**DLD STEM In-Class Exercise – Week 1 Monday PM**

We will move into breakout sessions to practice simulating circuits in Logisim

Problem 3b. Draw and simulate this circuit in Logisim. Verify the truth table you computed this morning, using the “poke” feature to toggle through the inputs.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  |  |  | | --- | --- | --- | | **X** | **Y** | **Z** | | **0** | **0** | 0 | | **0** | **1** | 1 | | **1** | **0** | 1 | | **1** | **1** | 0 | |

Problem 4b. Draw and simulate this circuit in Logisim. Verify the truth table you computed this morning, using the “poke” feature to toggle through the inputs.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  | |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Cin** | **E** | **F** | **Sum** | **Cout** | | **0** | **0** | **0** | **0** | **0** | | **0** | **0** | **1** | **1** | **0** | | **0** | **1** | **0** | **1** | **0** | | **0** | **1** | **1** | **0** | **1** | | **1** | **0** | **0** | **1** | **0** | | **1** | **0** | **1** | **0** | **1** | | **1** | **1** | **0** | **0** | **1** | | **1** | **1** | **1** | **1** | **1** | |

Problem 5. Draw and simulate this circuit in Logisim. Complete the truth table, filling in the inputs in the correct order.

|  |  |
| --- | --- |
|  | |
| |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | Inputs | | Outputs | | | | | | G | H | I | J | K | L | M | | 0 | 0 | 0 | 0 | 0 | 1 | 1 | | 0 | 1 | 0 | 1 | 1 | 0 | 1 | | 1 | 0 | 0 | 0 | 0 | 0 | 0 | | 1 | 1 | 1 | 1 | 0 | 0 | 1 |   Write Boolean expressions for I, J, K, L, M:  I = G⋅H  J = !G⋅H  K = !G⋅!H  L = G⋅H+!G⋅H  M = G⋅H+!G⋅H+!G⋅!H |

Problem 5. Introduction to design

So far, you have worked problems that require you to *analyze* an existing design. Analysis is an important part of engineering, but equally important is being able to *synthesize* a design. In this problem, we will pretend we are designing a home air-conditioning control system. If the home is vacant, the air conditioner should turn on when the indoor temperature reaches (or exceeds) 80 degrees Fahrenheit. However, if the home is occupied, 80 degrees is too warm, so the air conditioner should turn on when the indoor temperature reaches 76 degrees.

We assume that the home has a temperature sensor and an occupancy sensor.

The first step is to model this situation.

* We will assign the variable “P” to indicate that people are present in the home. Using Boolean logic, we define our variable as follows:
  + P=1 indicates that people are home,
  + P=0 indicates the home is vacant.
* There are two temperature thresholds we are concerned about.
* The first, T1, represents the 80-degree threshold.
  + T1 = 1 indicates that the indoor temperature is 80 degrees or higher.
  + T1 = 0 indicates the temperature is under 80 degrees.
* The second, T2, represents the 76-degree threshold. Use the same logic for T2 as T1.
  + T2 = 1 indicates **that the indoor temperature is 76 degrees or higher**
  + T2 = 0 indicates **the temperature is under 76 degrees**
* Finally, our output variable “A” indicates whether the air-conditioner is on or not.
  + A = 1 indicates **that the air-conditioner is on**
  + A = 0 indicates **the air-conditioner is off**

Now we can either write a Boolean expression to control the air conditioner or we can start with a truth table. It’s sometimes easier and often more thorough to start with the truth table.

The input variables, P, T1 and T2 go on the left, with the output variable, A, on the right. Label the input rows in ascending order, from 000, to 111. A few rows are filled out, complete the rest of the input rows.

|  |  |  |  |
| --- | --- | --- | --- |
| P | T1 | T2 | A |
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | X |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | X |
| 1 | 1 | 1 | 1 |

Now think about the problem statement and determine appropriate values for the output, “A.”

The first row is completed for you: since there are no people in the house and T1 is not over 80 degrees, the air conditioner is turned off. (Note: some combinations of inputs are not physically possible: the temperature cannot be under 76 and over 80 degrees at the same time. Models always make some simplification of reality.)

Problem 6. Design challenge (no Logisim required, yet!) Try this one from scratch! Given sensors that detect:

* Door open (D = 1 🡪 door is open)
* Key in ignition (K = 1 🡪 key inserted)
* Seat belt fastened (S = 1 🡪 belt fastened)
* Headlights on (H = 1 🡪 lights on)

Design a truth table that warns the driver when something is amiss by sounding a buzzer. For instance, if the door is open, the key is out, the seat belt is unfastened, but the headlights are on, it’s likely the person is getting out of the car and forgot to turn their headlights off. Sound the buzzer.

1. Define your output variable.
   1. Buzzer sounds (B = 1 -> buzzer makes a sound)
2. Create the truth table, with the appropriate number of rows.
3. Number the input rows in order.
4. Determine when the buzzer should sound.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| D | K | S | H | B |
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 1 |
| 0 | 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 1 | 1 |
| 0 | 1 | 0 | 0 | 1 |
| 0 | 1 | 0 | 1 | 1 |
| 0 | 1 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 1 |
| 1 | 0 | 1 | 0 | 0 |
| 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 0 | 0 | 1 |
| 1 | 1 | 0 | 1 | 1 |
| 1 | 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 | 1 |

**Explanations**

* When door is closed and key is in, I am probably driving – buzzer off
  + If seatbelt is not in while driving, then buzz
* When door is open and key is in, I probably left it there by mistake – buzzer on!
  + If door is opened and I’m wearing a seatbelt, I’m probably in the process of leaving
* If headlights are on while door is opened or keys off, probably a mistake