Building A Memory Reading Circuit*

Nifty Assignment

Bin Peng
Department of Computer Science and Information Systems
Park University
Parkville, MO 64152
bpeng@park.edu

1 Assignment Description

This assignment is for an undergraduate Computer Architecture course. Students are required to build a sequential circuit to simulate memory reading. Before this assignment, students have studied combinational circuits and sequential circuits such as adders, multiplexers, memory cells, and ripple binary counters. Students have also practiced building simple combinational and sequential circuits in Logisim[1], a well-known graphic tool for designing and simulating logic circuits. The purpose of the exercise is to combine knowledge of digital circuit components and ROM to create a memory reading circuit, which is an essential part of a computer.

This circuit will read a block of data out of a memory device and display the data on a user terminal. The block of data will be a string of ASCII characters. The characters are hardcoded into the memory device during design time. Memory addresses will be generated automatically using a counter. The students design proper control logic to have each character read out of the memory device sequentially and displayed. The memory device is simulated using a Logisim ROM component. The user terminal is simulated with a TeleTYpewriter (TTY) in Logisim.

Students are given the following instructions:

1. Pick a string with at least 35 characters (could be more than one sentence). The character count includes spaces and punctuation.
2. Decide the minimal number of address bits (n) needed to address each of those characters. n will be the data bits attribute of the counter as well as the address bit width attribute for the ROM component.

3. Encode the string in ASCII and express the values in hexadecimal.
4. Enter those ASCII values in the ROM component in Logisim. If there are still unfilled cells in the ROM, fill in space characters.
5. Build the circuit in Logisim. The basic connection is from the n-bit counter to the ROM, and then to the TTY. The data output of the ROM device needs to go through a bit selector to only let the lower 7 bits into the TTY. Both the counter and the TTY need a clock signal. The string should be displayed in the TTY character by character.
6. Add an On/Off button to turn on/off the circuit. This is to simulate the power button of a computer. The button is off initially. The ROM and the TTY should be enabled when the button is poked once (On) and then disabled when the button is poked again (Off). When a TTY is disabled, it should not accept any data for display (though previously displayed characters will remain on screen). Additional wiring plus basic gates like AND, NOT gates may be used.
7. For extra credits, set up the circuit so it will clear the TTY display and reset the counter back to 0 with some action(s) of the On/Off button.

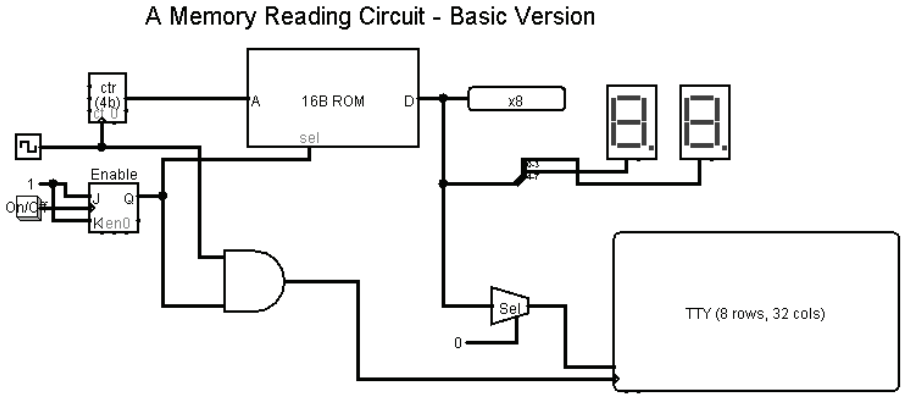

Figure 1: A Memory Reading Circuit

Figure 1 shows the basic circuit. This circuit uses those Logisim components: counter (the component with a label of "ctr" in Figure 1), ROM, bit selector (the component with a label of "Sel"), and TTY. A few optional components are included in this circuit: an 8-bit output data pin (the component labelled "x8" which connects to the ROM) to display the ROM output in binary, two Hex Digit displays to display the ROM output in Hexadecimal, and a splitter (the component directly connects to the two Hex digital display) to

split the 8-bit output of the ROM into the higher 4-bit and the lower 4-bit for the Hex displays. Students are expected to use the Logisim Documentation to figure out how to use those components. Students have used those components in previous assignments: clock, constant, button, JK flip-flop, and basic gates.

2 Additional Ideas

For an advanced class, the instructions may be further simplified to let students figure out the interconnection.

The Logisim counter component may be replaced by a synchronous counter built by students. In the author's class students built a 4-bit synchronous counter in a previous assignment. That circuit could be extended to an n-bit synchronous counter and then used in this circuit as a sub-circuit.

This assignment may be altered to build a memory writing circuit. With the Logisim keyboard component, the circuit may accept user input, echo display on a TTY and store the input in a RAM device.

References

[1] Logisim. `http://www.cburch.com/logisim/index.html`. Retrieved November 25, 2018.