Phoenix: The Reboot

A System Design Project Created By:

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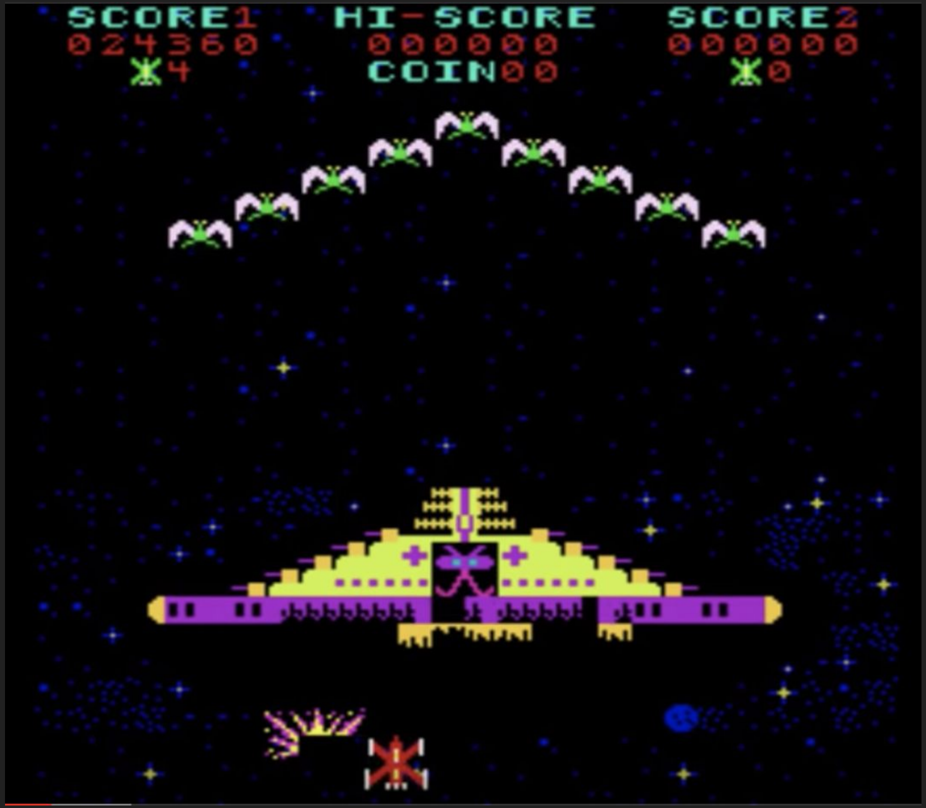
Phoenix

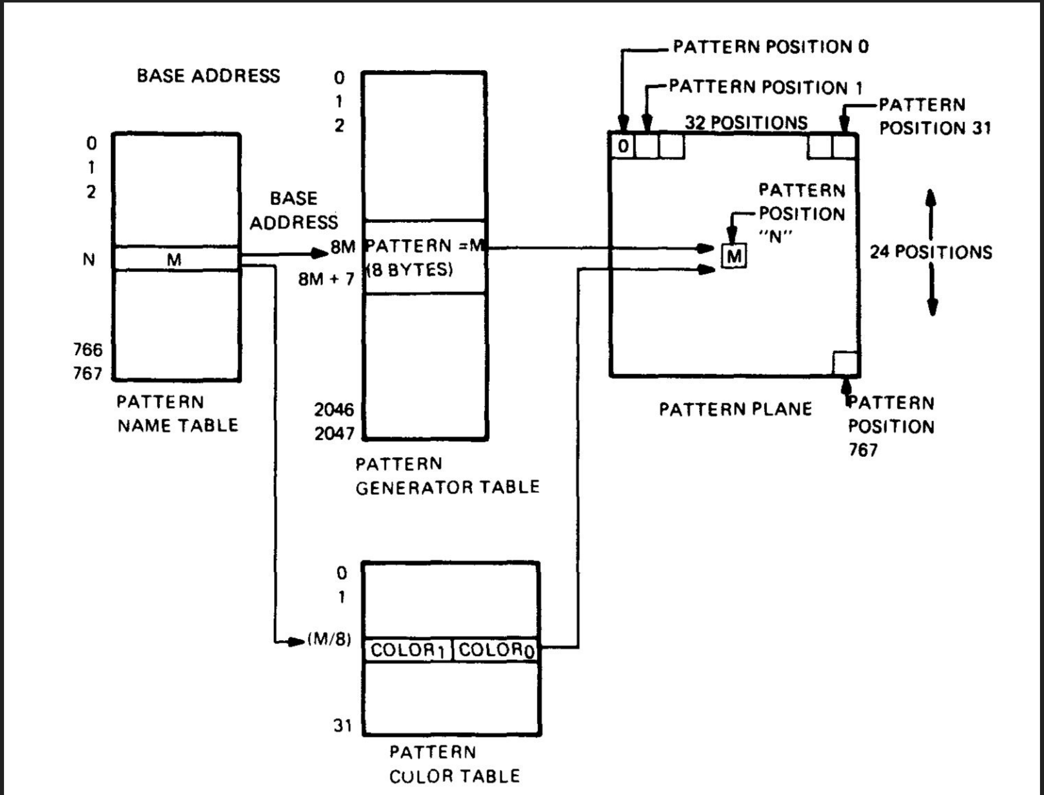
- Space-themed “slide and shoot” arcade game
- Game developed by Taito and Amstar Electronics in early 1980s
- Our original goal was to be able to implement one level of the game



