A Thomas Ware Capstone Project.

Solutions Calculator Club product development

Solutions Calculator Club Product Development

Project Charter

Scope:

Tasked with developing an educational tool to show how a Computational System and Subsystems processes inputs and outputs.

Resources:

A research grant for a development ***budget*** of $20,000.
The project **research phase time frame** of 4 months and an **implementation phase *time frame*** was 4 months.

Stakeholders:

Solutions calculator Club are the ***investors***
Thomas Ware is the ***project developer***
Trevor Murray ***consultant***
UFV potential ***client***
Ben Eater *8-bit computer kit* ***Supplier***

Risks and assessments:

Scope of the project for a single person, supply chain issues like chip shortages or obsolete components and shipping time if replacements are required. Limitations of the ALU and memory size of registers.

Gantt Chart

Solutions Calculator Club Product Development
CMNS-125 Research:
History and Innovations of the Calculator

The Abacus

- Binary
- Weighed Sum
- Register

The first calculating device known was the **Abacus.** Invented in China around the **2nd century B.C**. However, Abacus-like devices are first attested from ancient Mesopotamia around **2700 B.C.**

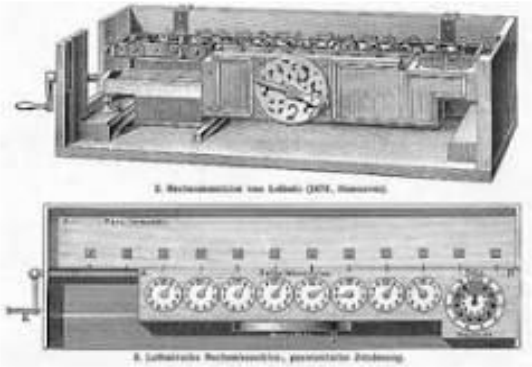
History and Innovations of the Calculator

antikythera mechanism

The Renaissance was a creative time that brought new marvels into the world such as Mechanical Gear Driven Calculators. A ***Clock*** and the **Astrolabe** are examples of the early mechanical devices used to calculate time, day, year and position.

History and Innovations of the Calculator

Step Reckoner



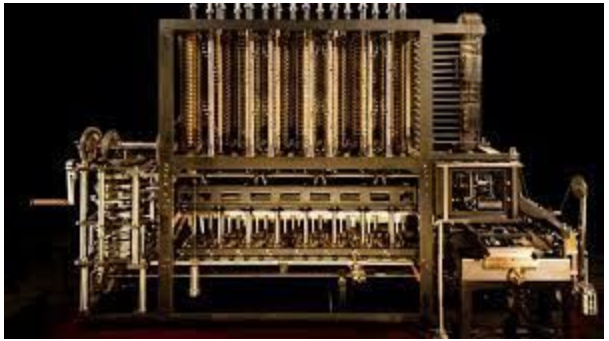
Gottfried Wilhelm Leibniz

(1671) . Leibniz Step Reckoner expanded upon Pascals Machine and did multiplication by repeated addition Before the Step Reckoner calculations were carried out with Precomputed Tables by human computers.

History of Computational Programming

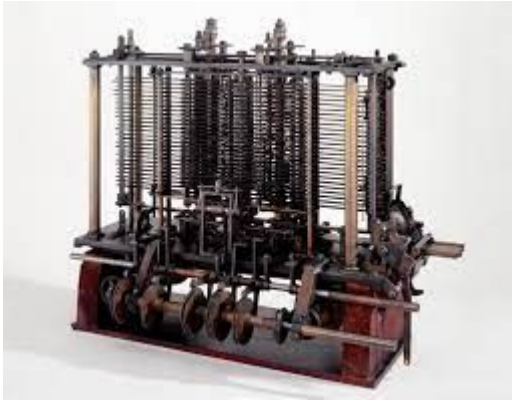
Herman Hollerith's (1819) Electro Mechanical Tabulating Machine featured **Punch Cards.** Hollerith's machine was roughly 10x faster than manual tabulations, and completed the Census in just two and a half years - saving the census office millions of dollars. Businesses saw the value in boosting profit and improving labor intensive tasks by using the machine for data entry in accounting, insurance appraisals and inventory. Hollerith founded the Tabulating Machine Company that merged with other tabulating machine companies to become **IBM**(International Business Machine Co.)

History and Innovations of the Calculator



The Difference Engine was one of Charles Babbage's inventions not completed until 1991 by historians. Which proved to work approximated polynomials. Polynomials describe the relationship between several variables, Polynomials used to approximate logarithms and trigonometric functions.

History and Innovations of the Calculator



During the building of The Difference Engine Babbage conceived of **The Analytical Engine.** Unlike the difference Engine, Step Reckoner and all other computational devices before it - the Analytical Engine was a “general purpose computer”.
Could used for more than just one particular computation also had memory and a primitive printer.

> “At each increase of knowledge, as well as on the contrivance of every new tool, human labour becomes abridged.”
>
> Charles Babbage(1827.)

