HV ='1' and launch =
"0000000000000001" then
                        if flag = '1' then
                         VGA_R <= VGA_R_buffer&"0000000";
                    VGA_G <= VGA_G_buffer&"0000000";
                    VGA_B <= VGA_B_buffer&"00000000";
                      elsif flag = '0' then
```

```
                        VGA_R <= VGA_R_buffer_next&"0000000";
                    VGA_G <= VGA_G_buffer_next&"0000000";
                    VGA_B <= VGA_B_buffer_next&"00000000";
                        end if;
--    constant score_VSTART   : integer := 387;elsif  shoot_ball_type=
"00000101" then

--  constant score_VEND     : integer := 427;
--  constant score_H1START  : integer := 526;
--  constant score_H1END    : integer := 558;
--  constant score_H2START  : integer := 558;
--  constant score_H2END    : integer := 590;
--  constant score_H3START  : integer := 590;
--  constant score_H3START  : integer := 622;

--               number0_select<=(to_integer((unsigned((Hcount))-HSYNC-
HBACK_PORCH-score_H1START)*40 +(Vcount-VSYNC-VBACK_PORCH-
score_VSTART)));
--             C1:case numberd0 is
--                         when "0000000000000000" =>
--                            VGA_R <= n0_R(number0_select)& "0000000";
--                    VGA_G <= n0_G(number0_select)& "0000000";
--                    VGA_B <= n0_B(number0_select)& "0000000";
--                           when "0000000000000001" =>
--                            VGA_R <= n1_R(number0_select)& "0000000";
--                    VGA_G <= n1_G(number0_select)& "0000000";
--                    VGA_B <= n1_B(number0_select)& "0000000";
--                           when "0000000000000010" =>
--                            VGA_R <= n2_R(number0_select)& "0000000";
--                    VGA_G <= n2_G(number0_select)& "0000000";
--                    VGA_B <= n2_B(number0_select)& "0000000"0;
--                           when "0000000000000011" =>
--                            VGA_R <= n3_R(number0_select)& "0000000";
--                    VGA_G <= n3_G(number0_select)& "0000000";
--                    VGA_B <= n3_B(number0_select)& "0000000";
--                           when "0000000000000100" =>
--                            VGA_R <= n4_R(number0_select)& "0000000";
--                    VGA_G <= n4_G(number0_select)& "0000000";
--                    VGA_B <= n4_B(number0_select)& "0000000";
--                           when "0000000000000101" =>
--                            VGA_R <= n5_R(number0_select)& "0000000";
--                    VGA_G <= n5_G(number0_select)& "0000000";
--                    VGA_B <= n5_B(number0_select)& "0000000";
--                           when "0000000000000110" =>
--                               VGA_R <= n6_R(number0_select)&
"0000000";
--                    VGA_G <= n6_G(number0_select)& "0000000";
--                    VGA_B <= n6_B(number0_select)& "0000000";
--                           when "0000000000000111" =>
--                    VGA_R <= n7_R(number0_select)& "0000000";
--                    VGA_G <= n7_G(number0_select)& "0000000";
--                    VGA_B <= n7_B(number0_select)& "0000000";
```

```
--                    when "0000000000001000" =>
--                      VGA_R <= n8_R(number0_select)& "0000000";
--                VGA_G <= n8_G(number0_select)& "0000000";
--                VGA_B <= n8_B(number0_select)& "0000000";
--                       when "0000000000001001" =>
--                         VGA_R <= n9_R(number0_select)& "0000000";
--                VGA_G <= n9_G(number0_select)& "0000000";
--                VGA_B <= n9_B(number0_select)& "0000000";
--                       when others =>
--                          VGA_R <= "0000000000";
--                VGA_G <= "0000000000";
--                VGA_B <= "0000000000";
--                       end case C1;
--                  if numberd0= "0000000000000000" then
--             VGA_R <= n0_R(number0_select)& "0000000";
--            VGA_G <= n0_G(number0_select)& "0000000";
--            VGA_B <= n0_B(number0_select)& "0000000";
--
--
--                elsif numberd0= "0000000000000001" then
--
--                       VGA_R <= n1_R(number0_select)& "0000000";
--            VGA_G <= n1_G(number0_select)& "0000000";
--            VGA_B <= n1_B(number0_select)& "0000000";
--
--                elsif numberd0= "0000000000000010" then
--
--                       VGA_R <= n2_R(number0_select)& "0000000";
--            VGA_G <= n2_G(number0_select)& "0000000";
--            VGA_B <= n2_B(number0_select)& "0000000";
--
--                elsif numberd0= "0000000000000011" then
--
--                       VGA_R <= n3_R(number0_select)& "0000000";
--            VGA_G <= n3_G(number0_select)& "0000000";
--            VGA_B <= n3_B(number0_select)& "0000000";
--
--                elsif numberd0= "0000000000000100" thenelsif
shoot_ball_type= "00000101" then

--                       VGA_R <= n4_R(number0_select)& "0000000";
--            VGA_G <= n4_G(number0_select)& "0000000";
--            VGA_B <= n4_B(number0_select)& "0000000";
--
--                elsif numberd0= "0000000000000101" then
--
--                       VGA_R <= n5_R(number0_select)& "0000000";
--            VGA_G <= n5_G(number0_select)& "0000000";
--            VGA_B <= n5_B(number0_select)& "0000000";
--
--                elsif numberd0= "0000000000000110" then
--
```

```
--                      VGA_R <= n6_R(number0_select)& "0000000";
--                VGA_G <= n6_G(number0_select)& "0000000";
--                VGA_B <= n6_B(number0_select)& "0000000";
--
--                 elsif numberd0= "0000000000000111" then
--
--                      VGA_R <= n7_R(number0_select)& "0000000";
--                VGA_G <= n7_G(number0_select)& "0000000";
--                VGA_B <= n7_B(number0_select)& "0000000";
--
--                 elsif numberd0= "0000000000001000" then
--                    elsif  shoot_ball_type= "00000101" then

--                      VGA_R <= n8_R(number0_select)& "0000000";
--                VGA_G <= n8_G(number0_select)& "0000000";
--                VGA_B <= n8_B(number0_select)& "0000000";
--
--                 elsif numberd0= "0000000000001001" then
--
--                      VGA_R <= n9_R(number0_select)& "0000000";
--                VGA_G <= n9_G(number0_select)& "0000000";
--                VGA_B <= n9_B(number0_select)& "0000000";
--



