**Solutions Calculator Club**

**Project Documentation**

**Main Presentation CPU Slide**

When the computer “ boots” up all of our registers start at 0. Initialize the RAM with a simple computer program The first phase of a CPU’s operation is called the fetch phase. This retrieves the first instruction.

First, wire the Instruction Address Register to the RAM module. The register’s value is 0, so the RAM returns whatever value is stored in address 0000. This is 0001 1110. Then this value is copied into the instruction register. After the instruction is fetched from memory, this instruction needs to be executed.

What does the instruction do when it is RUN?

This is called the decode phase. In this phase the opcode of the first four bits is: 0001. This opcode corresponds to the “LOAD A” (LDA 14) instruction, which loads a value from RAM into Register A. The RAM address is the last four bits of the instruction which are 1110, or 14 in decimal. Next, instructions are decoded and interpreted by a Control Unit.

For example, to recognize a LD 14 instruction, there is a logical circuit that checks if the opcode

matches 0010.

Next perform that instruction which is the beginning of the execute phase. Using the output of the LDA checking circuit the RAM’s read enable is enabled on the line and sent to address 14.

The RAM retrieves the value at that address, which is 00011100, or 28 in decimal. This is a LOAD\_A instruction,saved into Register A. Connect the RAM’s data wires to the two data registers, use the LDA instruction check circuit to enable the write enable only for Register A. This has loaded the value at RAM address 14 into Register A. Turn all of the control wires of. Ready to begin fetching the next instruction in memory. Increment the Instruction Address Register by 1 which completes the execute phase.

LDA is just one of several possible instructions that our CPU can execute. Different instructions are decoded by different logic circuits, which configure the CPU’s components to perform that action. The Control Unit is responsible for directing all of the different parts of the CPU.

Having completed one full fetch/decode/execute cycle, the cycle begins again with the fetch phase. The Instruction Address Register now has the value 0001 in it, so the RAM gives the value stored at address 0001, which is 0010 1111.

Decode phase, 0001 is the “ADD 15” instruction, which moves a value from RAM into Register B. The memory location this time is 1111, which is 15 in decimal. The next execution phase.

The Control Unit configures the RAM to read address 15 and configures Register B to receive the data. The Program just saved the value 00001110, or the number 14 in decimal, into Register B. Last thing to do is increment our instruction address register by 1, and we’re done with another cycle.

The Control Unit is responsible for selecting the right registers to pass in as inputs and configuring the ALU to perform the right operation. For this ADD instruction, the Control Unit enables Register B and feeds its value into the first input of the ALU. It also enables Register A and feeds it into the second ALU input. The ALU itself can perform several different operations. The Control Unit must configure it to perform an ADD operation by passing in the ADD opcode.

Finally, the output should be saved into Register A. But it can’t be written directly

because the new value would ripple back into the ALU and then keep adding to itself.

So the Control Unit uses an internal register to temporarily save the output, turn off the ALU, and then write the value into the proper destination register.

The inputs were 28 and 14, and so the sum is 42, or 00101010 in binary,

which is now sitting in Register A. As before, the last thing to do is increment the instruction

address by 1, and another cycle is complete.

Okay, so let’s fetch one last instruction: 01001101. Decode address 1110 is OUT instruction, with a RAM address of 13. The RAM module write-enable the memory. read-enable Register A. This allows the data line to pass in the value stored in register A.It loaded two values from memory, added them together, and then saved that sum back into memory.

So the responsibility of keeping the CPU ticking along falls to a component called the clock.

The clock triggers an electrical signal at a precise and regular interval. Its signal is used by the Control Unit to advance the internal operation of the CPU. The speed at which a CPU can carry out each step of the fetch-decode-execute cycle is called its Clock Speed. This speed is measured in Hertz - a unit of frequency. Addition of a clock, our CPU is complete.