

ELC 2137 Lab 7: Binary Coded Decimal

CJ Jones, Jake Simmons

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Summary

This lab explored using a Basys3 board to produce an 8-bit number on a 7-segment display through a MUX combinational logic design. This lab produced a cheat button that turns the display from hex to decimal, and back because of the difficulty of reading the decimal numbers. Using Verilog, some skills gained in this lab include: writing a multiplexer utilizing the conditional operator, use the double-dabble algorithm to convert hex values into BCD, using multi-bit signals, using constraint files, and creating a design on a FPGA board. Overall, this lab demonstrated how to utilize software and programmable logic to produce a hardware output.

Results

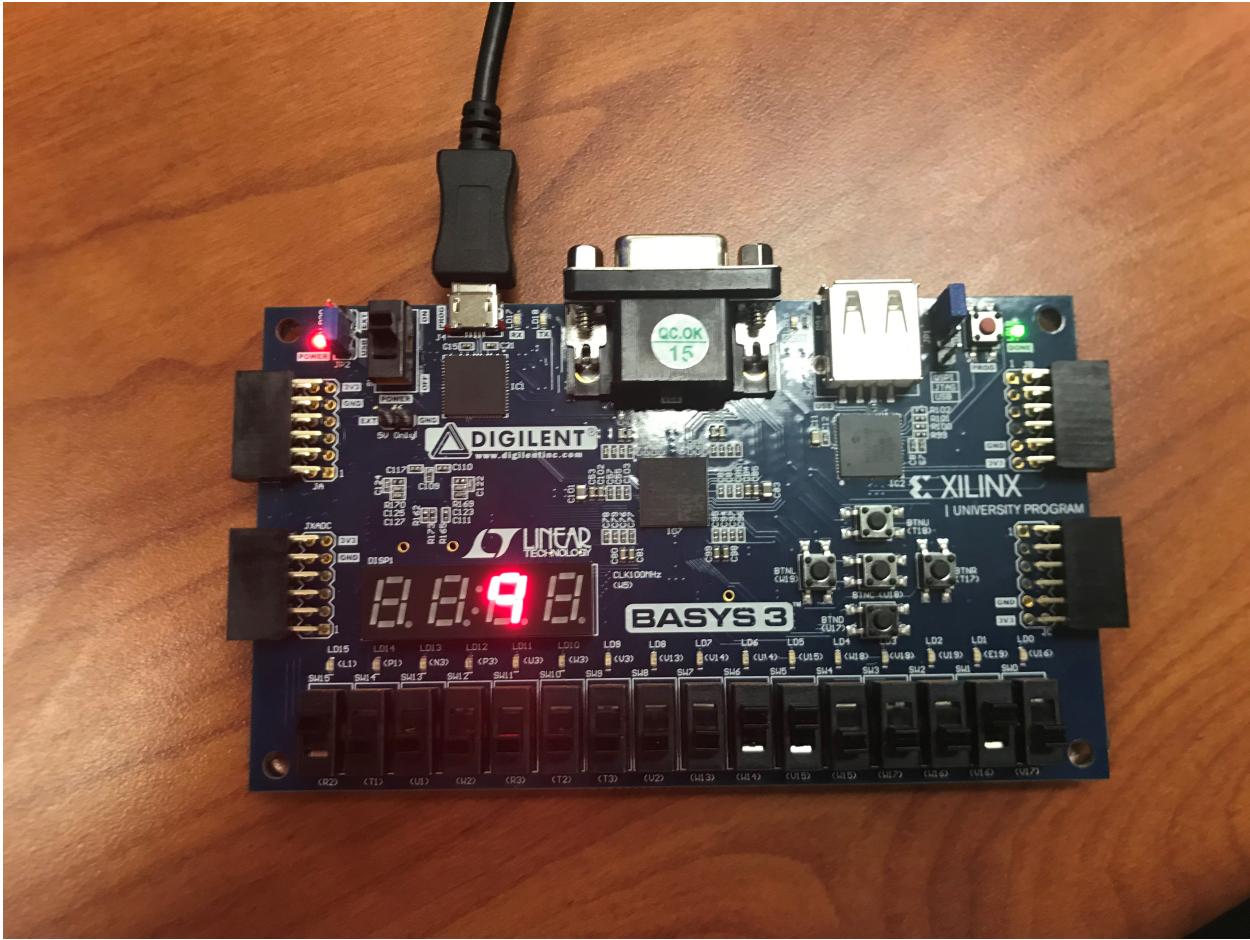


Figure 1: Picture of board

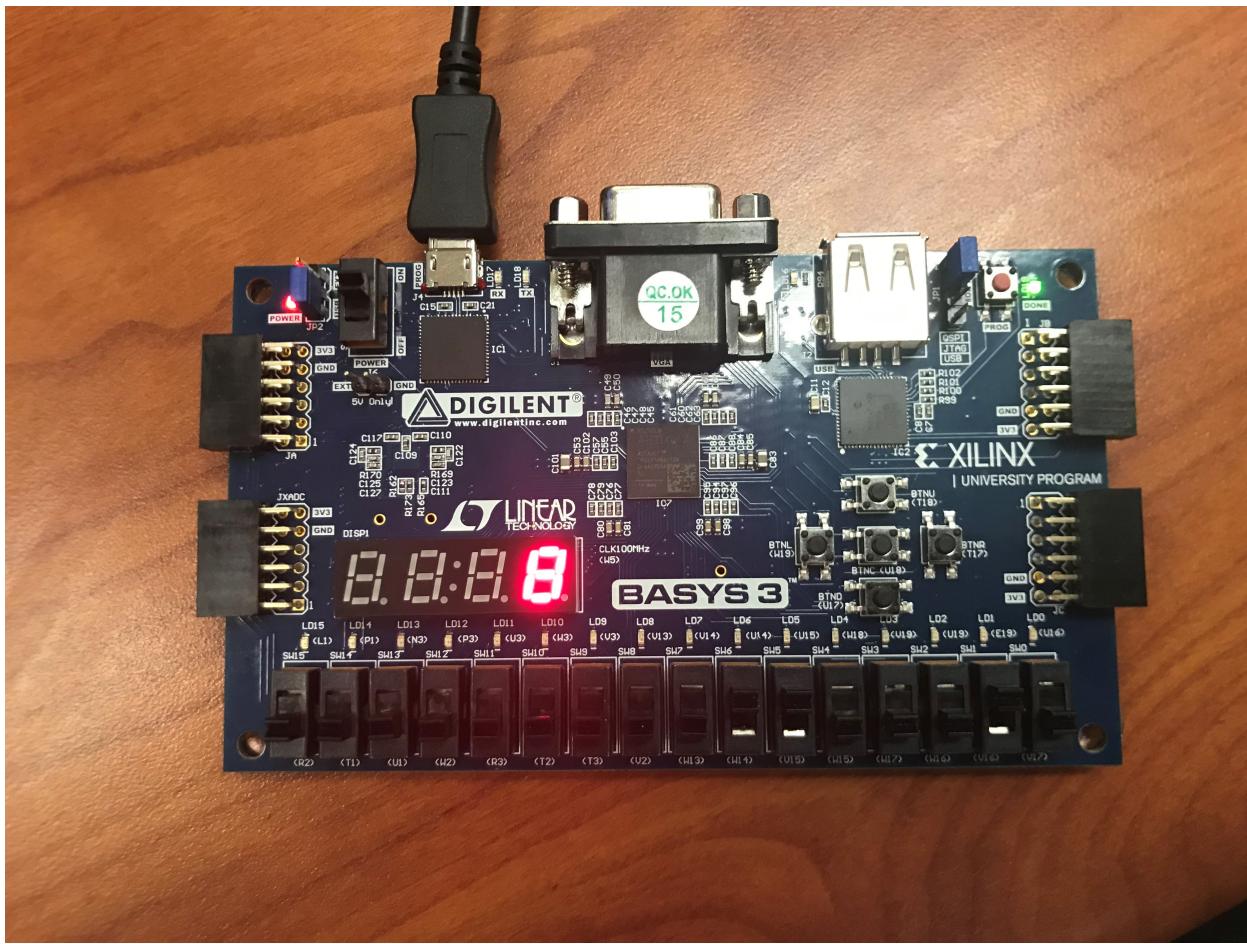


Figure 2: Picture of Board

Time (ns):	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
B	0	1	2	3	4	5	6	7	8	9	a	b	c	d	e
O	0	1	2	3	4	8	9	a	b	c	d	e	f	0	1