--             end if;
--             elsif score_sprite2_HV ='1' and launch =
"0000000000000001" then
--
--               number1_select<=(to_integer((unsigned((Hcount))-HSYNC-
HBACK_PORCH-score_H2START)*40 +(Vcount-VSYNC-VBACK_PORCH-
score_VSTART)));
--
--             if numberd1= "0000000000000000" then
--               VGA_R <= n0_R(number1_select)& "0000000";
--               VGA_G <= n0_G(number1_select)& "0000000";
--               VGA_B <= n0_B(number1_select)& "0000000";
--
--
--                  elsif numberd1= "0000000000000001" then
--
--                        VGA_R <= n1_R(number1_select)& "0000000";
--               VGA_G <= n1_G(number1_select)& "0000000";
--               VGA_B <= n1_B(number1_select)& "0000000";

--                   elsif numberd1= "0000000000000010" then
--
--                      VGA_R <= n2_R(number1_select)& "0000000";
--               VGA_G <= n2_G(number1_select)& "0000000";
--               VGA_B <= n2_B(number1_select)& "0000000";
--
--                   elsif numberd1= "0000000000000011" then
```

```
--
--                      VGA_R <= n3_R(number1_select)& "0000000";
--               VGA_G <= n3_G(number1_select)& "0000000";
--               VGA_B <= n3_B(number1_select)& "0000000";
--
--                 elsif numberd1= "0000000000000100" thenelsif
shoot_ball_type= "00000101" then

--                      VGA_R <= n4_R(number1_select)& "0000000";
--               VGA_G <= n4_G(number1_select)& "0000000";
--               VGA_B <= n4_B(number1_select)& "0000000";
--
--                elsif numberd1= "0000000000000101" then
--
--                      VGA_R <= n5_R(number1_select)& "0000000";
--               VGA_G <= n5_G(number1_select)& "0000000";
--               VGA_B <= n5_B(number1_select)& "0000000";
--
--                elsif numberd1= "0000000000000110" then
--
--                      VGA_R <= n6_R(number1_select)& "0000000";
--               VGA_G <= n6_G(number1_select)& "0000000";
--               VGA_B <= n6_B(number1_select)& "0000000";
--
--                elsif numberd1= "0000000000000111" then
--
--                      VGA_R <= n7_R(number1_select)& "0000000";
--               VGA_G <= n7_G(number1_select)& "0000000";
--               VGA_B <= n7_B(number1_select)& "0000000";
--
--                elsif numberd1= "0000000000001000" then
--
--                      VGA_R <= n8_R(number1_select)& "0000000";
--               VGA_G <= n8_G(nend if;umber1_select)& "0000000";
--               VGA_B <= n8_B(number1_select)& "0000000";
--
--                elsif numberd1= "0000000000001001" then
--
--                      VGA_R <= n9_R(number1_select)& "0000000";
--               VGA_G <= n9_G(number1_select)& "0000000";
--               VGA_B <= n9_B(number1_select)& "0000000";
--
--               end if;

--         elsif score_sprite3_HV ='1' and launch = "0000000000000001"
then
--                number2_select<=(to_integer((unsigned((Hcount))-
HSYNC-HBACK_PORCH-score_H3START)*40 +(Vcount-VSYNC-VBACK_PORCH-
score_VSTART)));
--
--
--            if numberd2= "0000000000000000" then
```

```
--                VGA_R <= n0_R(number2_select)& "0000000";
--               VGA_G <= n0_G(number2_select)& "0000000";
--               VGA_B <= n0_B(number2_select)& "0000000";
--
--
--                   elsif numberd2= "0000000000000001" then
--
--                        VGA_R <= n1_R(number2_select)& "0000000";
--               VGA_G <= n1_G(number2_select)& "0000000";
--               VGA_B <= n1_B(number2_select)& "0000000";
--
--                    elsif numberd2= "0000000000000010" then
--
--                        VGA_R <= n2_R(number2_select)& "0000000";
--               VGA_G <= n2_G(number2_select)& "0000000";
--               VGA_B <= n2_B(number2_select)& "0000000";
--
--                    elsif numberd2= "0000000000000011" then
--
--                        VGA_R <= n3_R(number2_select)& "0000000";
--               VGA_G <= n3_G(number2_select)& "0000000";
--               VGA_B <= n3_B(number2_select)& "0000000";
--
--                  elsif numberd2= "000end if;0000000000100" then
--
--                        VGA_R <= n4_R(number2_select)& "0000000";
--               VGA_G <= n4_G(number2_select)& "0000000";
--               VGA_B <= n4_B(number2_select)& "0000000";
--
--                 elsif numberd2= "0000000000000101" then
--
--                        VGA_R <= n5_R(number2_select)& "0000000";
--               VGA_G <= n5_G(number2_select)& "0000000";
--               VGA_B <= n5_B(number2_select)& "0000000";
--
--                 elsif numberd2= "0000000000000110" then
--
--                        VGA_R <= n6_R(number2_select)& "0000000";
--               VGA_G <= n6_G(number2_select)& "0000000";
--               VGA_B <= n6_B(number2_select)& "0000000";
--
--                 elsif numberd2= "0000000000000111" then
--
--                        VGA_R <= n7_R(number2_select)& "0000000";
--               VGA_G <= n7_G(number2_select)& "0000000";
--               VGA_B <= n7_B(number2_select)& "0000000";
--
--                 elsif numberd2= "0000000000001000" then
--
--                        VGA_R <= n8_R(number2_select)& "0000000";
--               VGA_G <= n8_G(number2_select)& "0000000";
--               VGA_B <= n8_B(number2_select)& "0000000";
```

```
--
--                elsif numberd2= "0000000000001001" then
--
--                       VGA_R <= n9_R(number2_select)& "0000000";
--               VGA_G <= n9_G(number2_select)& "0000000";
--               VGA_B <= n9_B(number2_select)& "0000000";


