CHESS ON THE FPGA

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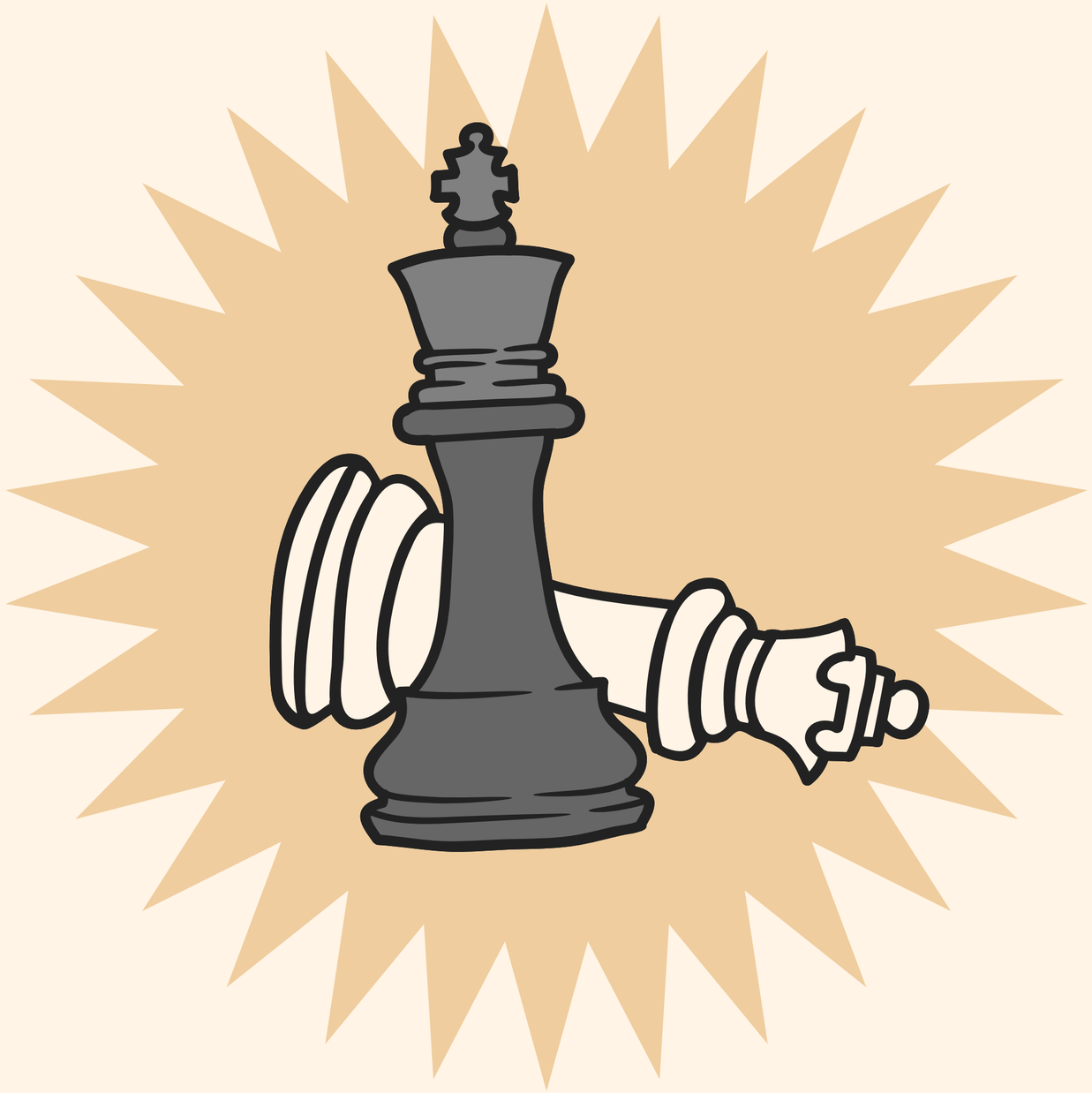


GOALS & MOTIVATION

- Create a pass n play game of chess on the FPGA using button inputs and the VGA display
- This design can be used for chess practice, fun among friends
- Chess is a notoriously difficult game to master, and we wanted get a different level of understanding about the game in order to improve