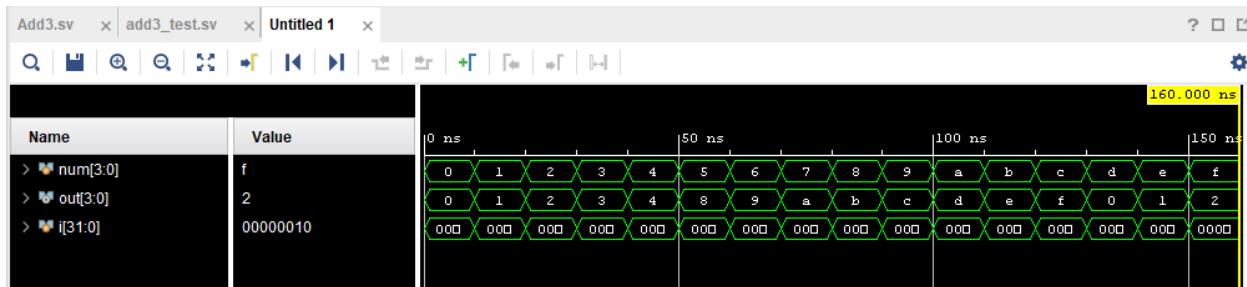


Figure 3: Add3 simulation waveform and ERT

	Time (ns): 0 10 20 610 620 630					
Input	0	1	2	3c	3d	3e
Output	0	1	2	60	61	62

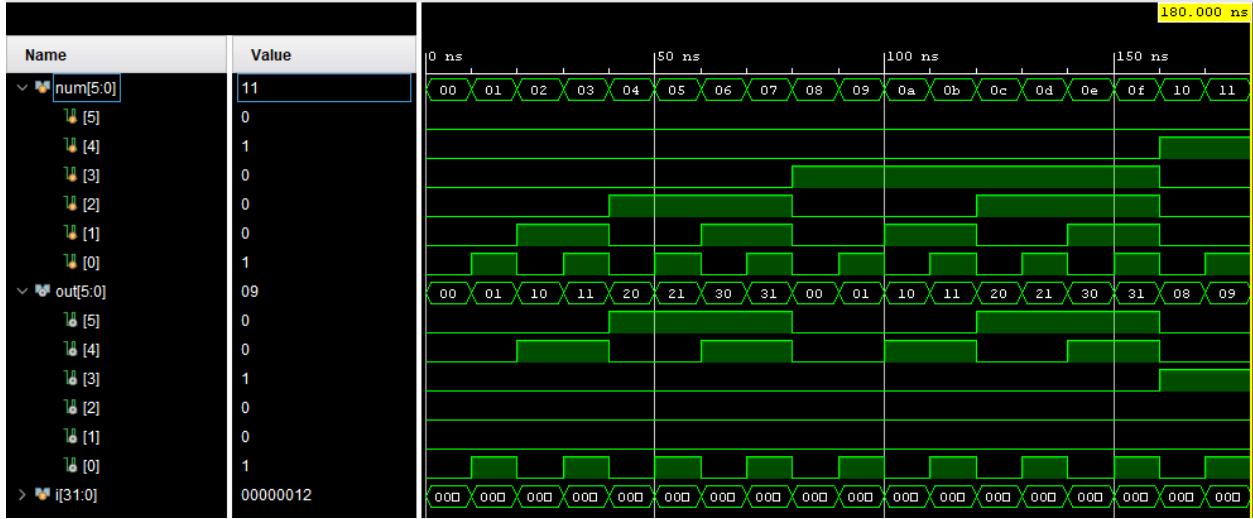


Figure 4: BCD6 simulation waveform and ERT

	Time (ns): 0 10 20 970 980 990					
Input	0	1	2	61	62	63
Output	0	1	2	897	898	899