--                end if;



        elsif rectangle = '1' then
            if chipselect = '1' and write = '1' then
             if flag = '1' then
                VGA_R <= VGA_R_buffer&"0000000";
           VGA_G <= VGA_G_buffer&"0000000";
           VGA_B <= VGA_B_buffer&"00000000";
             elsif flag = '0' then
                VGA_R <= VGA_R_buffer_next&"0000000";
           VGA_G <= VGA_G_buffer_next&"0000000";
           VGA_B <= VGA_B_buffer_next&"00000000";
                 end if;
             end if;
      elsif vga_hblank = '0' and vga_vblank ='0' then
        VGA_R <= "1111111111";
        VGA_G <= "1111111111";
        VGA_B <= "1111111111";
      else
        VGA_R <= "0000000000";
        VGA_G <= "0000000000";
        VGA_B <= "0000000000";
      end if;
    end if;
  end process VideoOut;

  VGA_CLK <= clk25;
  VGA_HS <= not vga_hsync;
  VGA_VS <= not vga_vsync;
  VGA_SYNC <= '0';
  VGA_BLANK <= not (vga_hsync or vga_vsync);

end rtl;
```

```
library ieee;
use ieee.std_logic_1164.all;
use ieee.numeric_std.all;

entity de2_wm8731_audio is
```

```
port (
    clk : in std_logic;       --  Audio CODEC Chip Clock AUD_XCK
(18.43 MHz)
    reset_n : in std_logic;
    test_mode : in std_logic;       --    Audio CODEC controller test
mode
    audio_request : out std_logic;  --    Audio controller request new
data
    data : in std_logic_vector(15 downto 0) := "0000000000000000";

      address    : in  std_logic_vector(16 downto 0);
      write      : in std_logic;
      chipselect : in std_logic;
--    irq        : out std_logic;
    counter_out:  out unsigned (6 downto 0);

    -- Audio interface signals
    AUD_ADCLRCK  : out  std_logic;   --    Audio CODEC ADC LR Clock
    AUD_ADCDAT   : in   std_logic;   --    Audio CODEC ADC Data
    AUD_DACLRCK  : out  std_logic;   --    Audio CODEC DAC LR Clock
    AUD_DACDAT   : out  std_logic;   --    Audio CODEC DAC Data
    AUD_BCLK     : inout std_logic  --    Audio CODEC Bit-Stream Clock
  );
end  de2_wm8731_audio;

architecture rtl of de2_wm8731_audio is

    signal lrck : std_logic;
    signal bclk : std_logic;
    signal xck  : std_logic;

    signal lrck_divider : unsigned(15 downto 0);
    signal bclk_divider : unsigned(11 downto 0);

    signal set_bclk : std_logic;
    signal set_lrck : std_logic;
    signal clr_bclk : std_logic;
    signal lrck_lat : std_logic;

    signal shift_out : unsigned(15 downto 0);

    signal sin_out     : unsigned(15 downto 0);
    signal sin_counter : unsigned(5 downto 0);

      signal key         : unsigned(1 downto 0);
    signal count_in    : unsigned(13 downto 0);
    signal data_in     : unsigned(15 downto 0);

      signal ram_address : unsigned(16 downto 0);
      signal a           : unsigned(15 downto 0);
      signal backcounter : unsigned(6 downto 0);
```

```
begin

        counter_out<=backcounter;
        data_in    <= unsigned(data);

    -- LRCK divider
    -- Audio chip main clock is 18.432MHz / Sample rate 48KHz
    -- Divider is 18.432 MHz / 48KHz = 192 (X"C0")
    -- Left justify mode set by I2C controller

  process (clk)
  begin
    if rising_edge(clk) then
      if reset_n = '0' then
        lrck_divider <= (others => '0');
      elsif lrck_divider = X"030C"  then        -- "C0" minus 1
        lrck_divider <= X"0000";
      else
        lrck_divider <= lrck_divider + 1;
      end if;
    end if;
  end process;


  process (clk)
  begin
    if rising_edge(clk) then
      if reset_n = '0' then
        bclk_divider <= (others => '0');
      elsif bclk_divider = X"030" or set_lrck = '1'  then
        bclk_divider <= X"000";
      else
        bclk_divider <= bclk_divider + 1;
      end if;
    end if;
  end process;

  set_lrck <= '1' when lrck_divider = X"030C" else '0';

  process (clk)
  begin
    if rising_edge(clk) then
      if reset_n = '0' then
        lrck <= '0';
      elsif set_lrck = '1' then
        lrck <= not lrck;
      end if;
    end if;
  end process;

  -- BCLK divider
  set_bclk <= '1' when bclk_divider(11 downto 0) = X"018" else '0';
```

```
  clr_bclk <= '1' when bclk_divider(11 downto 0) = X"030" else '0';

  process (clk)
  begin
    if rising_edge(clk) then
      if reset_n = '0' then
        bclk <= '0';
      elsif set_lrck = '1' or clr_bclk = '1' then
        bclk <= '0';
      elsif set_bclk = '1' then
        bclk <= '1';
      end if;
    end if;
  end process;

  -- Audio data shift output
  process (clk)
  begin
    if rising_edge(clk) then
      if reset_n = '0' then
        shift_out <= (others => '0');
      elsif set_lrck = '1' then
        if test_mode = '1' then
          shift_out <= sin_out;
        else
          shift_out <= data_in;
        end if;
      elsif clr_bclk = '1' then
        shift_out <= shift_out (14 downto 0) & '0';
      end if;
    end if;
  end process;

    -- Audio outputs

    AUD_ADCLRCK  <= lrck;
    AUD_DACLRCK  <= lrck;
    AUD_DACDAT   <= shift_out(15);
    AUD_BCLK     <= bclk;

    -- Self test with Sin wave

    process(clk)
    begin
      if rising_edge(clk) then
        if reset_n = '0' then
            sin_counter <= (others => '0');
        elsif lrck_lat = '1' and lrck = '0'  then
                audio_request <= '1';
--               a <= a + 1;
--               if a = x"4E20" then
--                  a <= x"0000";
```