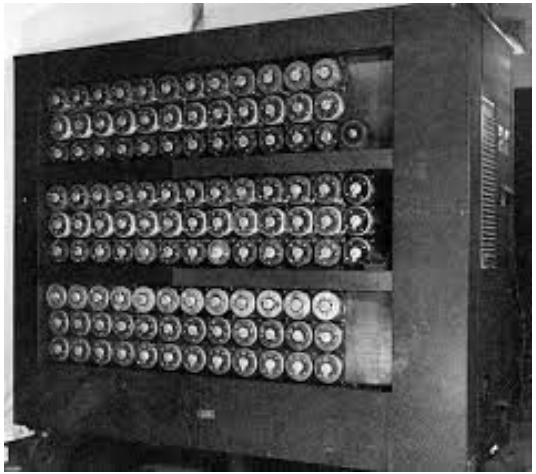
History of Computational Programming

The foreshadowing of computer programming, **Ada Lovelace** a mathematician and first programmer wrote hypothetical programs for the Analytical Engine.

> “A new, a vast, and a powerful Language is developed for the future use of analysis. ”
> **Ada Lovelace(1842)**

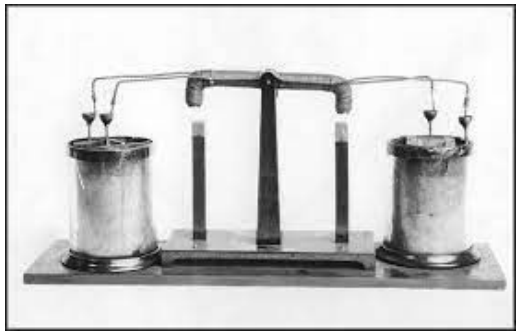
Babbage inspired the first generation of computer scientists and was considered the Father of computing. At the end of the 19th century special use in Sciences and engineering. Not seen in business and government until.1818.

History and Innovations of the Calculator



The Enigma Machine aka the Bombe (1941) Alan Turing Cipher cracking machine.

History and Innovations of the Calculator



Joseph Henry

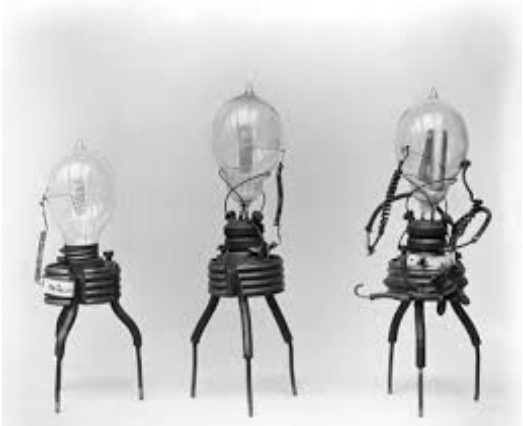
The 1940’s was the era of Room Scale Computers Starting with the **Harvard Mark I (1939-1944).** This **Relay** driven machine ran simulations for the Manhattan Project. Innovation was the **Relay(1940)** Relay lifespan 10yrs wear and tear and higher probability of failure the more relays are in the circuit. The mechanical arm inside of the relay has mass, and therefore cannot move instantly between open and close states

History and Innovations of the Calculator

The Colossus MK 1 (1943). Tommy Flower's machine used **The Vacuum Tube.** 10 Colossus were built to break codes using a ***plug board*** like telephone switchboard to program.

History and Innovations of the Calculator

Thermionic Valve or Vacuum Tube(1904)



John Ambrose Fleming

Triode Vacuum Tube(1906)

Lee DeForest

Moving closer to the modern age earlier inventions such as Relay and Vacuum Tube design lead to newer innovations of Diodes, Transistors, and the ICs.

History and Innovations of the Calculator

The ENIAC (1945) Electronic Numerical Integrator and Calculator Designed by **John Mauckly and J, Presper Eckert**. ENAIC was a general purpose programmable Electronic computer

History and Innovations of the Calculator

In **1947 Bell Laboratory's William Shockley, Walter Houser Brattain and John Bardeen** invented the **Transistor**. An electronic switch is also called a solid state component. **1950** Vacuum Tube computing reached it Zenith. After **1960's** the shift form

History and Innovations of the Calculator

Miniaturization of Calculators in Japan
Sharp VS Casio
Thin Film Technology
Solar Cells
Reduce Keypad Travel

History and Innovations of the Calculator
ELTR-130 Data Logic

We can speak about the history of Calculators without mentioning Computer Science and Levels of Abstraction. In computers, an “on” state when electricity is flowing, represents true. The “off” state, no electricity flowing. Represents false. This is called Logic also referred to as **Boolean Algebra**. Named after **George Boole** Self Taught Mathematician in **1815**. Boolean logic goes beyond Aristotle’s Logic. Boole’s approach allowed truth to be systematically and formally proven, through logic equations which he introduced in his first book,”The Mathematical Analysis of Logic”.