FUNCTIONALITY

What was the design supposed to do:

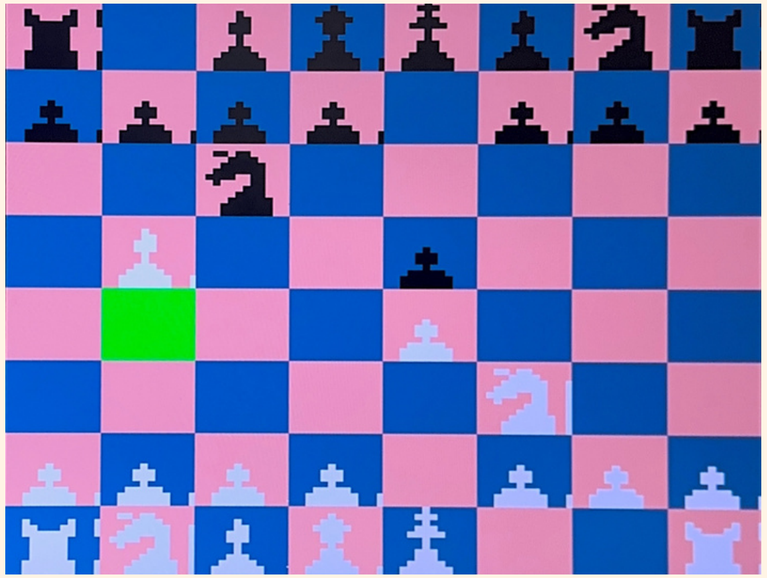
- **store the board as an array with 2 dimensions**
- **use an FSM to determine whether it is a pawn's first move to check if it can move 2 pieces**

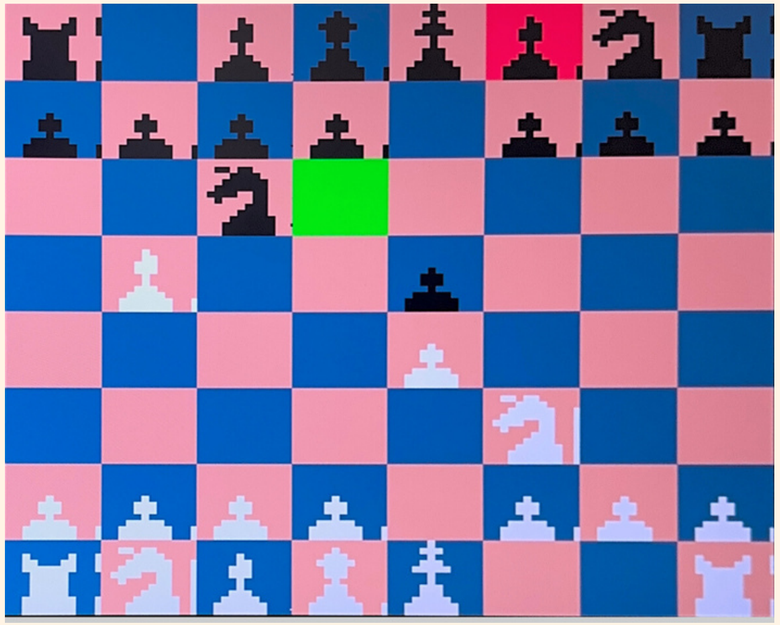
What we are doing:

- **store the board as a 256 bit register, and then convert to a board with 2 dimensions using genvar when necessary**
- **Using the pawn's coordinate to determine if movement is allowed;**

SPECIFICATIONS

- Display chess board on a VGA display that will update given player inputs
- Use button inputs to grab and move pieces
- Permit only allowed moves within the rules of chess
- Disallow moves which would cause a check
- Custom sprites for each piece
- Determine winner based on conditions such as checkmate, stalemate…