```
--          if sin_counter >= "101111" then
--             sin_counter <= "000000";
--                 if key = 0 then
          else
                  audio_request <= '0';
            sin_counter <= sin_counter + 1;
--                    elsif key = 1 then
--                       sin_counter <= sin_counter + 2;
--                    end if;
          end if;
        end if;
    end process;


     process(clk)
    begin
      if rising_edge(clk) then
        if reset_n = '0' then
            backcounter<= (others => '0');
        elsif lrck_lat = '1' and lrck = '0'  then
            backcounter <= backcounter + 1;
        end if;
      end if;
    end process;


    process(clk)
    begin
      if rising_edge(clk) then
        lrck_lat <= lrck;
      end if;
    end process;

end architecture;
```

```
--
-- DE2 top-level module that includes the simple VGA raster generator
--
-- Stephen A. Edwards, Columbia University, sedwards@cs.columbia.edu
--
-- From an original by Terasic Technology, Inc.
-- (DE2_TOP.v, part of the DE2 system board CD supplied by Altera)
--

library ieee;
use ieee.std_logic_1164.all;
use ieee.numeric_std.all;
```

```
entity lab3_audio is

  port (
    -- Clocks

    CLOCK_27,                                          -- 27 MHz
    CLOCK_50,                                          -- 50 MHz
    EXT_CLOCK : in std_logic;                          -- External Clock

    -- Buttons and switches

    KEY : in std_logic_vector(3 downto 0);             -- Push buttons
    SW : in std_logic_vector(17 downto 0);             -- DPDT switches

    -- LED displays

    HEX0, HEX1, HEX2, HEX3, HEX4, HEX5, HEX6, HEX7 -- 7-segment
displays
       : out std_logic_vector(6 downto 0);
    LEDG : out std_logic_vector(8 downto 0);           -- Green LEDs
    LEDR : out std_logic_vector(17 downto 0);          -- Red LEDs

    -- RS-232 interface

    UART_TXD : out std_logic;                          -- UART transmitter
    UART_RXD : in std_logic;                           -- UART receiver

    -- IRDA interface

--    IRDA_TXD : out std_logic;                          -- IRDA
Transmitter
    IRDA_RXD : in std_logic;                           -- IRDA Receiver

    -- SDRAM

    DRAM_DQ : inout std_logic_vector(15 downto 0); -- Data Bus
    DRAM_ADDR : out std_logic_vector(11 downto 0); -- Address Bus
    DRAM_LDQM,                                         -- Low-byte Data
Mask
    DRAM_UDQM,                                         -- High-byte Data
Mask
    DRAM_WE_N,                                         -- Write Enable
    DRAM_CAS_N,                                        -- Column Address
Strobe
    DRAM_RAS_N,                                        -- Row Address
Strobe
    DRAM_CS_N,                                         -- Chip Select
    DRAM_BA_0,                                         -- Bank Address 0
    DRAM_BA_1,                                         -- Bank Address 0
    DRAM_CLK,                                          -- Clock
    DRAM_CKE : out std_logic;                          -- Clock Enable
```

```
    -- FLASH

    FL_DQ : inout std_logic_vector(7 downto 0);      -- Data bus
    FL_ADDR : out std_logic_vector(21 downto 0);  -- Address bus
    FL_WE_N,                                          -- Write Enable
    FL_RST_N,                                         -- Reset
    FL_OE_N,                                          -- Output Enable
    FL_CE_N : out std_logic;                          -- Chip Enable

    -- SRAM

    SRAM_DQ : inout std_logic_vector(15 downto 0); -- Data bus 16 Bits
    SRAM_ADDR : out std_logic_vector(18 downto 0); -- Address bus 18
Bits
    SRAM_UB_N,                                        -- High-byte Data
Mask
    SRAM_LB_N,                                        -- Low-byte Data
Mask
    SRAM_WE_N,                                        -- Write Enable
    SRAM_CE_N,                                        -- Chip Enable
    SRAM_OE_N : out std_logic;                        -- Output Enable

    -- USB controller

    OTG_DATA : inout std_logic_vector(15 downto 0); -- Data bus
    OTG_ADDR : out std_logic_vector(1 downto 0);    -- Address
    OTG_CS_N,                                         -- Chip Select
    OTG_RD_N,                                         -- Write
    OTG_WR_N,                                         -- Read
    OTG_RST_N,                                        -- Reset
    OTG_FSPEED,                    -- USB Full Speed, 0 = Enable, Z =
Disable
    OTG_LSPEED : out std_logic;     -- USB Low Speed, 0 = Enable, Z =
Disable
    OTG_INT0,                                         -- Interrupt 0
    OTG_INT1,                                         -- Interrupt 1
    OTG_DREQ0,                                        -- DMA Request 0
    OTG_DREQ1 : in std_logic;                         -- DMA Request 1
    OTG_DACK0_N,                                      -- DMA Acknowledge
0
    OTG_DACK1_N : out std_logic;                      -- DMA Acknowledge
1

    -- 16 X 2 LCD Module

    LCD_ON,                    -- Power ON/OFF
    LCD_BLON,                  -- Back Light ON/OFF
    LCD_RW,                    -- Read/Write Select, 0 = Write, 1 =
Read
    LCD_EN,                    -- Enable
    LCD_RS : out std_logic;     -- Command/Data Select, 0 = Command, 1
= Data
```

```
    LCD_DATA : inout std_logic_vector(7 downto 0); -- Data bus 8 bits

    -- SD card interface

    SD_DAT,                     -- SD Card Data
    SD_DAT3,                    -- SD Card Data 3
    SD_CMD : inout std_logic;   -- SD Card Command Signal
    SD_CLK : out std_logic;     -- SD Card Clock

    -- USB JTAG link

    TDI,                        -- CPLD -> FPGA (data in)
    TCK,                        -- CPLD -> FPGA (clk)
    TCS : in std_logic;         -- CPLD -> FPGA (CS)
    TDO : out std_logic;        -- FPGA -> CPLD (data out)

    -- I2C bus

    I2C_SDAT : inout std_logic; -- I2C Data
    I2C_SCLK : out std_logic;   -- I2C Clock

    -- PS/2 port

    PS2_DAT,                    -- Data
    PS2_CLK : in std_logic;     -- Clock

    -- VGA output

    VGA_CLK,                                                -- Clock
    VGA_HS,                                                 -- H_SYNC
    VGA_VS,                                                 -- V_SYNC
    VGA_BLANK,                                              -- BLANK
    VGA_SYNC : out std_logic;                               -- SYNC
    VGA_R,                                                  -- Red[9:0]
    VGA_G,                                                  -- Green[9:0]
    VGA_B : out std_logic_vector(9 downto 0);                       --
Blue[9:0]