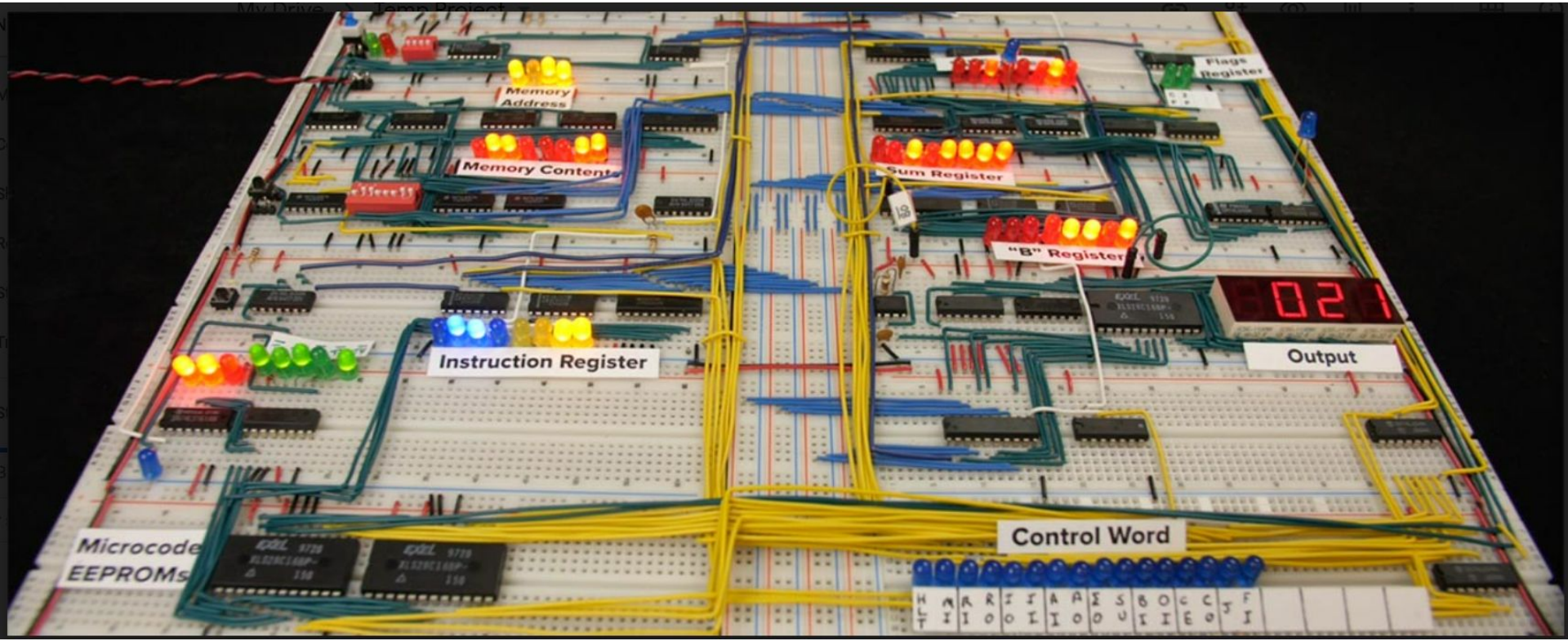
Boolean Logic Table For:

Not	
INPUT	OUTPUT
TRUE	FALSE
FALSE	TRUE

AND		
INPUT A	INPUT B	OUTPUT
TRUE	TRUE	TRUE
TRUE	FALSE	FALSE
FALSE	TRUE	FALSE
FALSE	FALSE	FALSE

OR		
INPUT A	INPUT B	OUTPUT
TRUE	TRUE	TRUE
TRUE	FALSE	TRUE
FALSE	TRUE	TRUE
FALSE	FALSE	FALSE

Ben Eater's 8 Bit Computer



(2016)

Ben Eater’s 8 Bit Computer

Module 1 The System Clock

Module 2

Registers
- A register
- B register
- Instruction Register

Arithmetic unit (ALU)

