

ELC 2137 Lab 9: ALU

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Summary

Results

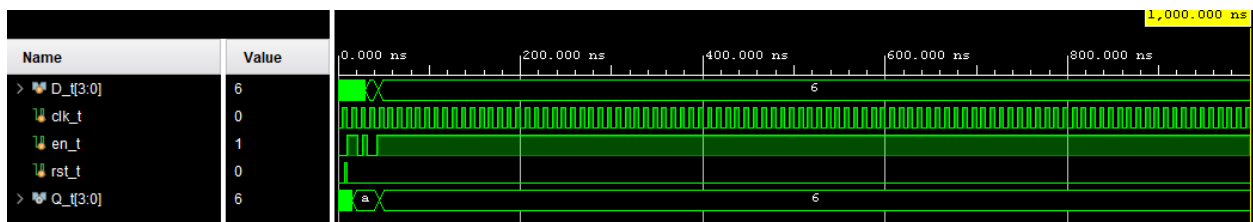


Figure 1: register simulation waveform

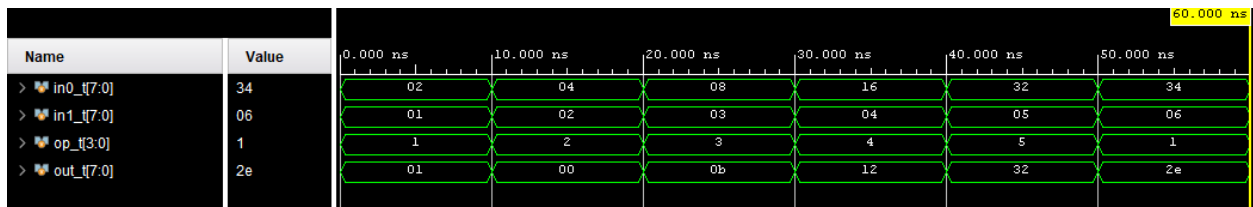


Figure 2: alu simulation waveform

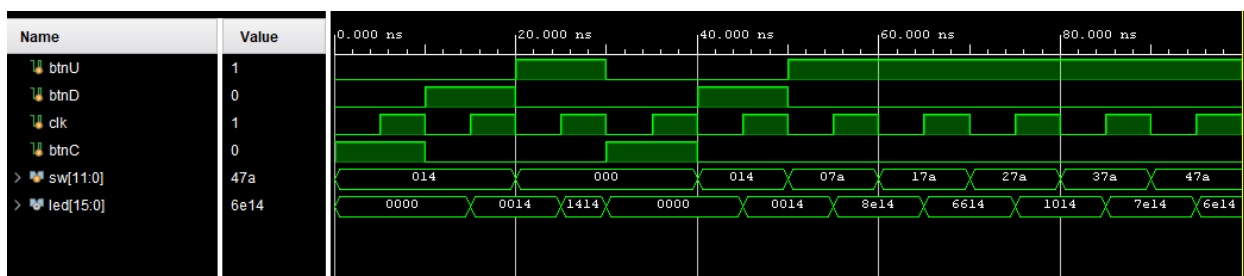


Figure 3: top level simulation waveform

Expected results tables

Code

Figure 4: 14 displayed in hexadecimal

Table 1: *register* expected results table

Time (ns):	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55
D (hex)	0	0	A	A	3	3	0	0	0→6	6	6
clk	0	1	0	1	0	1	0	1	0	1	0
en	0	0	1	1	1→0	0→1	1→0	0	0→1	1	1
rst	0	0→1	0	0	0	0	0	0	0	0	0
Q (hex)	X	X→0	A	A	A	A	A	A	6	6	6

Listing 1: register code

```

`timescale 1ns / 1ps
//
// //////////////////////////////////////
//
// Company:
// Engineer:
//
// Create Date: 10/22/2020 11:19:22 AM
// Design Name:
// Module Name: register
// Project Name:
// Target Devices:
// Tool Versions:
// Description:
//
// Dependencies:
//
// Revision:
// Revision 0.01 - File Created
// Additional Comments:
//
//
// //////////////////////////////////////

module register #(parameter N=1)(
    input clk,
    input rst,
    input en,
    input [N-1:0] D,
    output reg [N-1:0] Q
);

    always @ (posedge clk, posedge rst)
        if (rst==1)
            Q <= 0;
        else if (en==1)

