A_4

Assignment IV

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1. The block diagram is sketched and attached to this assignment. The function table in figure 1 shows the output of the ALU in relation to the inputs x, y, and z and the controls S_{0-2}. Note the x in the controls column is a placeholder for any value, and not the input x.

S_0	S_1	S_2	ALU
0	0	0	$x + y$
0	0	1	$x - y$
0	1	0	$x \wedge y$
0	1	1	x
1	0	x	y
1	1	x	z'

Figure 1: Truth table for ALU

2. Figure 2 shows the internal circuitry of the ALU. Notice that I have made a design descision alternate to that made in lecure five by bundling the negation of z into the ALU. I understand that in a real situation, the Control Unit would have to coordinate the operations of more than one operational unit e.g. an FPU. For this reason, I will use an external not to create z', to give the Control Unit something else to control.

3. The datapath diagram is sketched and attached to this assignment. The control points are S_{0-2} for controlling the operation of the ALU, and loads for x, y, and z.

4. Figure 3 shows the internal circuitry of the datapath.

5. Figure 4 is the control point table which includes all six operations and their relevant control points settings.

6. Figure 6 shows the internal circuitry of the Control Unit.

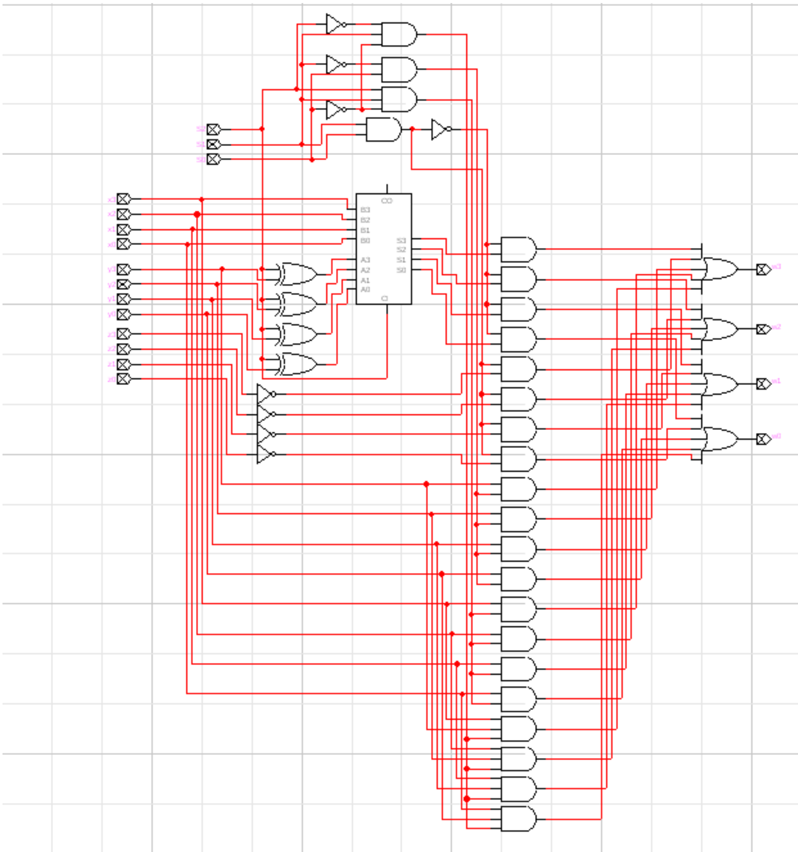

Figure 2: Internal circuit of the ALU

7. (a) I set the registers to the appropriate numbers. The testing circuit in the next question is photographed with those properties.

   (b) Figure 7 shows the testing circuit.

   (c) The calculations are shown in figure 8.

   (d) Figure 9 waveform shows the testing. As you can see, the registers simulate with a fuzzy value after a few iterations. I have used those same registers before and they performed well. The circuit seems valid and the CU is making correct decisions. I also tested the ALU several times and it also seems to function properly. I have no idea what is causing the blurring. I have retried the simulation several times. Also the g signal for x is not shown properly as it is possibly labeled incorrectly. But you can see from the values propogating to it that it is functioning properly.