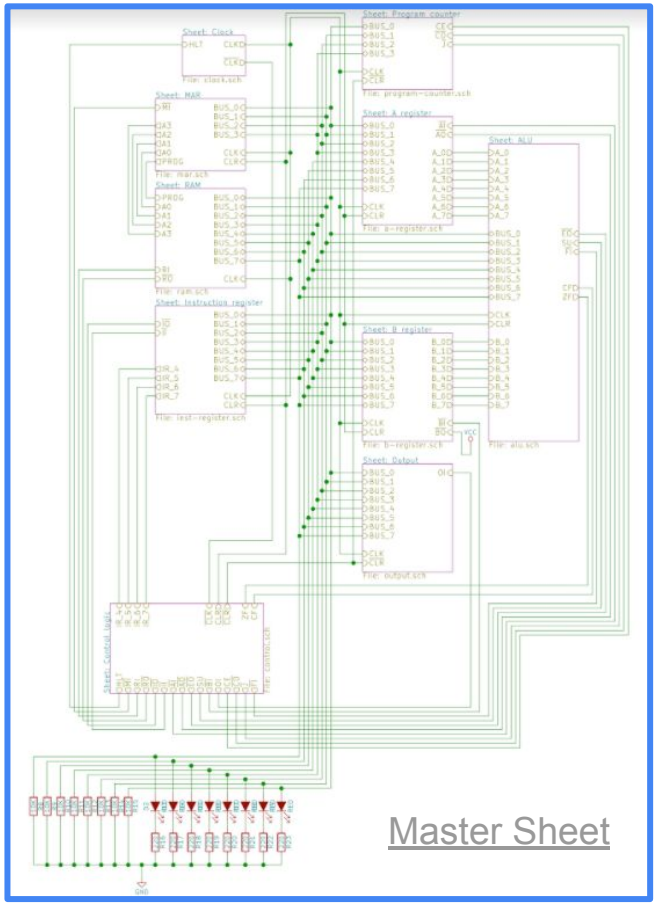
Module 3

Memory Address Register (MAR)
Random access memory (RAM)
Program counter
Step Counter
Timing Interval

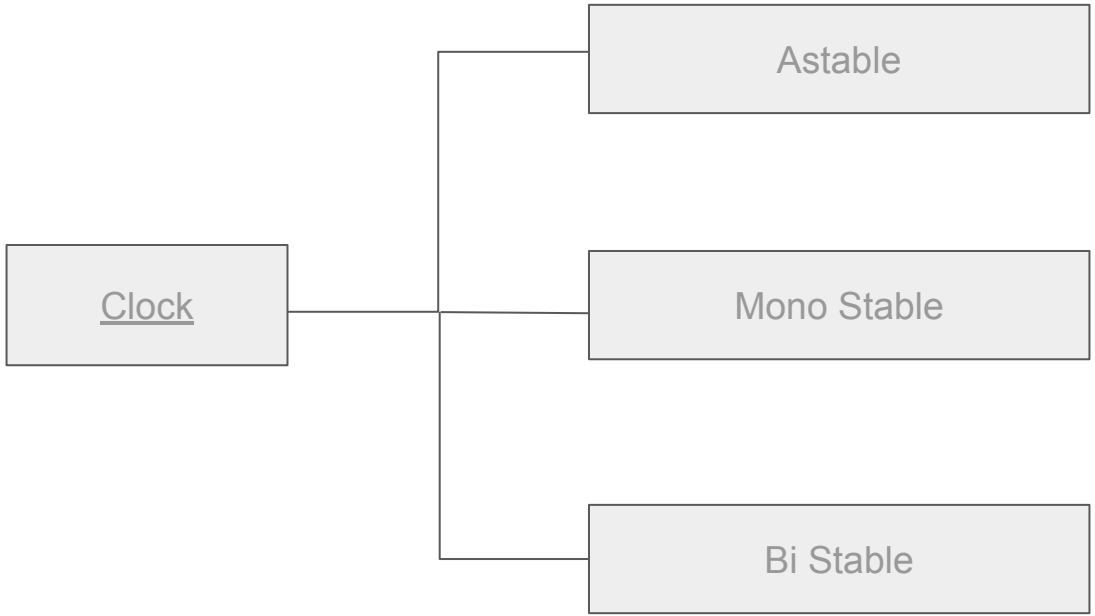
Module 4

CPU control logic
Output Register (Display 7 Segment)
The Bus communication
Flag Register (Carry bit, Zero)

Module 5 AC adapter for development of project and safety.