```

Table 2: *alu* expected results table skeleton

Time (ns):	0-10	10-20	20-30	30-40	40-50	50-60
in0 0	2	4	8	16	32	34
in1 0	1	2	3	4	5	6
op 0	1	2	3	4	5	1
out 0	1	0	11/b	12	32	2e

```

        Q <= D;
endmodule

```

Listing 2: register testbench code

```

`timescale 1ns / 1ps
//
// //////////////////////////////////////
//
// Company:
// Engineer:
//
// Create Date: 10/22/2020 11:23:18 AM
// Design Name:
// Module Name: register_testbench
// Project Name:
// Target Devices:
// Tool Versions:
// Description:
//
// Dependencies:
//
// Revision:
// Revision 0.01 - File Created
// Additional Comments:
//
//
// //////////////////////////////////////

module register_testbench();

reg [3:0] D_t;
reg clk_t, en_t, rst_t;
wire [3:0] Q_t;

register #(N(4)) dut(
    .clk(clk_t),
    .rst(rst_t),
    .en(en_t),
    .D(D_t),
    .Q(Q_t)
);

```

```

always begin
    clk_t = ~clk_t; #5;
end

initial begin
    clk_t = 0; en_t = 0; rst_t = 0; D_t = 4'h0; #7;
    rst_t = 1; #3;
    D_t = 4'hA; en_t = 1; rst_t = 0; #10;
    D_t = 4'h3; #2;
    en_t = 0; #5;
    en_t = 1; #3;
    D_t = 4'b0; #2;
    en_t = 0; #10;
    en_t = 1; #2;
    D_t = 4'h6; #11;
end

endmodule

```

Listing 3: alu code

```

`timescale 1ns / 1ps
//
// //////////////////////////////////////
// Company:
// Engineer:
//
// Create Date: 10/22/2020 11:44:04 AM
// Design Name:
// Module Name: alu
// Project Name:
// Target Devices:
// Tool Versions:
// Description:
//
// Dependencies:
//
// Revision:
// Revision 0.01 - File Created
// Additional Comments:
//
//
// //////////////////////////////////////

module alu #(parameter N=8)(
    input [N-1:0] in0,
    input [N-1:0] in1,
    input [3:0] op,
    output reg[N-1:0] out
);

```

```

        parameter ADD = 0;
        parameter SUB = 1;
        parameter AND = 2;
        parameter OR  = 3;
        parameter XOR = 4;

always @*
    begin
        case(op)
            ADD: out = in0 + in1;
            SUB: out = in0 - in1;
            AND: out = in0 & in1;
            OR : out = in0 | in1;
            XOR: out = in0 ^ in1;
            default: out = in0;
        endcase
    end

endmodule

```

Listing 4: alu testbench code

```

`timescale 1ns / 1ps
//
// //////////////////////////////////////
//
// Company:
// Engineer:
//
// Create Date: 10/22/2020 11:23:18 AM
// Design Name:
// Module Name: register_testbench
// Project Name:
// Target Devices:
// Tool Versions:
// Description:
//
// Dependencies:
//
// Revision:
// Revision 0.01 - File Created
// Additional Comments:
//
//
// //////////////////////////////////////
//

module alu_testbench();
    reg [7:0] in0_t;
    reg [7:0] in1_t;
    reg [3:0] op_t;