    --  Ethernet Interface

    ENET_DATA : inout std_logic_vector(15 downto 0);    -- DATA bus
16Bits
    ENET_CMD,           -- Command/Data Select, 0 = Command, 1 = Data
    ENET_CS_N,                                              -- Chip Select
    ENET_WR_N,                                              -- Write
    ENET_RD_N,                                              -- Read
    ENET_RST_N,                                             -- Reset
    ENET_CLK : out std_logic;                               -- Clock 25
MHz
    ENET_INT : in std_logic;                                -- Interrupt

    -- Audio CODEC
```

```
    AUD_ADCLRCK : inout std_logic;                      -- ADC LR
Clock
    AUD_ADCDAT : in std_logic;                          -- ADC Data
    AUD_DACLRCK : inout std_logic;                      -- DAC LR
Clock
    AUD_DACDAT : out std_logic;                         -- DAC Data
    AUD_BCLK : inout std_logic;                         -- Bit-Stream
Clock
    AUD_XCK : out std_logic;                            -- Chip Clock

    -- Video Decoder

    TD_DATA : in std_logic_vector(7 downto 0);  -- Data bus 8 bits
    TD_HS,                                      -- H_SYNC
    TD_VS : in std_logic;                       -- V_SYNC
    TD_RESET : out std_logic;                   -- Reset

    -- General-purpose I/O

    GPIO_0,                                      -- GPIO Connection 0
    GPIO_1 : inout std_logic_vector(35 downto 0) -- GPIO Connection 1
    );

end lab3_audio;

architecture datapath of lab3_audio is

  signal clk25 : std_logic := '0';
  signal counter : unsigned(15 downto 0);
  signal reset_n : std_logic;
  signal audio_clock : unsigned(1 downto 0) := "00";
  signal clk_18 : std_logic;
  signal DQM    : std_logic_vector(1 downto 0);
  signal BA     : std_logic_vector(1 downto 0);
  signal c0     : std_logic;
  signal c1     :  std_logic;
  signal CLK_50:  std_logic;

     component sdram IS
     PORT
     (
          inclk0: IN STD_LOGIC;
          c0         : OUT STD_LOGIC ;
          c1         : OUT STD_LOGIC
     );
  end component sdram;



  component de2_i2c_av_config is
  port (
```

```
    iCLK : in std_logic;
    iRST_N : in std_logic;
    I2C_SCLK : out std_logic;
    I2C_SDAT : inout std_logic
  );
  end component;

--  component de2_audio_pll is
--  PORT
--   (
--    inclk0          : IN STD_LOGIC  := '0';
--     c0           : OUT STD_LOGIC
--    );
--end component de2_audio_pll;



begin

   V2: sdram port map (
      inclk0 => CLOCK_50,
      c0 => c0,
      c1 => c1
      );

  process (CLOCK_50)
  begin
   if rising_edge(CLOCK_50) then
          clk25 <= not clk25;
      if counter = x"ffff" then
                reset_n <= '1';
          else
                reset_n <= '0';
                counter <= counter + 1;
          end if;
    end if;
  end process;

 process (CLOCK_50)
  begin
    if rising_edge(CLOCK_50) then
      audio_clock <= audio_clock + "1";
    end if;
  end process;

  AUD_XCK <= clk25;

--  v1 : de2_audio_pll port map(
--  inclk0 => clock_50,
--  c0 => clk_18
--  );
```

```
  i2c : de2_i2c_av_config port map (
    iCLK     => CLOCK_50,
    iRST_n   => '1',
    I2C_SCLK => I2C_SCLK,
    I2C_SDAT => I2C_SDAT
  );


  nios: entity work.nios_system port map (
    reset_n => reset_n,
    clk_0 => CLOCK_50,
       AUD_ADCDAT_to_the_musiccontroller_0        => AUD_ADCDAT,
       AUD_ADCLRCK_from_the_musiccontroller_0     => AUD_ADCLRCK,
       AUD_BCLK_to_and_from_the_musiccontroller_0 => AUD_BCLK,
       AUD_DACDAT_from_the_musiccontroller_0      => AUD_DACDAT,
       AUD_DACLRCK_from_the_musiccontroller_0     => AUD_DACLRCK,
    PS2_Clk_to_the_de2_ps2_0                   => PS2_CLK,
       PS2_Data_to_the_de2_ps2_0                  => PS2_DAT,

       zs_addr_from_the_sdram_0 => DRAM_ADDR,
       zs_ba_from_the_sdram_0 => BA,
       zs_cas_n_from_the_sdram_0 => DRAM_CAS_N,
       zs_cke_from_the_sdram_0 => DRAM_CKE,
       zs_cs_n_from_the_sdram_0 => DRAM_CS_N,
       zs_dq_to_and_from_the_sdram_0 => DRAM_DQ,
       zs_dqm_from_the_sdram_0 => DQM,
       zs_ras_n_from_the_sdram_0 => DRAM_RAS_N,
       zs_we_n_from_the_sdram_0 => DRAM_WE_N,

       SRAM_ADDR_from_the_VGA_mux_0 => SRAM_ADDR,
       SRAM_CE_N_from_the_VGA_mux_0 => SRAM_CE_N,
       SRAM_DQ_to_and_from_the_VGA_mux_0 => SRAM_DQ,
       SRAM_LB_N_from_the_VGA_mux_0 => SRAM_LB_N,
       SRAM_OE_N_from_the_VGA_mux_0 => SRAM_OE_N,
       SRAM_UB_N_from_the_VGA_mux_0 => SRAM_UB_N,
       SRAM_WE_N_from_the_VGA_mux_0 => SRAM_WE_N,

    VGA_BLANK_from_the_VGA_mux_0 => VGA_BLANK,
    VGA_CLK_from_the_VGA_mux_0 => VGA_CLK,
    VGA_HS_from_the_VGA_mux_0 => VGA_HS,
    VGA_SYNC_from_the_VGA_mux_0 => VGA_SYNC,
    VGA_VS_from_the_VGA_mux_0 => VGA_VS,
       VGA_R_from_the_VGA_mux_0 => VGA_R,
    VGA_G_from_the_VGA_mux_0 => VGA_G,
    VGA_B_from_the_VGA_mux_0 => VGA_B