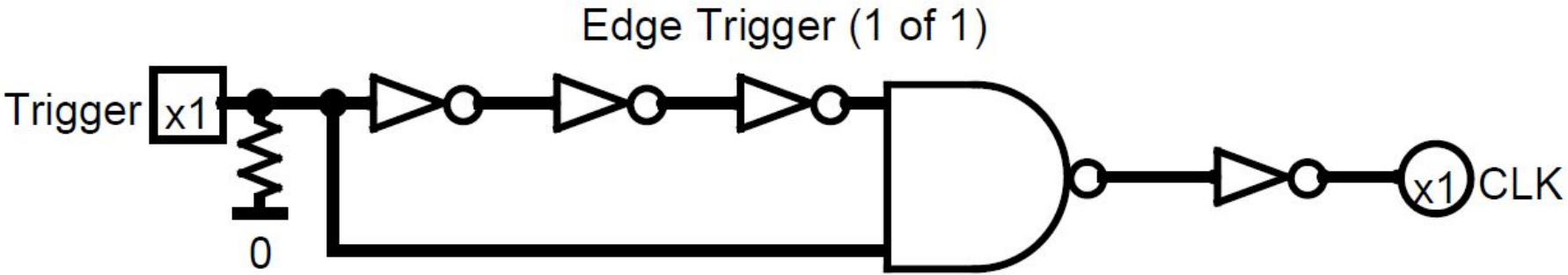


Ben Eater’s 8 Bit Computer

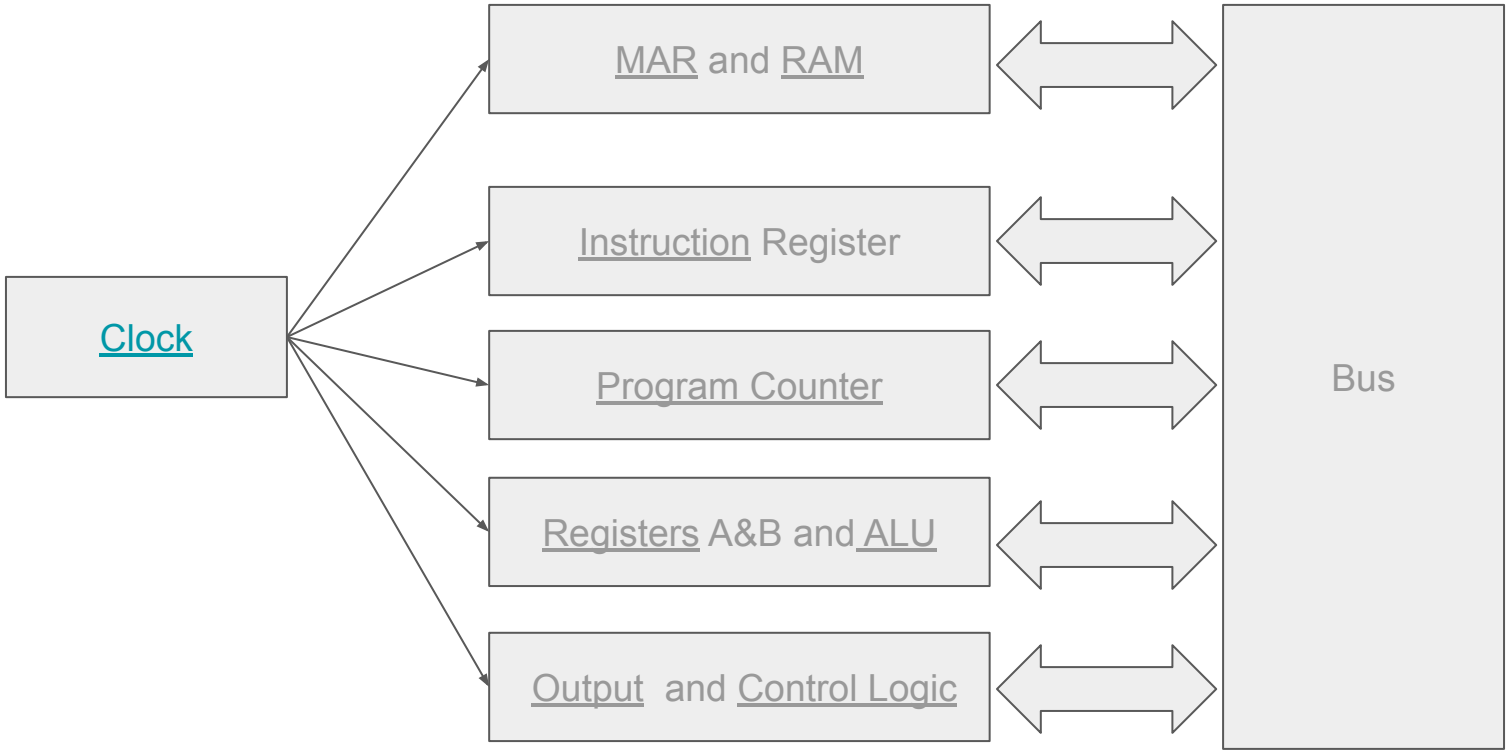