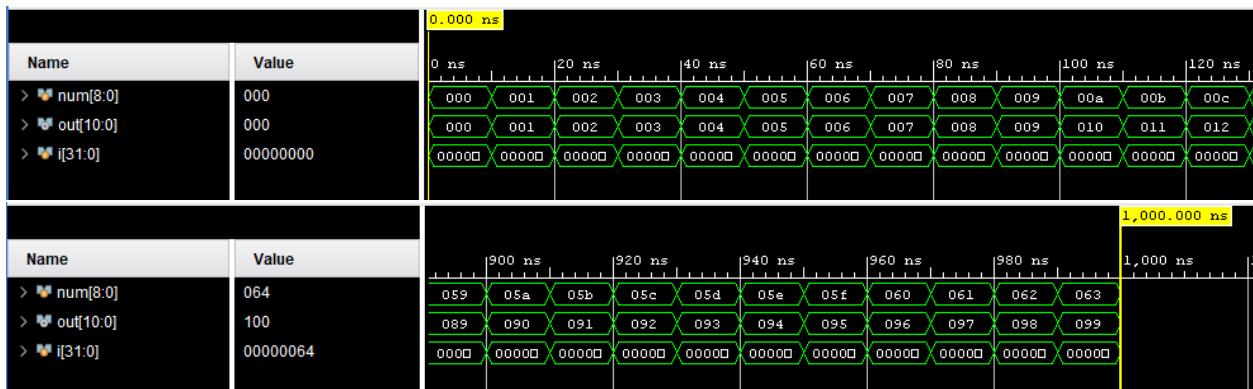


Figure 5: BCD11 simulation waveform and ERT

11-bit BCD

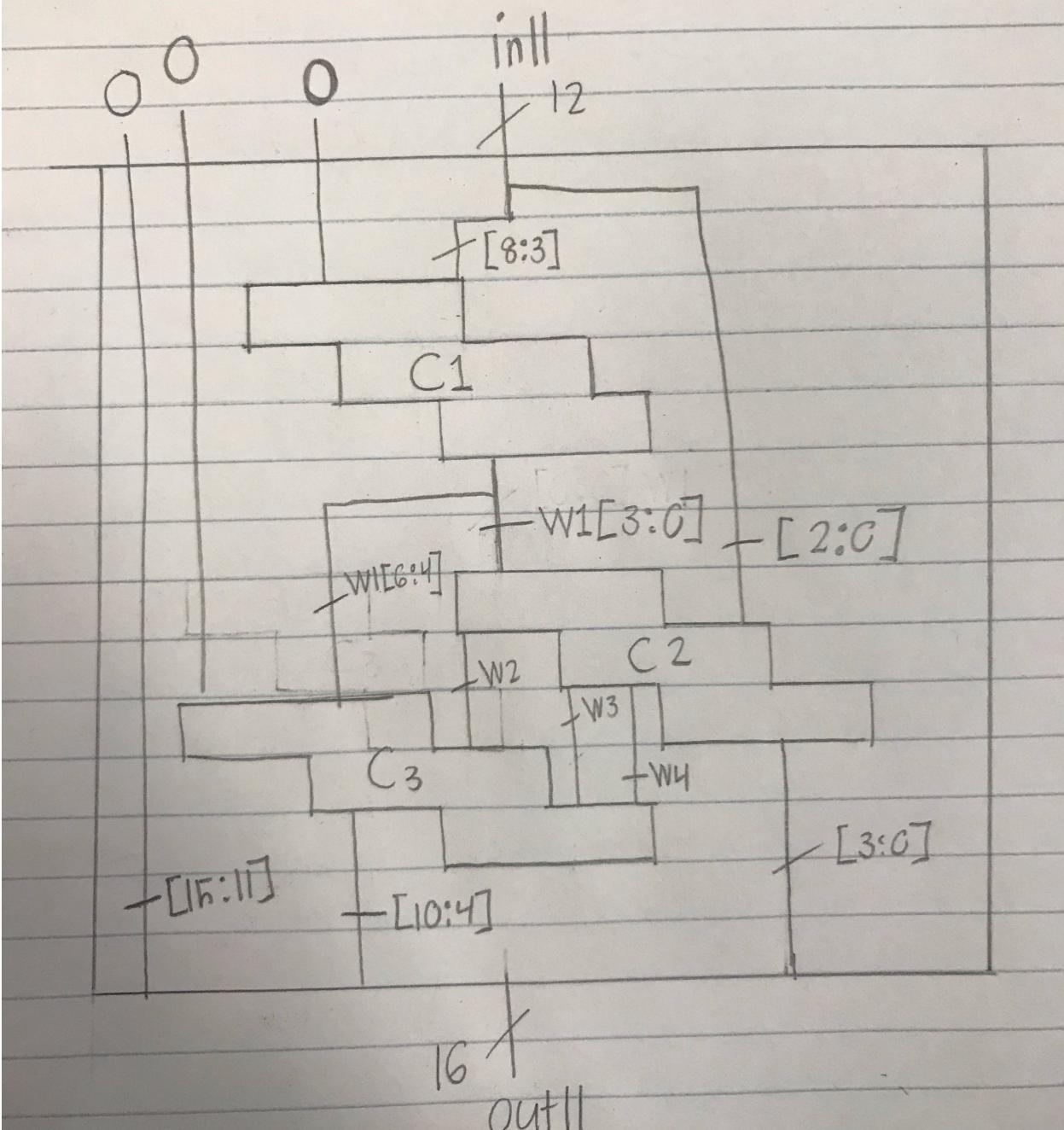


Figure 6: Circuit Diagram

Code

Listing 1: Add3 Module Code

```
// Jake Simmons and Chris Jones , ELC 2137, 2020 -3-24

module add3(
input [3:0] Cin,
output reg [3:0] Cout);

always @*
begin
if (Cin > 4'd4)
Cout = Cin + 4'd3;
else
Cout = Cin;
end

endmodule // Add3
```

Listing 2: Add3 Testbench Code

```
// Jake Simmons and Chris Jones , ELC 2137, 2020 -3-24

module add3_test () ;

reg [3:0] num;
wire [3:0] out;

integer i ; // Declare loop variable

Add3 C1 (.Cin(num), .Cout(out));

initial begin

for ( i =0; i <=8'hF ; i = i +1) begin
num = i;
#10;
end
$finish ;
end

endmodule // sseg_decoder_test
```

Listing 3: BCD6 Module Code

```
// Jake Simmons and Chris Jones , ELC 2137, 2020 -3-24
module BCD6(
input [6:0] B,
output [6:0] Out
);
wire W1, W2, W3;
wire W4, W5, W6;

Add3 C1(.Cin(B[6:3]), .Cout({Out[6],W3, W2, W1}));
Add3 C2(.Cin({W3,W2,W1,B[2]}), .Cout({Out[5],W4,W5,W6}));
Add3 C3(.Cin({W4,W5,W6,B[1]}), .Cout({Out[4], Out[3], Out[2], Out[1]}));
assign Out[0] = B[0];
endmodule
```

Listing 4: BCD6 Test Bench Code

```
// Jake Simmons and Chris Jones , ELC 2137, 2020 -3-24

module BCD6_Test () ;

reg [5:0] num;

wire [5:0] out;

integer i ; // Declare loop variable

BCD6 BCD (.B(num), .Out(out));