Hardware

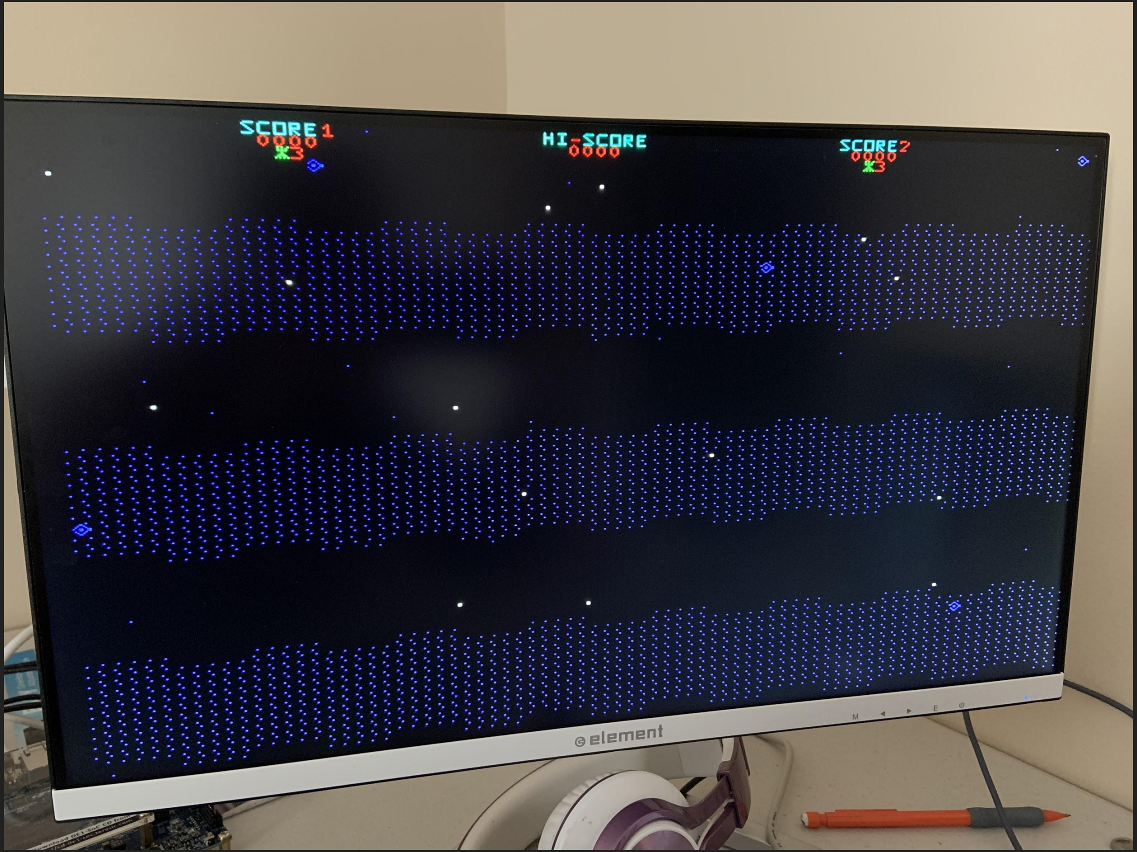
Hardware

- Hardware
  - Sprite and Tile generation based off of the TMS9918 video processor
  - Tile and Sprite modules in System Verilog code with generator table, name table, and color table
  - Priority encoder in the top level hardware module to decide whether sprites or tiles display on that