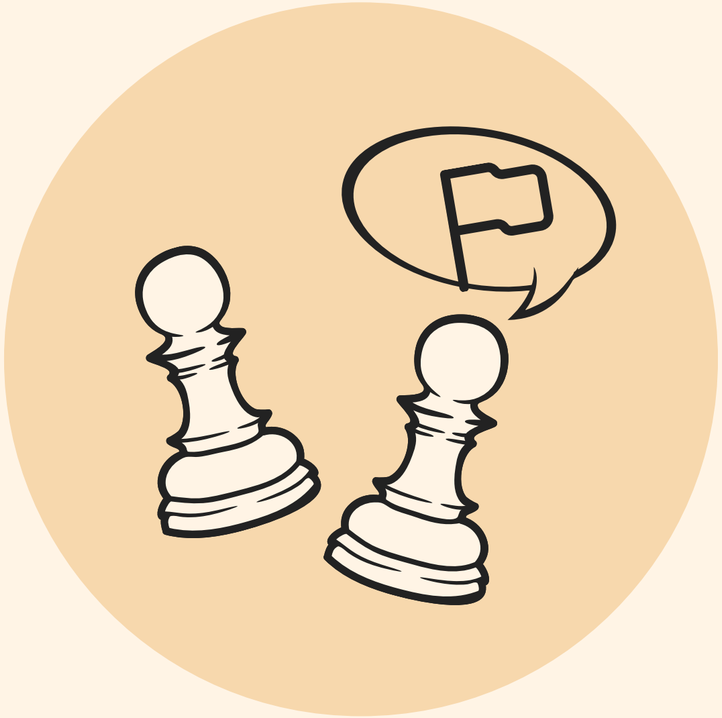
SUCCESSES

- VGA Display
- Button Inputs
- Grabbing Pieces
- Capturing
- Checking allowed moves
- Cursor
- Reset Functionality