Prototype 2

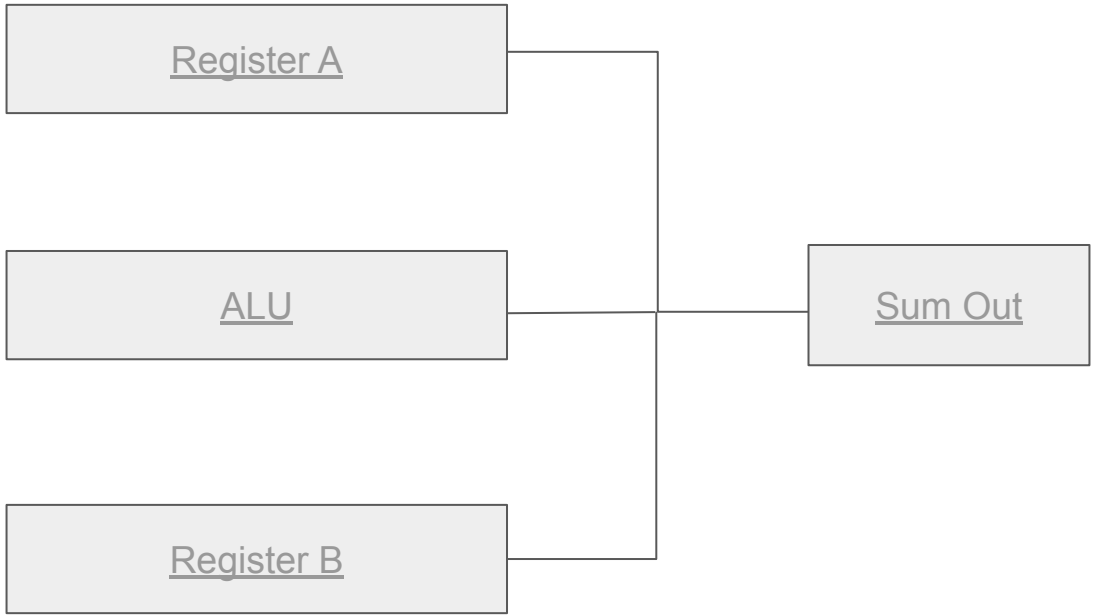
Ben Eater's 8 Bit Computer
Edge Trigger Detection