initial begin
for ( i =0; i <=6'h111111 ; i = i +1) begin
num = i;
#10;
end
$finish ;
end
endmodule // sseg_decoder_test
```

Listing 5: BCD11 Module Code

```
// Jake Simmons and Chris Jones , ELC 2137, 2020 -3-24

module BCD11(
input [11:0] in11,
output [15:0] out11
);

wire [6:0] W1;
wire W2, W3, W4;
BCD6 C1( .B({0, in11[8:3]}), .Out(W1)
);

BCD6 C2( .B({W1[3:0], in11[2:0]}), .Out({W2, W3, W4, out11[3:0]})
);

BCD6 C3( .B({0,W1[6:4]}, W2, W3, W4)), .Out(out11[10:4])
);
assign out11[15:11] = 0;
endmodule
```

Listing 6: BCD11 Test Bench Code

```
// Jake Simmons and Chris Jones , ELC 2137, 2020 -3-24

module BCD11_Test () ;

reg [8:0] num;

wire [10:0] out;

integer i ; // Declare loop variable

BCD11 BCD (.in11(num), .out11(out));

initial begin
for ( i =0; i <=9'h111111111 ; i = i +1) begin
num = i;
#10;
end
$finish ;
end
endmodule // sseg_decoder_test
```

Listing 7: sseg1 module Code

```
// Jake Simmons and Chris Jones , ELC 2137, 2020 -3-24

module sseg1(
input [15:0] sw,
output [3:0] an,
output [6:0] seg,
output dp
);

wire [3:0] muxwire;
wire [7:0] W1;

BCD11 BD11(
.in11(sw[10:0]), .out11(W1));

mux2_4b m1(
.in1(W1[7:4]), .in0(W1[3:0]),
.sel(sw[15]), .out(muxwire[3:0])
);

sseg_decoder sseg1(
.sseg(seg), .num(muxwire[3:0])
);

assign an[3:2] = 3;
assign dp = 1;
assign an[1] = ~sw[15];
assign an[0] = sw[15];
endmodule
```