```



```

input btnC,
output [15:0] led
);

wire [7:0] reg1_out;
wire [7:0] alu_out;

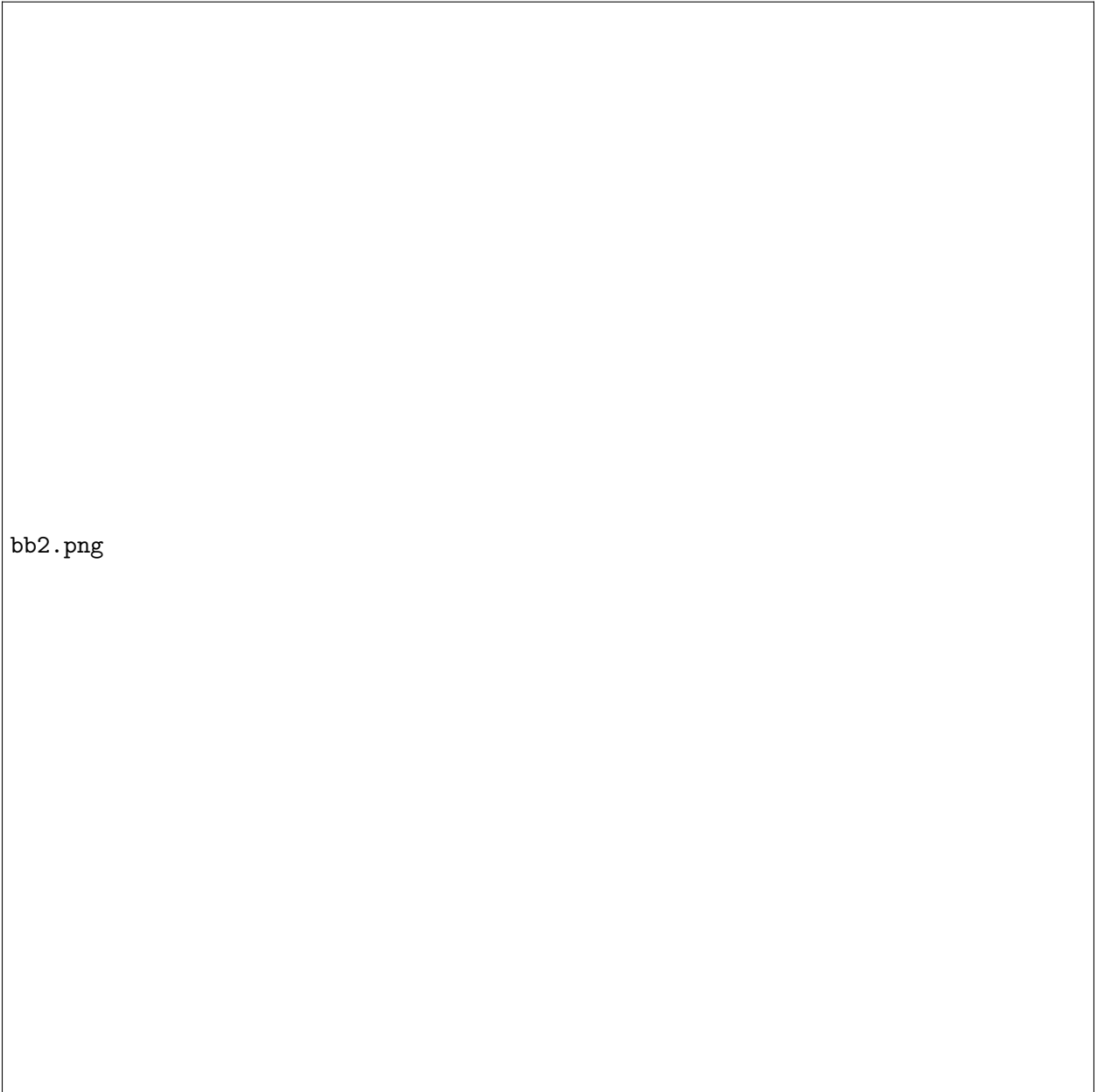
register #(.N(8)) Reg1 (
    .clk(clk),
    .rst(btnC),
    .en(btnD),
    .D(sw[7:0]),
    .Q(reg1_out)
);
assign led [7:0] = reg1_out;