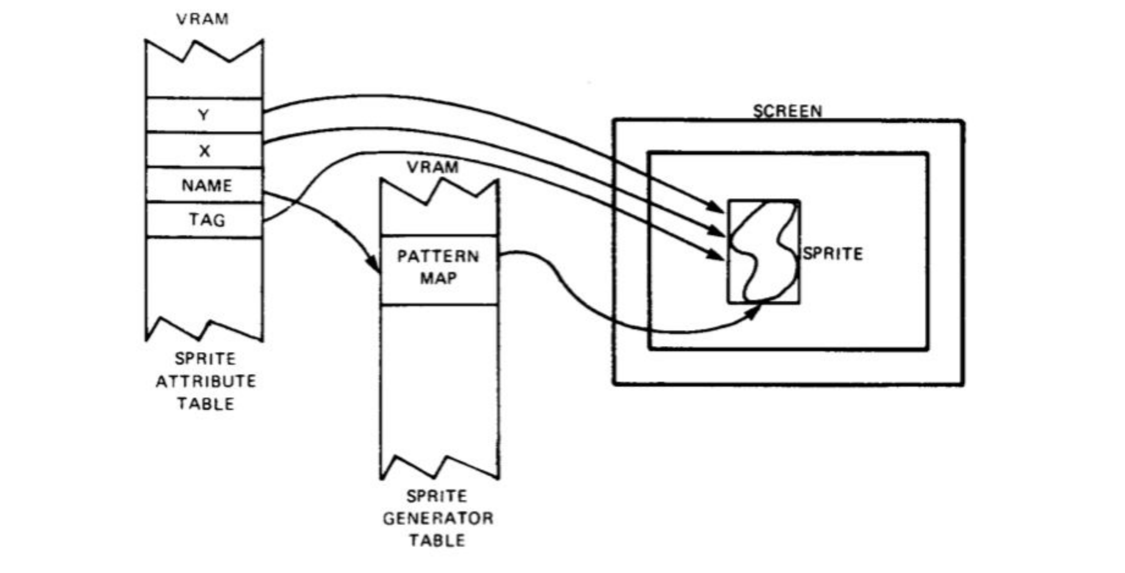


Background

- Created with Tile generator module
- Various tiles and color patterns referenced for different types of stars, letters, numbers



Sprites



Just like the TMS9918 document, we use this flow to build our sprites for display

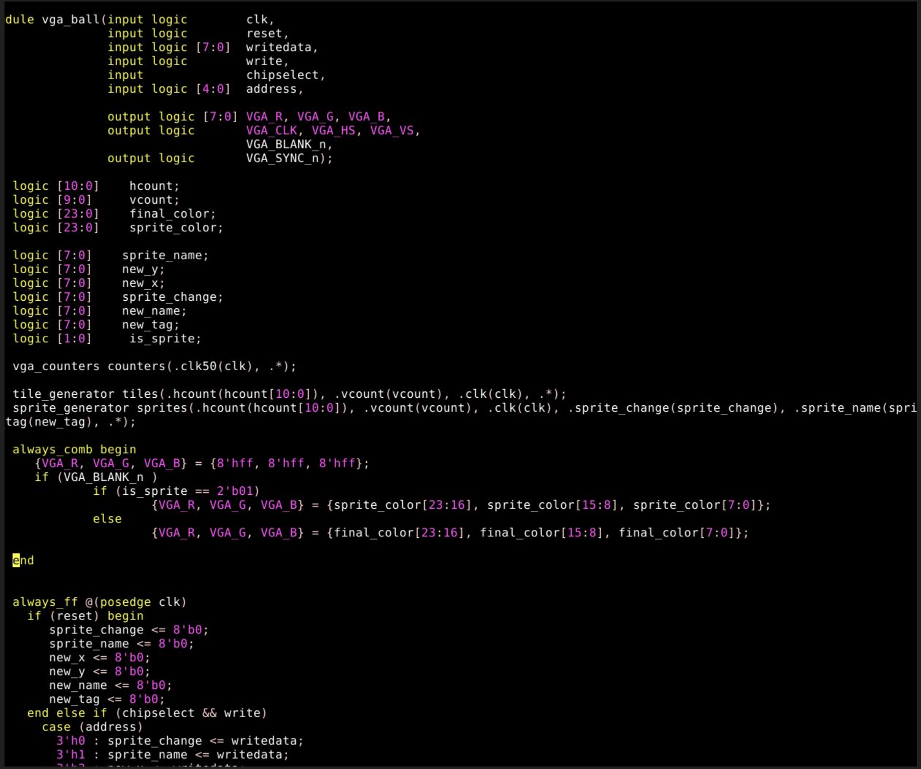
The Sprite Module

Separate module that works to generate the correct sprite colors if they are assigned to a certain position on the screen