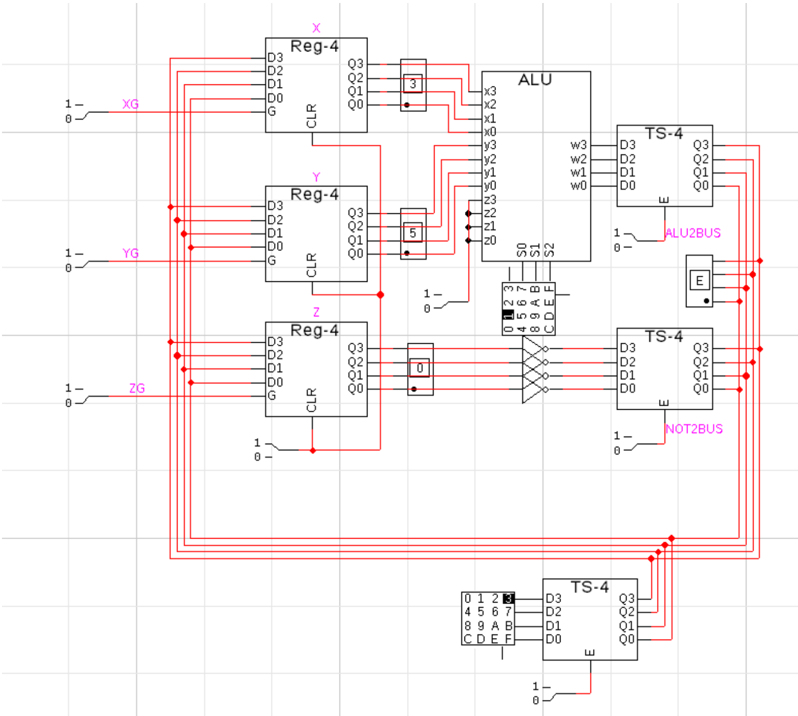

Figure 3: Internal circuit of the datapath

		S_0	S_1	S_2	load x	load y	load z	ALU to bus	not to bus
α	$x \leftarrow x + y$	0	0	0	1	0	0	1	0
β	$y \leftarrow x - y$	0	0	1	0	1	0	1	0
γ	$x \leftarrow x \wedge y$	0	1	0	1	0	0	1	0
δ	$z \leftarrow x$	0	1	1	0	0	1	1	0
ϵ	$x \leftarrow y$	1	0	0	1	0	0	1	0
θ	$x \leftarrow z'$	1	1	0	1	0	0	0	1

Figure 4: Control Point table

$$S_0 = \epsilon + \theta \tag{1}$$
$$S_1 = \gamma + \delta + \theta \tag{2}$$
$$S_2 = \beta + \delta \tag{3}$$
$$\text{load } x = \alpha + \gamma + \epsilon + \theta \tag{4}$$
$$\text{load } y = \beta \tag{5}$$
$$\text{load } z = \delta \tag{6}$$
$$\text{ALU to bus} = \alpha + \beta + \gamma + \delta + \epsilon \tag{7}$$
$$\text{not to bus} = \theta \tag{8}$$
$$\tag{9}$$