alu      ALU (
    .in0(sw[7:0]),
    .in1(reg1_out),
    .op(sw[11:8]),
    .out(alu_out)
);

register #(.N(8)) Reg2 (
    .clk(clk),
    .en(btnU),
    .rst(btnC),
    .D(alu_out),
    .Q(led [15:8])
);

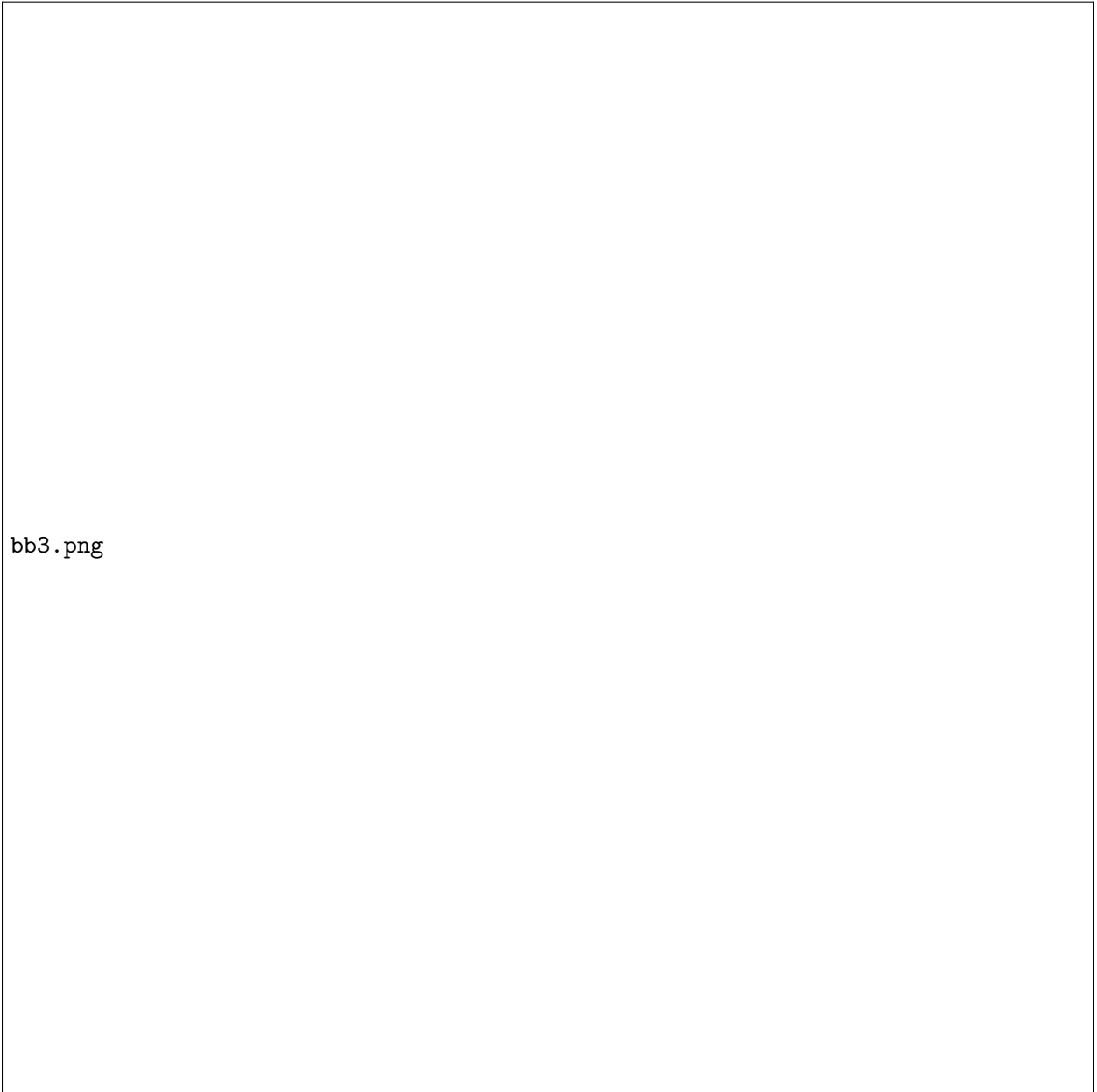
endmodule