- Table to hold the sprite positions
- Table to keep sprite patterns
- Table to hold the possible colors needed for design

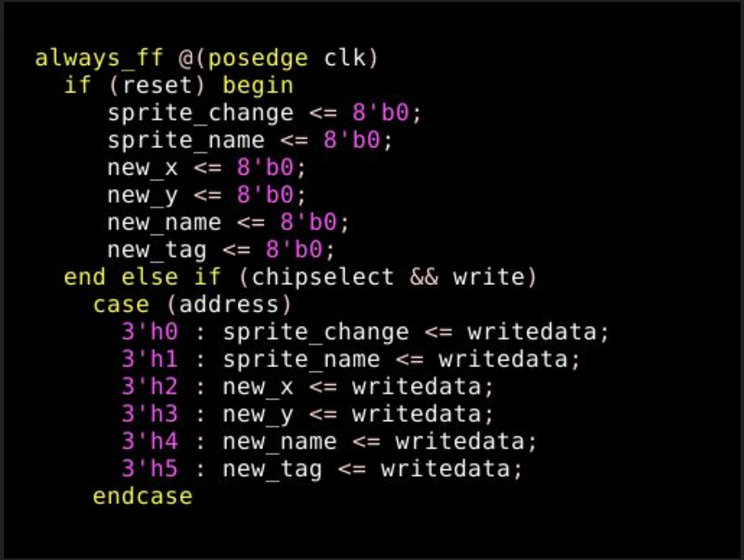
The VGA Display

From the output of the tile and sprite module, we use a priority encoder to decide which of the returned colors will take precedence on the screen



```
dule vga_ball(input logic        clk,
              input logic        reset,
              input logic [7:0]  writedata,
              input logic        write,
              input              chipselect,
              input logic [4:0]  address,

              output logic [7:0] VGA_R, VGA_G, VGA_B,
              output logic       VGA_CLK, VGA_HS, VGA_VS,
                                 VGA_BLANK_n,
              output logic       VGA_SYNC_n);

 logic [10:0]    hcount;
 logic [9:0]     vcount;
 logic [23:0]    final_color;
 logic [23:0]    sprite_color;

 logic [7:0]    sprite_name;
 logic [7:0]    new_y;
 logic [7:0]    new_x;
 logic [7:0]    sprite_change;
 logic [7:0]    new_name;
 logic [7:0]    new_tag;
 logic [1:0]     is_sprite;

 vga_counters counters(.clk50(clk), .*);

 tile_generator tiles(.hcount(hcount[10:0]), .vcount(vcount), .clk(clk), .*);
 sprite_generator sprites(.hcount(hcount[10:0]), .vcount(vcount), .clk(clk), .sprite_change(sprite_change), .sprite_name(spri
tag(new_tag), .*);

 always_comb begin
    {VGA_R, VGA_G, VGA_B} = {8'hff, 8'hff, 8'hff};
    if (VGA_BLANK_n )
            if (is_sprite == 2'b01)
                    {VGA_R, VGA_G, VGA_B} = {sprite_color[23:16], sprite_color[15:8], sprite_color[7:0]};
            else
                    {VGA_R, VGA_G, VGA_B} = {final_color[23:16], final_color[15:8], final_color[7:0]};

 end


 always_ff @(posedge clk)
   if (reset) begin
      sprite_change <= 8'b0;
      sprite_name <= 8'b0;
      new_x <= 8'b0;
      new_y <= 8'b0;
      new_name <= 8'b0;
      new_tag <= 8'b0;
   end else if (chipselect && write)
     case (address)
       3'h0 : sprite_change <= writedata;
       3'h1 : sprite_name <= writedata;
```