Ben Eater's 8 Bit Computer



Ben Eater’s 8 Bit Computer



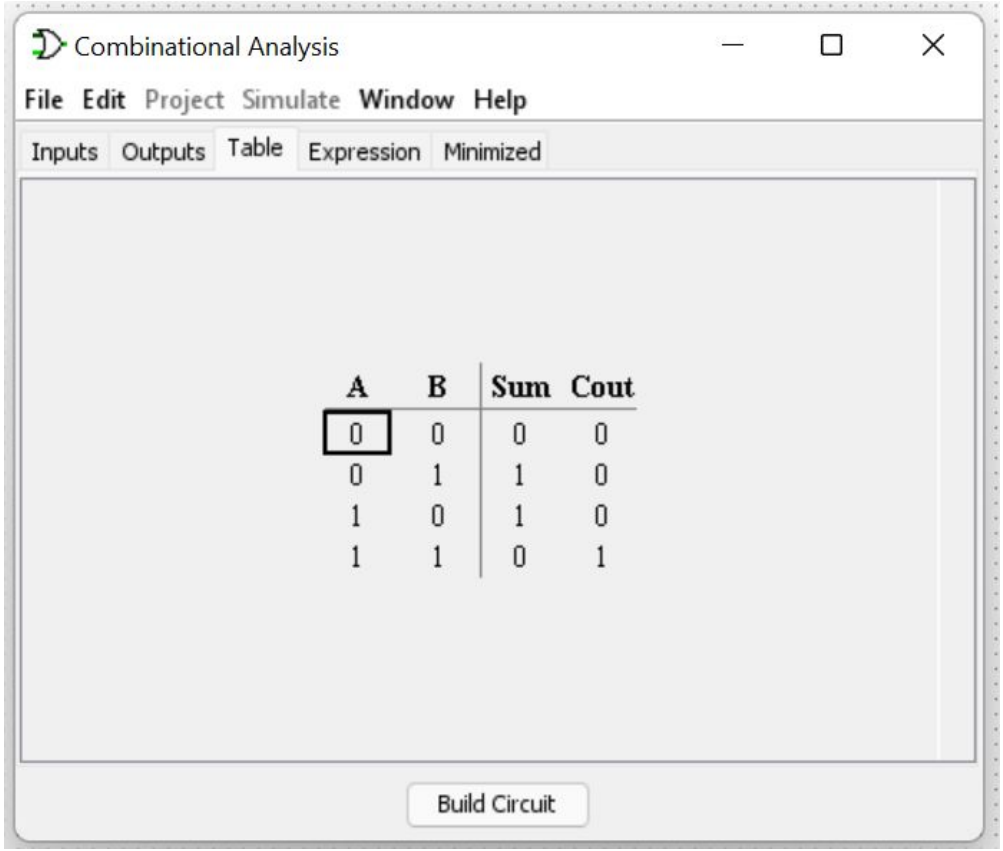
ADD and Subtraction Operations

Ben Eater's 8 Bit Computer
ELTR-130 Data logic

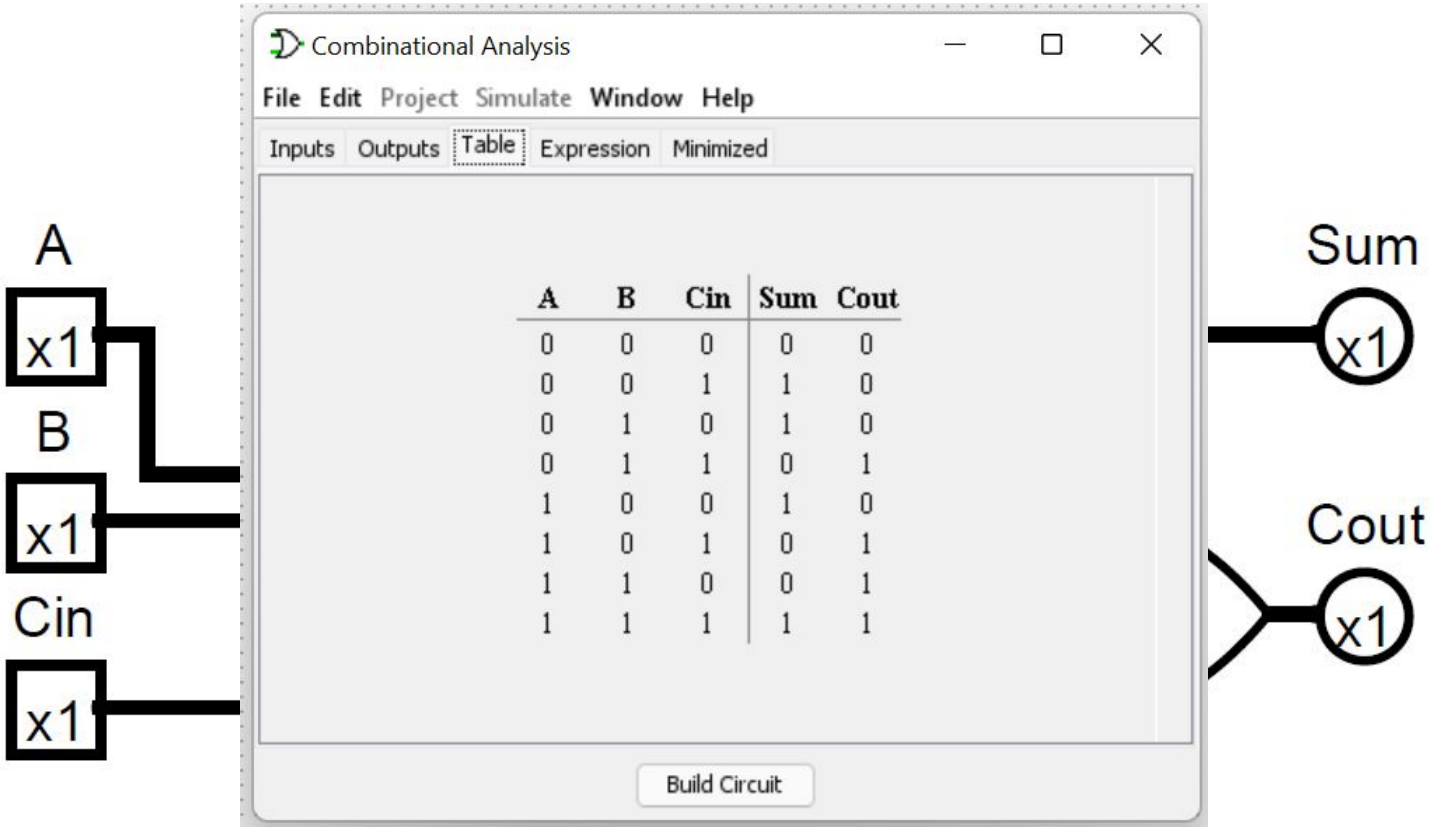
How Do Binary Values ADD?