```



bb2.png

Figure 5: 1414 displayed in leds



bb3.png

Figure 6: addition displayed on leds

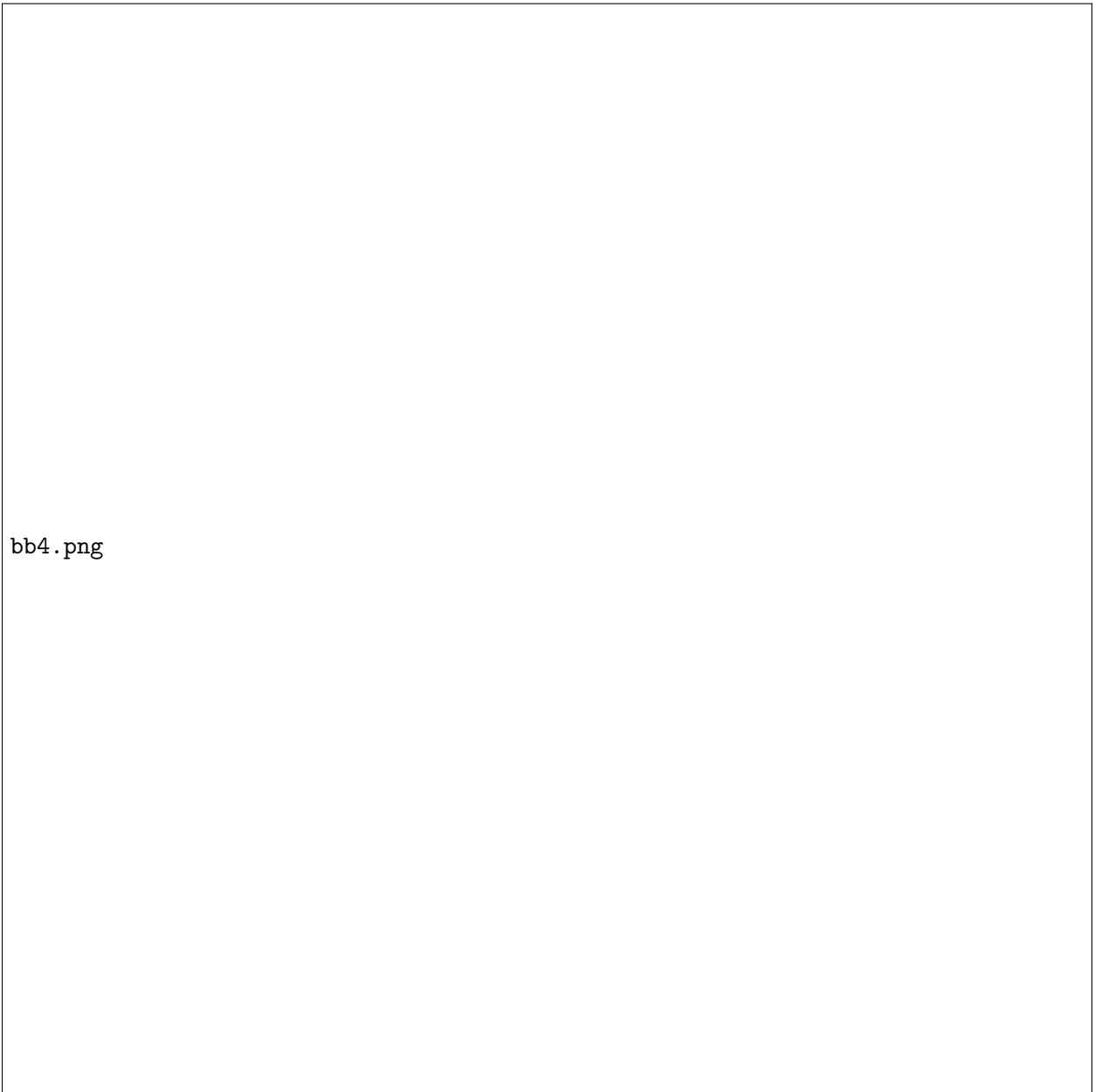