Controlling through Software

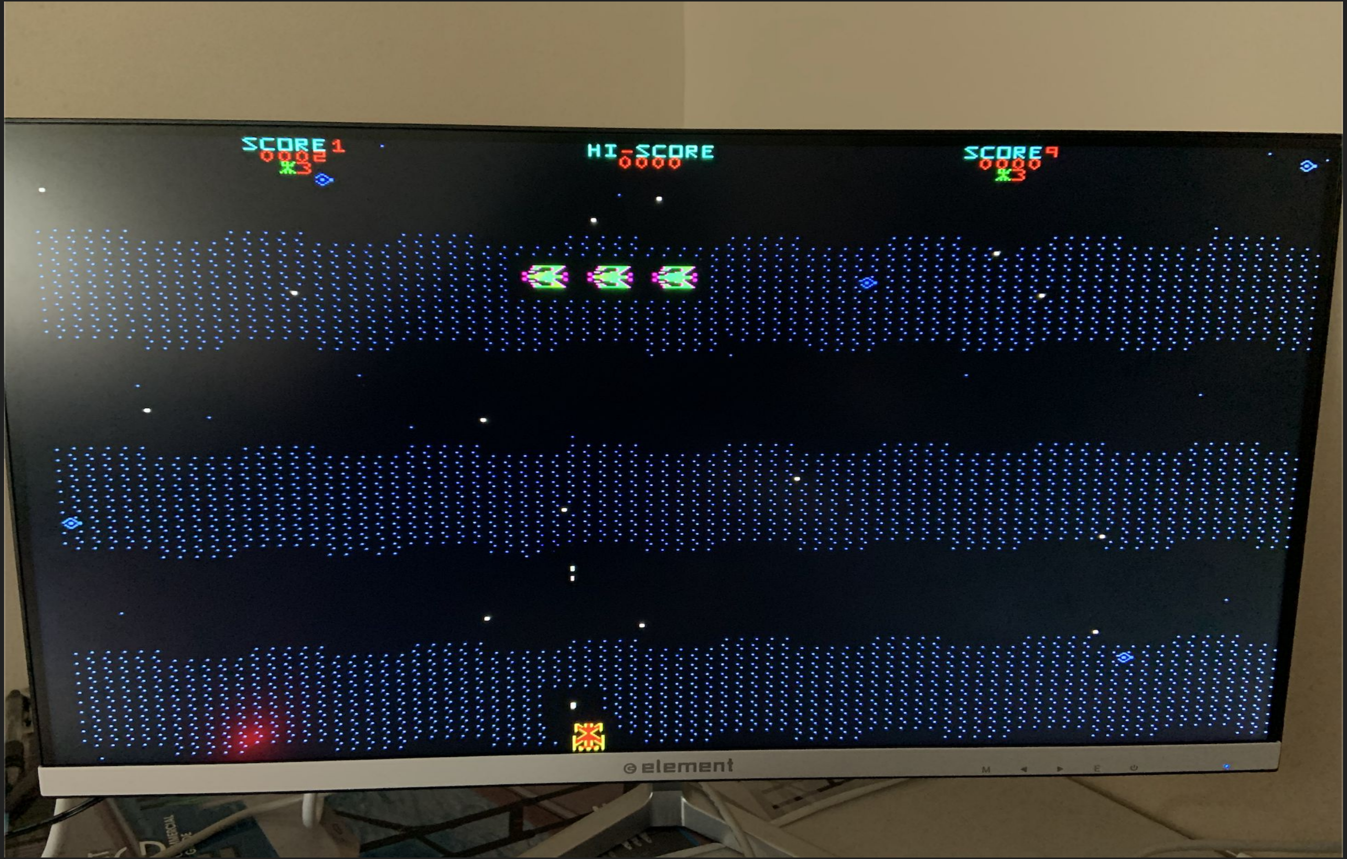


```
always_ff @(posedge clk)
  if (reset) begin
     sprite_change <= 8'b0;
     sprite_name <= 8'b0;
     new_x <= 8'b0;
     new_y <= 8'b0;
     new_name <= 8'b0;
     new_tag <= 8'b0;
  end else if (chipselect && write)
    case (address)
      3'h0 : sprite_change <= writedata;
      3'h1 : sprite_name <= writedata;
      3'h2 : new_x <= writedata;
      3'h3 : new_y <= writedata;
      3'h4 : new_name <= writedata;
      3'h5 : new_tag <= writedata;
    endcase
```

- Use methods from software to control the sprites and score on the screen. 5 inputs:
  - Sprite_change, sprite_num, new_x, new_y, new_name, new_tag
- Use a flip flop to both read the data coming from software and write the resulting data back to the sprite_att_table
- Data is being passed back and forth with the help of the Avalon bus

Software

Game Screen



Game Logic

- Different threads to handle sprite movements
- Birds move randomly - shoot when ship is directly below
- One thread to handle joystick input and move ship left/right
- Function to calculate collisions
- Sprites explode when hit - keep track of score & lives
- TIME_CONSTANT determines speed of the game

Handling collisions

- Checks if bullet sprite coordinates are within ship and/or bird sprite coordinates
- Return the name of the sprite that is hit
- One thread per bullet continuously calls this function

Score Manipulation

- Increment score whenever a collision occurs
- Changed from main thread

Live Demo