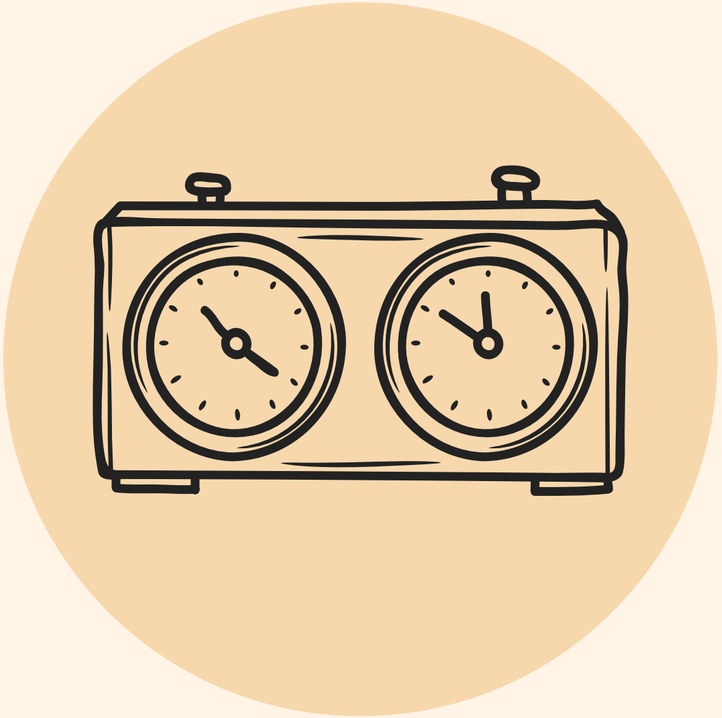
FUTURE IMPROVEMENTS

WIN CONDITIONS

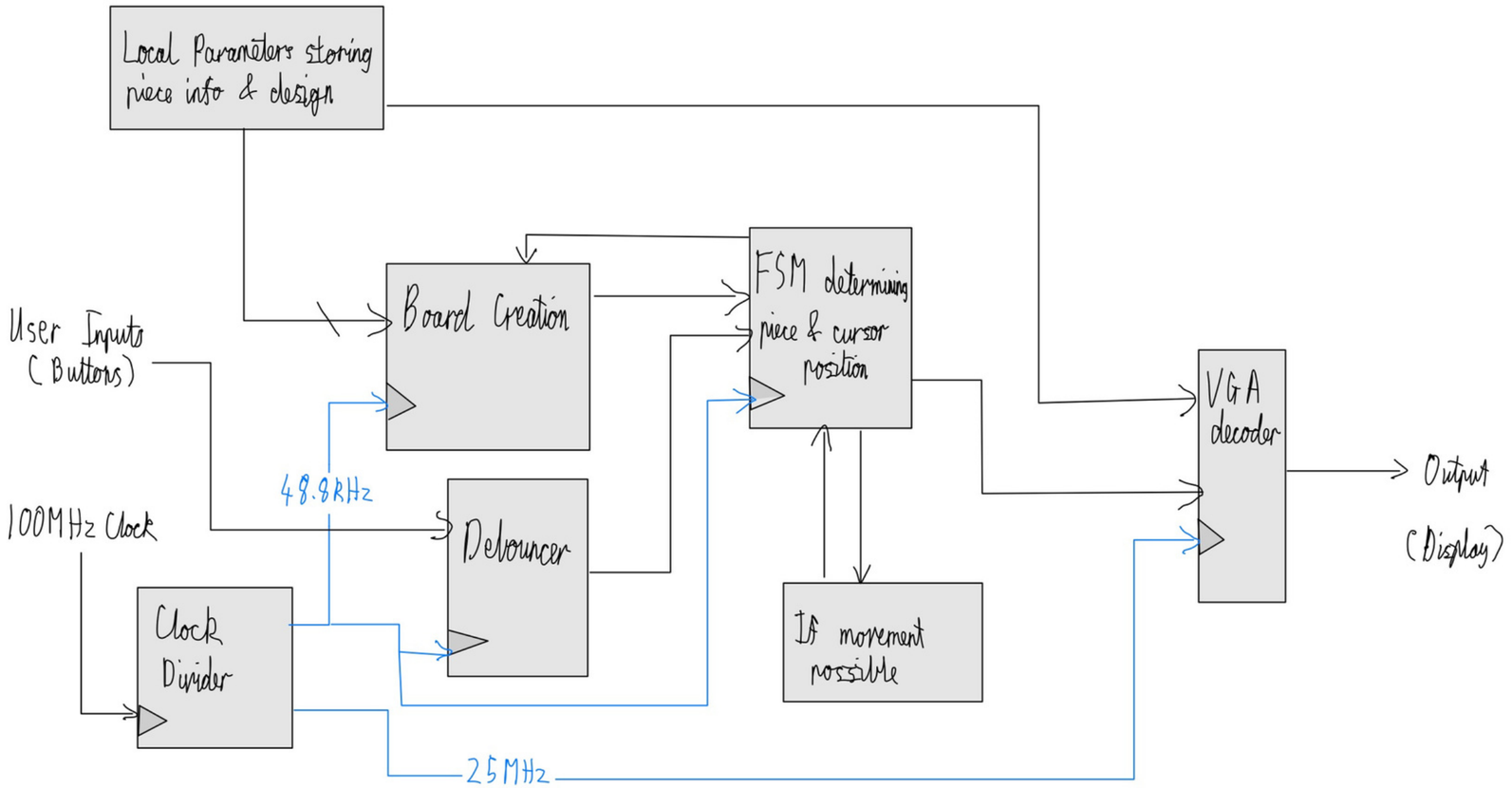
EN PASSANT



TIMING OUT



BLOCK DIAGRAM



CODE SNIPPETS

TOP

```
module top(
    input boardCLK,
    output [3:0] redVGA,
    output [3:0] greenVGA,
    output [3:0] blueVGA,
    input BTNC, BTNU, BTND, BTNR, BTNL,
    input resetSwitch,
    output horizontalVGA,
    output verticalVGA
    );

    //Reset
    wire reset;
    assign reset = resetSwitch;

    //Clock Management
    wire vgaCLK, gameCLK;
    clock_divider divide(.boardCLK(boardCLK), .vgaCLK(vgaCLK), .gameCLK(gameCLK), .reset(reset));

    //Button Management
    wire cleanBTNC, cleanBTNU, cleanBTND, cleanBTNR, cleanBTNL;
    button_debouncer debounceUp(.clk(gameCLK), .reset(reset), .BTN(BTNU), .clean(cleanBTNU));
    button_debouncer debounceDown(.clk(gameCLK), .reset(reset), .BTN(BTND), .clean(cleanBTND));
    button_debouncer debounceRight(.clk(gameCLK), .reset(reset), .BTN(BTNR), .clean(cleanBTNR));
    button_debouncer debounceLeft(.clk(gameCLK), .reset(reset), .BTN(BTNL), .clean(cleanBTNL));
    button_debouncer debounceCenter(.clk(gameCLK), .reset(reset), .BTN(BTNC), .clean(cleanBTNC));

    //Game Logic
    wire [255:0] board;
    wire [12:0] moveData;

    board create(                                                                    //rename t
    .reset(reset),
    .clk(gameCLK),
    .BTNC(cleanBTNC), .BTNU(cleanBTNU), .BTND(cleanBTND), .BTNR(cleanBTNR), .BTNL(cleanBTNL),
    .board(board), .moveData(moveData)
    );

    //Display on the VGA
    vga_paint paint(
    .board(board),
    .moveData(moveData),
    .clk(boardCLK),                                                 //changed vgaCLK
    .reset(reset),
    .greenVGA(greenVGA), .blueVGA(blueVGA), .redVGA(redVGA), .horizontalVGA(horizontalVGA), .verticalVGA(verticalVGA)
    );

endmodule
```

ENCODINGS

```
localparam WHITETILECOLOR = 12'b111010101001;
localparam CURSORTILECOLOR = 12'b000011110011;
localparam SELECTEDTILECOLOR = 12'b111101010110;
localparam BLACKPIECECOLOR = 12'b000100010011;
localparam WHITEPIECECOLOR = 12'b111011101111;

//Storing piece data and design
localparam WHITE = 1'b0;
localparam BLACK = 1'b1;
localparam EMPTY = 3'b000;
localparam KING = 3'b001;