  );
--  VGA_CLK <= '0';
--  VGA_HS <= '0';
--  VGA_VS <= '0';
--  VGA_BLANK <= '0';
--  VGA_SYNC <= '0';
```

```
--  VGA_R <= (others => '0');
--  VGA_G <= (others => '0');
--  VGA_B <= (others => '0');
  HEX7     <= "0001001"; -- Leftmost
  HEX6     <= "0000110";
  HEX5     <= "1000111";
  HEX4     <= "1000111";
  HEX3     <= "1000000";
  HEX2     <= (others => '1');
  HEX1     <= (others => '1');
  HEX0     <= (others => '1');          -- Rightmost
  LEDG     <= (others => '1');
  LEDR     <= (others => '1');
  LCD_ON   <= '1';
  LCD_BLON <= '1';
  LCD_RW <= '1';
  LCD_EN <= '0';
  LCD_RS <= '0';

  SD_DAT3 <= '1';
  SD_CMD <= '1';
  SD_CLK <= '1';

--  SRAM_DQ <= (others => 'Z');
--  SRAM_ADDR <= (others => '0');
--  SRAM_UB_N <= '1';
--  SRAM_LB_N <= '1';
--  SRAM_CE_N <= '1';
--  SRAM_WE_N <= '1';
--  SRAM_OE_N <= '1';
  DRAM_LDQM <= DQM(0);
  DRAM_UDQM <= DQM(1);
  DRAM_BA_0 <= BA(0);
  DRAM_BA_1 <= BA(1);

  UART_TXD <= '0';
--  DRAM_ADDR <= (others => '0');
--  DRAM_LDQM <= '0';
--  DRAM_UDQM <= '0';
--  DRAM_WE_N <= '1';
--  DRAM_CAS_N <= '1';
--  DRAM_RAS_N <= '1';
--  DRAM_CS_N <= '1';
--  DRAM_BA_0 <= '0';
--  DRAM_BA_1 <= '0';
    DRAM_CLK <= c0;
--  DRAM_CKE <= '0';
  FL_ADDR <= (others => '0');
  FL_WE_N <= '1';
  FL_RST_N <= '0';
  FL_OE_N <= '1';
  FL_CE_N <= '1';
```

```
  OTG_ADDR <= (others => '0');
  OTG_CS_N <= '1';
  OTG_RD_N <= '1';
  OTG_RD_N <= '1';
  OTG_WR_N <= '1';
  OTG_RST_N <= '1';
  OTG_FSPEED <= '1';
  OTG_LSPEED <= '1';
  OTG_DACK0_N <= '1';
  OTG_DACK1_N <= '1';

  TDO <= '0';

  ENET_CMD <= '0';
  ENET_CS_N <= '1';
  ENET_WR_N <= '1';
  ENET_RD_N <= '1';
  ENET_RST_N <= '1';
  ENET_CLK <= '0';

  TD_RESET <= '0';

--  I2C_SCLK <= '1';

--  AUD_DACDAT <= '1';
--    AUD_XCK    <='1';
  -- Set all bidirectional ports to tri-state
  DRAM_DQ     <= (others => 'Z');
  FL_DQ       <= (others => 'Z');
  SRAM_DQ     <= (others => 'Z');
  OTG_DATA    <= (others => 'Z');
  LCD_DATA    <= (others => 'Z');
  SD_DAT      <= 'Z';
  I2C_SDAT    <= 'Z';
  ENET_DATA   <= (others => 'Z');
  AUD_ADCLRCK <= 'Z';
  AUD_DACLRCK <= 'Z';
  AUD_BCLK    <= 'Z';
  GPIO_0      <= (others => 'Z');
  GPIO_1      <= (others => 'Z');

end datapath;
```

```
library ieee;
use ieee.std_logic_1164.all;
use ieee.numeric_std.all;

entity musiccontroller is
port (
```

```
    clk        : in  std_logic;
    reset_n    : in  std_logic;
    read       : in  std_logic;
    write      : in  std_logic;
    chipselect : in  std_logic;
    address    : in  std_logic_vector(16 downto 0);
    readdata   : out std_logic_vector(15 downto 0);
    writedata  : in  std_logic_vector(15 downto 0);
    irq        : out std_logic;


     AUD_ADCLRCK  : out  std_logic;   --    Audio CODEC ADC LR Clock
     AUD_ADCDAT   : in   std_logic;   --    Audio CODEC ADC Data
     AUD_DACLRCK  : out  std_logic;   --    Audio CODEC DAC LR Clock
     AUD_DACDAT   : out  std_logic;   --    Audio CODEC DAC Data
     AUD_BCLK     : inout std_logic --    Audio CODEC Bit-Stream Clock
  );

  end musiccontroller;

  architecture mc of musiccontroller is

  signal audio_request : std_logic;
  signal audio_clock : unsigned(1 downto 0) := "00";
  signal store : std_logic;
  signal clk_25:std_logic;
  type buffer_type is array (0 to 127) of std_logic_vector (15 downto
0);
  signal buffer1 : buffer_type;
  signal data    : std_logic_vector(15 downto 0);
  signal counter : unsigned(6 downto 0);
  signal ram_address : unsigned(16 downto 0);



   component de2_wm8731_audio is port(
              clk : in std_logic;       --  Audio CODEC Chip Clock
AUD_XCK (18.43 MHz)
           reset_n : in std_logic;
              test_mode : in std_logic;       --    Audio CODEC
controller test mode
              audio_request : out std_logic;  --    Audio controller
request new data
              data       : in std_logic_vector(15 downto 0);
                address    : in  std_logic_vector(16 downto 0);
                write      : in std_logic;
                chipselect : in std_logic;
                counter_out:  out unsigned (6 downto 0);

              -- Audio interface signals
           AUD_ADCLRCK  : out  std_logic;   --    Audio CODEC ADC LR
Clock
```