Figure 7: register simulation waveform

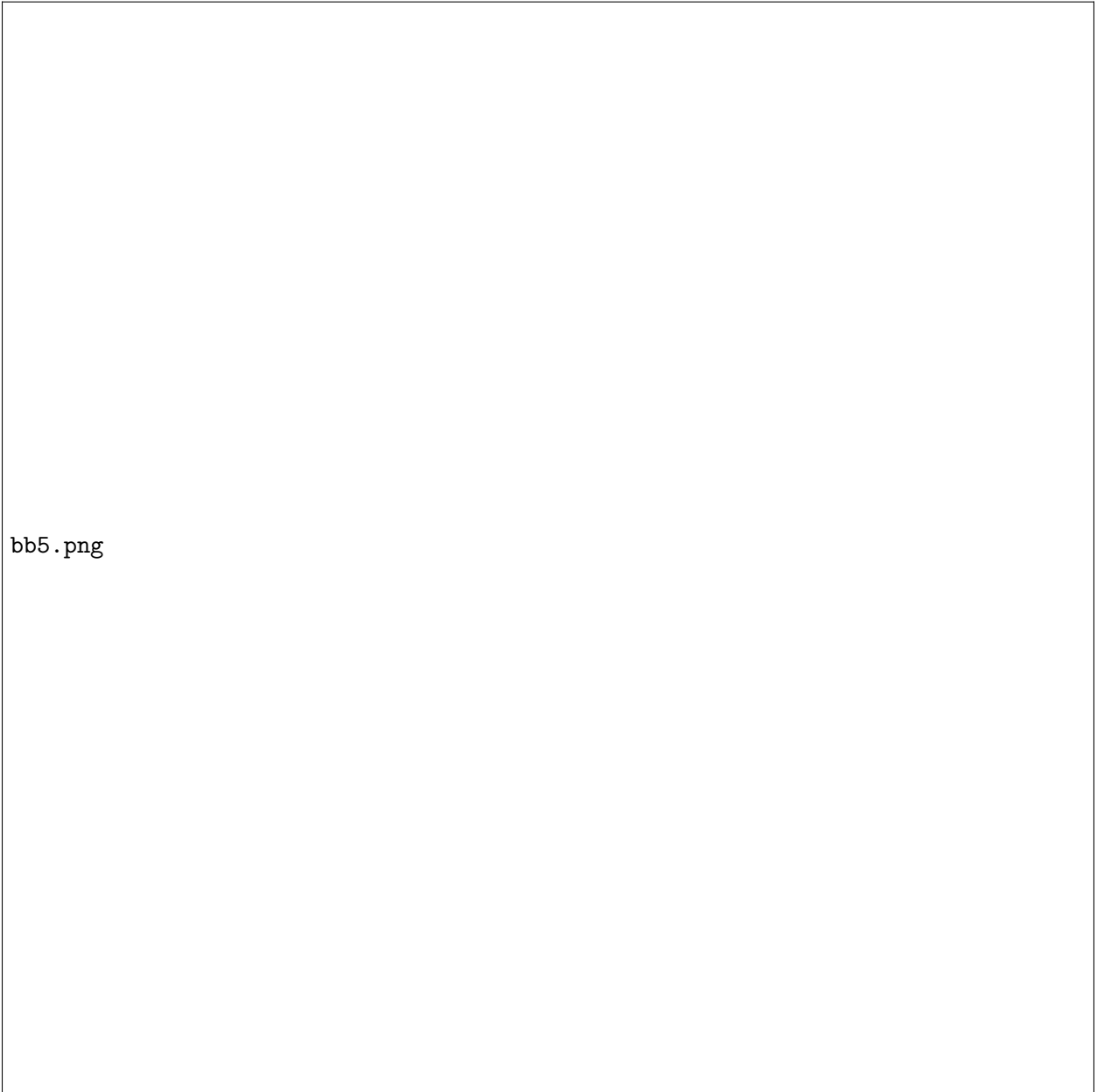


Figure 8: register simulation waveform