Figure 5: Boolean equations for controls

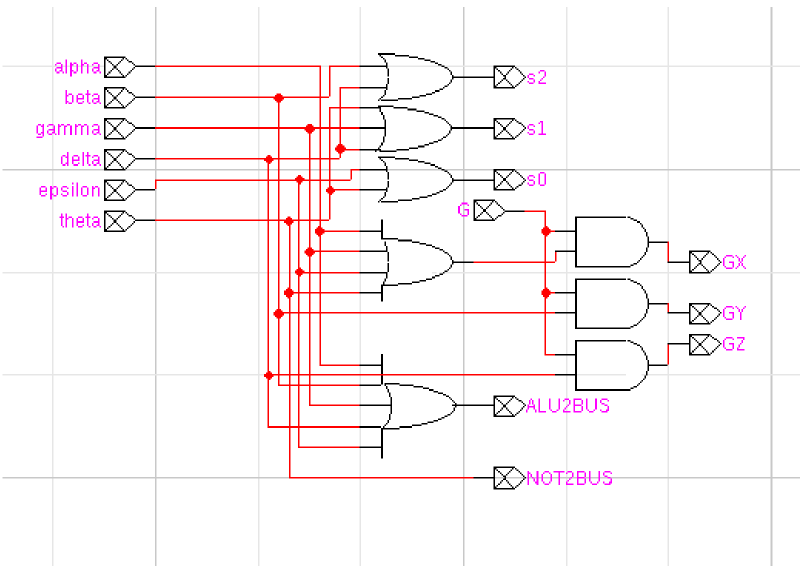

Figure 6: Internal circuit of the control unit

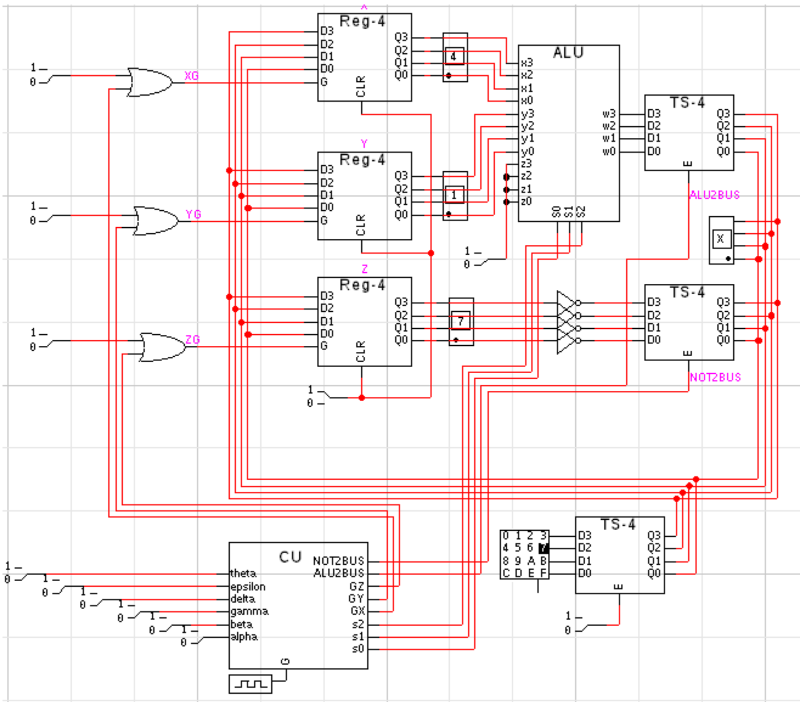

Figure 7: Testing circuit

$$x \leftarrow 4 + 1 = 5 \tag{10}$$
$$y \leftarrow 5 - 1 = 4 \tag{11}$$
$$x \leftarrow 5 \wedge 4 = 4 \tag{12}$$
$$z \leftarrow 4 \tag{13}$$
$$x \leftarrow 4 \tag{14}$$
$$x \leftarrow 4' = 11 \tag{15}$$
$$x = 11 \tag{16}$$
$$y = 4 \tag{17}$$
$$z = 4 \tag{18}$$
$$\tag{19}$$

Figure 8: Calculations of value changes.

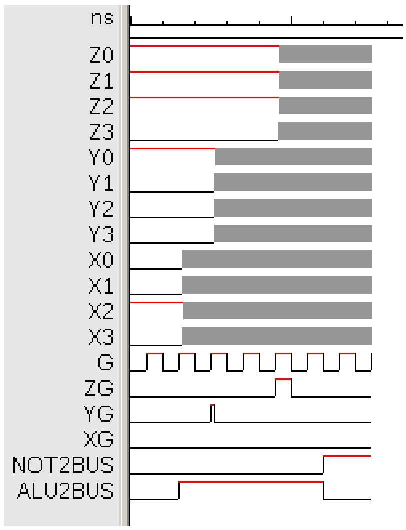

Figure 9: Waveform for circuit