```
               AUD_ADCDAT   : in   std_logic;   --    Audio CODEC ADC
Data
               AUD_DACLRCK  : out  std_logic;   --    Audio CODEC DAC
LR Clock
               AUD_DACDAT   : out  std_logic;   --    Audio CODEC DAC
Data
               AUD_BCLK     : inout std_logic--      Audio CODEC Bit-
Stream Clock

            );
            end component de2_wm8731_audio;



--          component de2_audio_pll is
--PORT
--(
--inclk0         : IN STD_LOGIC  := '0';
--c0       : OUT STD_LOGIC
--);end component de2_audio_pll;



--    process (clk)
--    begin
--         if rising_edge(clk) then
--              if reset_n = '0' then
--                      store <= '0';
--              else
--                   if chipSelect = '1' and write = '1'  then
--                        store <= '1';
--                   end if;    5
--              end if;
--         end if;
--    end process;
begin

ram_address <= unsigned(address(16 downto 0));

V1: de2_wm8731_audio port map (
    clk => clk_25,
    reset_n   => '1',
    test_mode => '0',
    audio_request => audio_request,
    data =>  data ,
      address => address,
      write   => write,
      chipselect => chipselect,
      counter_out=> counter,

    -- Audio interface signals
    AUD_ADCLRCK  => AUD_ADCLRCK,
```

```
    AUD_ADCDAT   => AUD_ADCDAT,
    AUD_DACLRCK  => AUD_DACLRCK,
    AUD_DACDAT   => AUD_DACDAT,
    AUD_BCLK     => AUD_BCLK
  );


--  V2: de2_audio_pll port map(
--  inclk0 => clk,
--  c0     => clk_18
--  );

 process (clk)
  begin
    if rising_edge(clk) then
        clk_25 <= not clk_25;
      if reset_n = '0' then
        irq <= '0';
      else
        if counter = "1111111"  then
          irq <= '1';
        elsif write = '1' and chipselect = '1' then
          irq <= '0';  -- important to reset the irq
        end if;
      end if;
    end if;
  end process;

  process (clk) begin
     if rising_edge (clk) then
          data <= buffer1(to_integer(counter));
     if chipselect = '1' and write = '1'  then
        buffer1 (to_integer (ram_address)) <= writedata;
          end if;
     end if;
end process;

  end architecture;
```

```
library ieee;
use ieee.std_logic_1164.all;
use ieee.numeric_std.all;

entity VGA_mux is
port(
    clk        : in  std_logic;
    reset      : in  std_logic;
    read       : in  std_logic;
    write      : in  std_logic;
```

```
    chipselect : in  std_logic;
    address    : in  std_logic_vector(18 downto 0);
    readdata   : out std_logic_vector(15 downto 0);
    writedata  : in  std_logic_vector(15 downto 0);
      byteenable : in  std_logic_vector(1 downto 0);


      VGA_CLK,                          -- Clock
    VGA_HS,                           -- H_SYNC
    VGA_VS,                           -- V_SYNC
    VGA_BLANK,                        -- BLANK
    VGA_SYNC : out std_logic;         -- SYNC
    VGA_R,                            -- Red[9:0]
    VGA_G,                            -- Green[9:0]
    VGA_B : out std_logic_vector(9 downto 0); -- Blue[9:0]

      SRAM_DQ   : inout std_logic_vector(15 downto 0);
    SRAM_ADDR : out std_logic_vector(18 downto 0);
    SRAM_UB_N, SRAM_LB_N : out std_logic;
    SRAM_WE_N, SRAM_CE_N : out std_logic;
    SRAM_OE_N            : out std_logic
      );
end VGA_mux;


architecture rtl of VGA_mux is

component de2_sram_controller is
  port (
      chipselect : in std_logic;
      write, read : in std_logic;
      address  :  in std_logic_vector(18 downto 0);
      readdata : out std_logic_vector(15 downto 0);
      writedata : in std_logic_vector(15 downto 0);
      byteenable : in std_logic_vector(1 downto 0);

      SRAM_DQ : inout std_logic_vector(15 downto 0);
      SRAM_ADDR : out std_logic_vector(18 downto 0);
      SRAM_UB_N, SRAM_LB_N : out std_logic;
      SRAM_WE_N, SRAM_CE_N : out std_logic;
      SRAM_OE_N            : out std_logic
    );
      end component de2_sram_controller;

component de2_vga_raster is
  port (
    clk   : in std_logic;                    -- Should be 25.125 MHz
    reset : in std_logic;

    read       : in  std_logic;
    write      : in  std_logic;
    chipselect : in  std_logic;
```

```
    address    : in  std_logic_vector(18 downto 0);
    readdata   : out std_logic_vector(18 downto 0);
    writedata  : in  std_logic_vector(15 downto 0);
      write_inf  : in  std_logic_vector(15 downto 0);
      address_inf: in  std_logic_vector(18 downto 0);

    VGA_CLK,                          -- Clock
    VGA_HS,                           -- H_SYNC
    VGA_VS,                           -- V_SYNC
    VGA_BLANK,                        -- BLANK
    VGA_SYNC : out std_logic;         -- SYNC
    VGA_R,                            -- Red[9:0]
    VGA_G,                            -- Green[9:0]
    VGA_B : out std_logic_vector(9 downto 0) -- Blue[9:0]

    );
      end component de2_vga_raster;

      signal internal_VGA_R :  STD_LOGIC_VECTOR (9 DOWNTO 0);
    signal internal_VGA_G :  STD_LOGIC_VECTOR (9 DOWNTO 0);
    signal internal_VGA_B :  STD_LOGIC_VECTOR (9 DOWNTO 0);
    signal internal_VGA_SYNC :   STD_LOGIC;
    signal internal_VGA_BLANK :  STD_LOGIC;
    signal internal_VGA_VS :     STD_LOGIC ;
      signal internal_VGA_HS : STD_LOGIC;
      signal internal_VGA_CLK : STD_LOGIC;
      signal internal_readdata: std_logic_vector(15 downto 0);
      signal address_from_VGA: std_logic_vector(18 downto 0);
      signal internal_readdata_sram_vga : std_logic_vector(15 downto
0);
      signal data_to_VGA : std_logic_vector(15 downto 0);
    signal data_to_SRAM: std_logic_vector(15 downto 0);
    signal read_address: std_logic_vector(18 downto 0);
    signal read_enable : std_logic;
      signal read_abc:std_logic;
      signal write_abc:std_logic;
      signal address_abc:std_logic_vector(18 downto 0);
      signal chipselect_vga :std_logic;
      signal read_sram      : std_logic;
      signal flag           :std_logic:='0';
      signal write_0        :std_logic;
      signal counter        :unsigned(3 downto 0);
      signal counter_address        :unsigned(15 downto 0);
      signal clk25 : std_logic := '0';
      signal clk_half: std_logic :='0';
      signal sram_write     :std_logic;
      signal sram_read      :std_logic;
      signal sram_address   :std_logic_vector(18 downto 0);
      signal sram_writedata :std_logic_vector(15 downto 0);
      signal chipselect_sram:std_logic;
      signal chipselect_abc :std_logic;
```