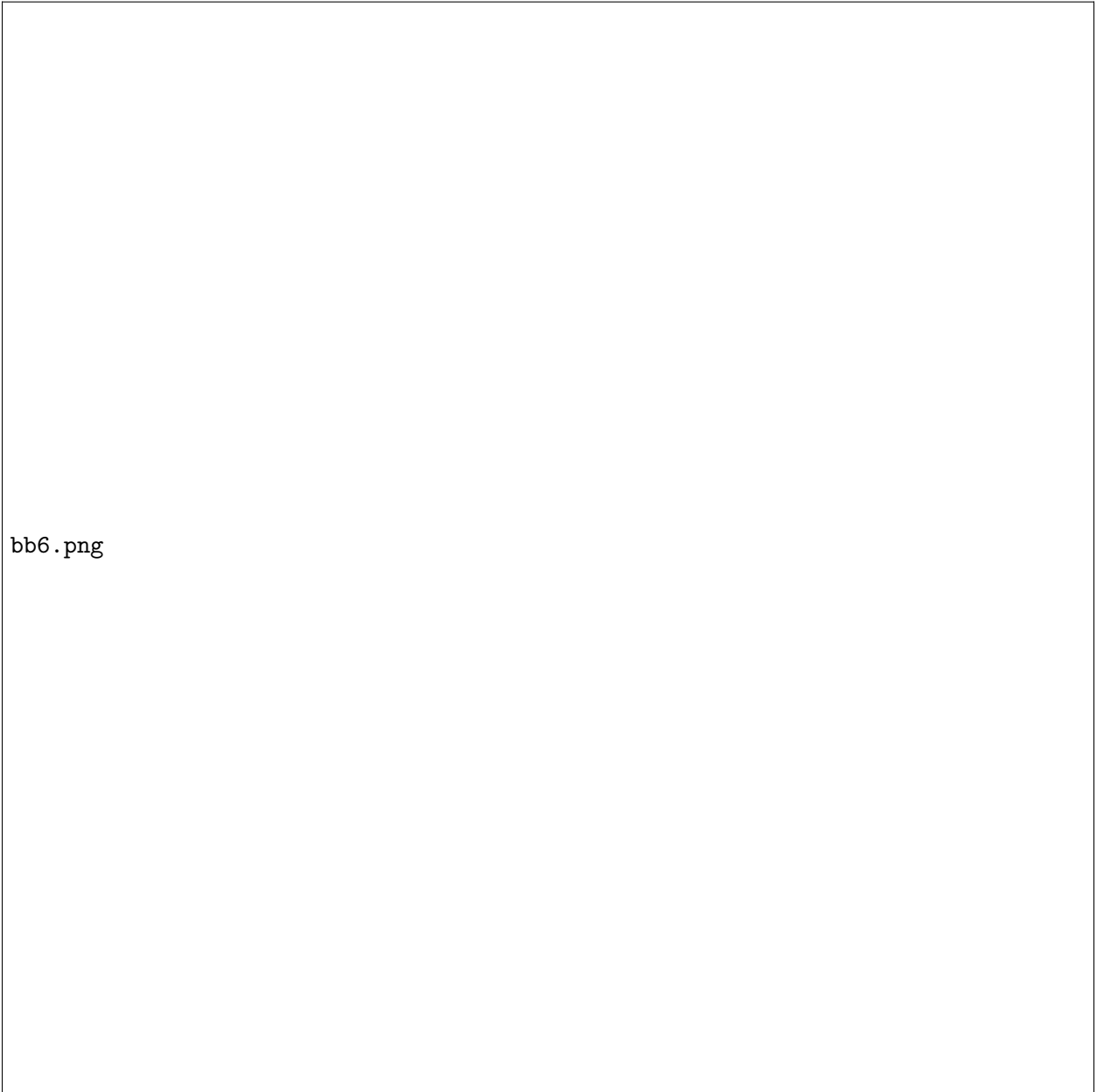
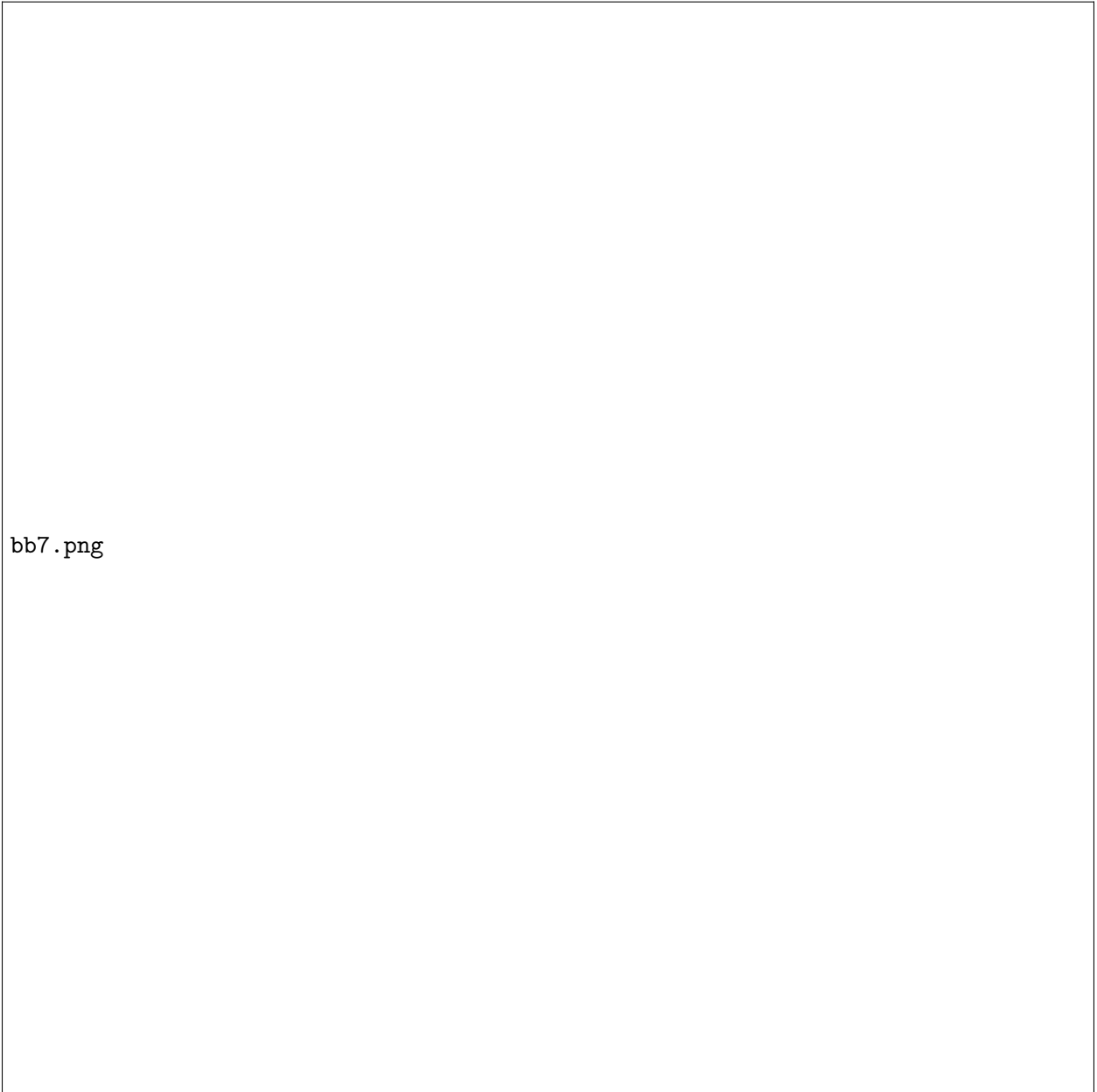
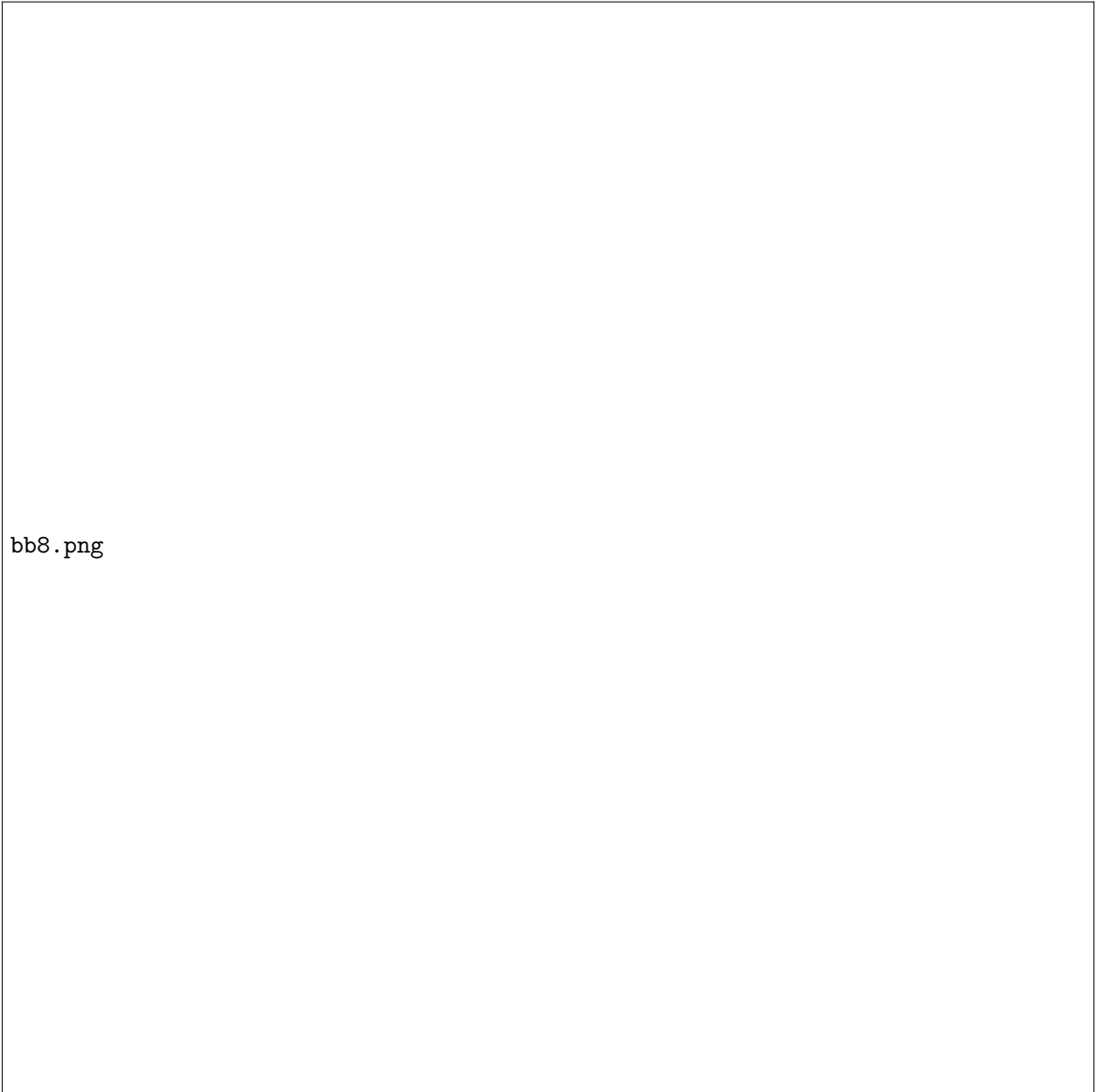


Figure 9: register simulation waveform



bb7.png

Figure 10: register simulation waveform



bb8.png

Figure 11: register simulation waveform