localparam QUEEN = 3'b010;
localparam BISHOP = 3'b011;
localparam KNIGHT = 3'b100;
localparam ROOK = 3'b101;
localparam PAWN = 3'b110;

localparam [120:0] pawn =
    121'b00000000000_00000000000_10000000000_11000000000_11011000000_11111100000_11011000000_11000000000_10000000000_000

localparam [120:0] rook =
    121'b00000000000_00000000000_11000011100_11111111000_11111110000_11111110000_11111110000_11111111000_11000011100_000

localparam [120:0] bishop =
    121'b00000000000_00000000000_10000000000_11000000000_11100111000_11111111100_11100110000_11000000000_10000000000_000

localparam [120:0] knight =
    121'b00000000000_11000000000_11111111000_11111111100_11110011110_11100011110_11000111100_10000111010_00001110010_000

localparam [120:0] king =
    121'b00000000000_00000000000_10000000000_11000010000_11110011010_11111111111_11110011010_11000010000_10000000000_000

localparam [120:0] queen =
    121'b00000000000_00000000000_10000000000_11000001000_11110111100_11111111110_11110111100_11000001000_10000000000_000
```

```
module board(
    input reset,
    input clk, //25 MHz
    input BTNC, BTNU, BTND, BTNR, BTNL,
    output wire [255:0] board,
    output wire [12:0] moveData
    );

    //Define local parameters
    //wire allowMove = 1;                                    //TESTING wire allowMove;
    wire [10:0] changePiece;
    wire [2:0] currentState;

    //Run the State Machine
    user_state play(.clk(clk), .reset(reset), .allowMove(allowMove), .entireBoard(board),
    .BTNC(BTNC), .BTNU(BTNU), .BTND(BTND), .BTNR(BTNR), .BTNL(BTNL),
    .changePiece(changePiece), .moveData(moveData), .currentState(currentState));

    //Check if move is legal
    allow_move check(.allowMove(allowMove), .moveData(moveData));                                    //TESTING

    //Generate the board/Move the pieces
    build_board build(.clk(clk), .boardPass(board), .changePiece(changePiece), .currentState(currentState));    //TESTING try no boardPass

endmodule
```

GAMELOGIC

Lines of Code per File
<1560 total>

top.v	clock_divider.v	button_debouncer.v	checkAllow.v	checkDistance.v	vga_paint.v
70	46	91	55	413	392
board.v	build_board.v	user_state.v	checkPath.v	checkSquare.v	vga_generator.v
47	139	141	55	41	70

THANK YOU FOR LISTENING

LET'S PLAY CHESS!