```
      signal write_inf      :std_logic_vector(15 downto 0):=(others =>
'0');
      signal address_inf    :std_logic_vector(18 downto 0);
      signal mode_control   :std_logic_vector(18 downto 0);


      begin

    V1:  de2_vga_raster port map (
    clk => clk,
       reset => reset,
       address => address_abc,
       writedata => internal_readdata,
       read => read_abc,
       write => write_abc,
       chipselect => chipselect_vga,
       readdata  => address_from_VGA,
       write_inf => write_inf,
       address_inf => address_inf,

       VGA_CLK => internal_VGA_CLK,
       VGA_HS => internal_VGA_HS,
       VGA_VS => internal_VGA_VS,
       VGA_BLANK => internal_VGA_BLANK,
       VGA_SYNC => internal_VGA_SYNC,
       VGA_R => internal_VGA_R,
       VGA_G => internal_VGA_G,
       VGA_B => internal_VGA_B
  );

  V_final:de2_sram_controller port map(
       chipselect => chipselect_sram,
       write => sram_write,
       read =>  sram_read,
       address => sram_address,
       readdata => internal_readdata_sram_vga,
       writedata => sram_writedata,
       byteenable => byteenable,

       SRAM_DQ   => SRAM_DQ,
       SRAM_ADDR => SRAM_ADDR,
       SRAM_UB_N => SRAM_UB_N,
       SRAM_LB_N => SRAM_LB_N,
       SRAM_WE_N => SRAM_WE_N,
       SRAM_CE_N => SRAM_CE_N,
       SRAM_OE_N => SRAM_OE_N
       );

       flag_process: process(clk)
       begin
           if rising_edge(clk) then
             mode_control<=address;
```

```
                if chipselect = '1' and write = '1' then
                 if mode_control = "1111100100000110000" then
                     flag <= '1';
                 elsif mode_control = "1111100100000101000" then
                     flag <= '0';
                 end if;
          end if;
       end if;
       end process;

       V_f:  process(clk)
       begin
          if rising_edge(clk) then
                 if chipselect = '1' and write = '1' then

                    if  flag = '0' then
                    chipselect_vga <= '0';
                           chipselect_sram<= '1';
                    write_abc <= '0';
                           sram_write<= '1';
                           read_abc  <= '0';
                           sram_read <= '0';
                           sram_writedata <= writedata;
                    address_abc <= "00000000000000000000";
                           sram_address <= address;

                       else
                           address_inf    <= address;
                      write_inf      <= writedata;
                           chipselect_vga <= '1';
                           chipselect_sram<='1';
                           write_abc <= '1';
                           read_abc <= '0';
                           sram_read<='1';
                           read_abc <= '0';
                         address_abc <= "00000000000000000000";
                           sram_address <= address_from_VGA;

      internal_readdata<=internal_readdata_sram_vga;
                       end if;

            else

                       chipselect_vga <= '1';
                           chipselect_sram<='1';
                           write_abc <= '1';
                           sram_write <= '0';
                           read_abc <= '0';
                           sram_read<='1';
                    address_abc <= "00000000000000000000";
                           sram_address <= address_from_VGA;-----
signal????
```

```
      internal_readdata<=internal_readdata_sram_vga;
                          end if;
            end if;
       end process;


--    V2:de2_sram_controller port map(
--     chipselect => chipselect_abc,
--     write => '0',
--     read =>  write_abc,
--     address => read_address,
--     readdata => internal_readdata_sram_vga,
--     writedata => writedata,
--     byteenable => byteenable,
--
--     SRAM_DQ   => SRAM_DQ,
--     SRAM_ADDR => SRAM_ADDR,
--     SRAM_UB_N => SRAM_UB_N,
--     SRAM_LB_N => SRAM_LB_N,
--     SRAM_WE_N => SRAM_WE_N,
--     SRAM_CE_N => SRAM_CE_N,
--     SRAM_OE_N => SRAM_OE_N
--     );
--    V2:de2_sram_controller port map(
--     chipselect => chipselect,
--     write => write,
--     read =>  read,
--     address => address,
--     readdata => readdata,
--     writedata => writedata,
--     byteenable => byteenable,
--
--     SRAM_DQ   => SRAM_DQ,
--     SRAM_ADDR => SRAM_ADDR,
--     SRAM_UB_N => SRAM_UB_N,
--     SRAM_LB_N => SRAM_LB_N,
--     SRAM_WE_N => SRAM_WE_N,
--     SRAM_CE_N => SRAM_CE_N,
--     SRAM_OE_N => SRAM_OE_N
--     );
--
  VGA_R<=internal_VGA_R;
  VGA_G<=internal_VGA_G;
  VGA_B<=internal_VGA_B;
  VGA_SYNC<=internal_VGA_SYNC;
  VGA_BLANK<=internal_VGA_BLANK;
  VGA_VS<=internal_VGA_VS;
  VGA_HS<=internal_VGA_HS;
  VGA_CLK<=internal_VGA_CLK;
--
```

```
--  process(clk)
--    begin
--       if rising_edge(clk) then
--            -- if write_enable = '1' then
--                 chipselect_vga <= '1';
--                 write_abc <= '1';
--                 internal_readdata <= internal_readdata_sram_vga;
--                 address_abc <= "0000000000000000000";
--                 read_sram <= '1';
--                        read_address <= address_from_VGA;
--           --elsif write_enable = '0' then
--
--            end if;
--    end process;


end architecture;
```