	00011100			28
+	00001110		+	14
	00101010			42

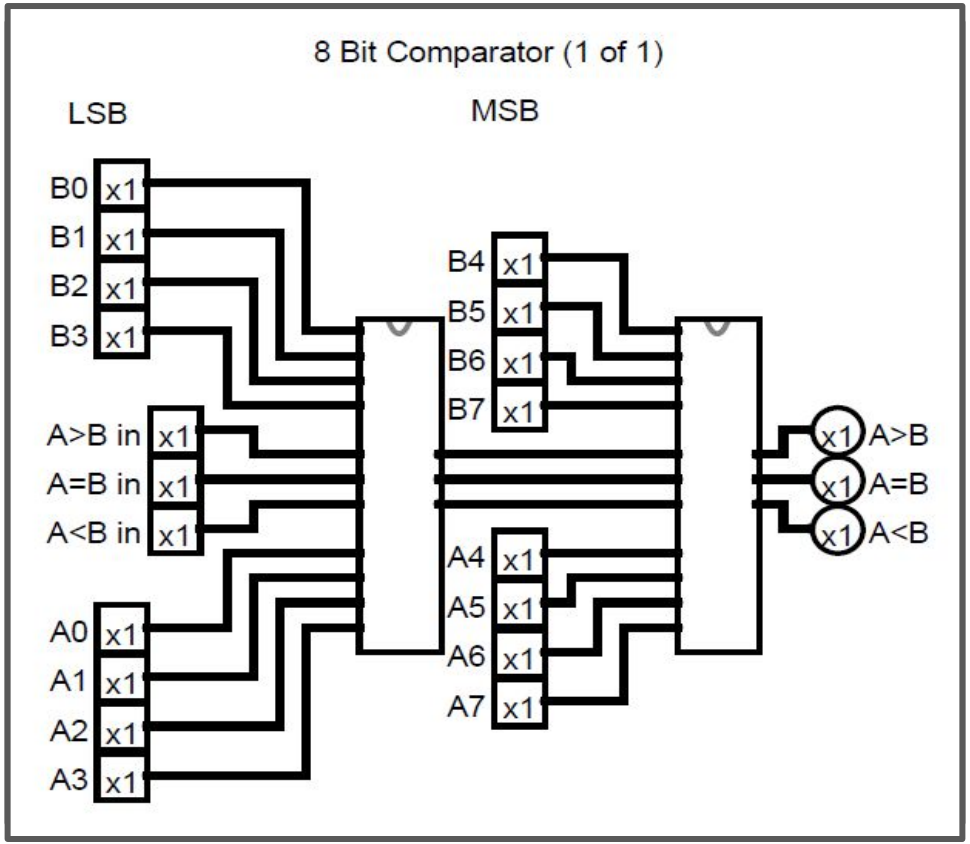
Ben Eater's 8 Bit Computer
Half ADDER



Ben Eater's 8 Bit Computer
Full ADDER



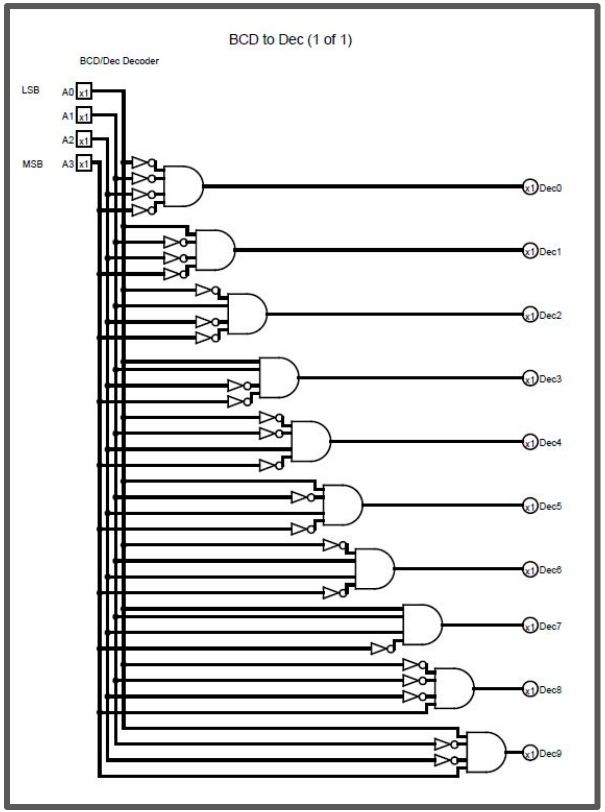
Ben Eater's 8 Bit Computer Comparator



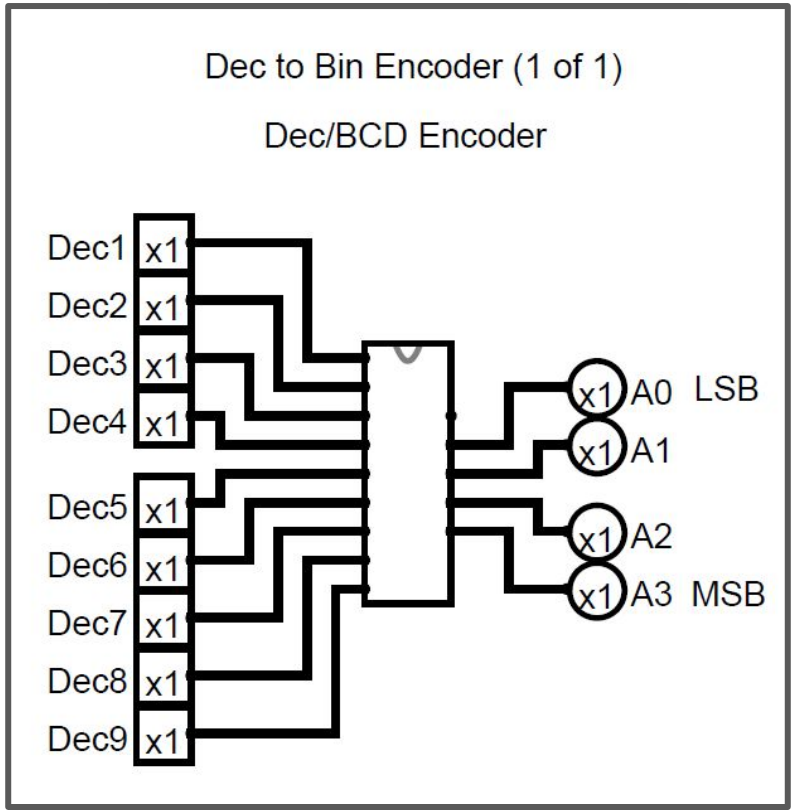
Ben Eater’s 8 Bit Computer

Logisim ALU
RUN Here.

Ben Eater’s 8 Bit Computer
Binary To Decimal to 7 Segment Conversion



Ben Eater's 8 Bit Computer
Dec TO Bin Encoder

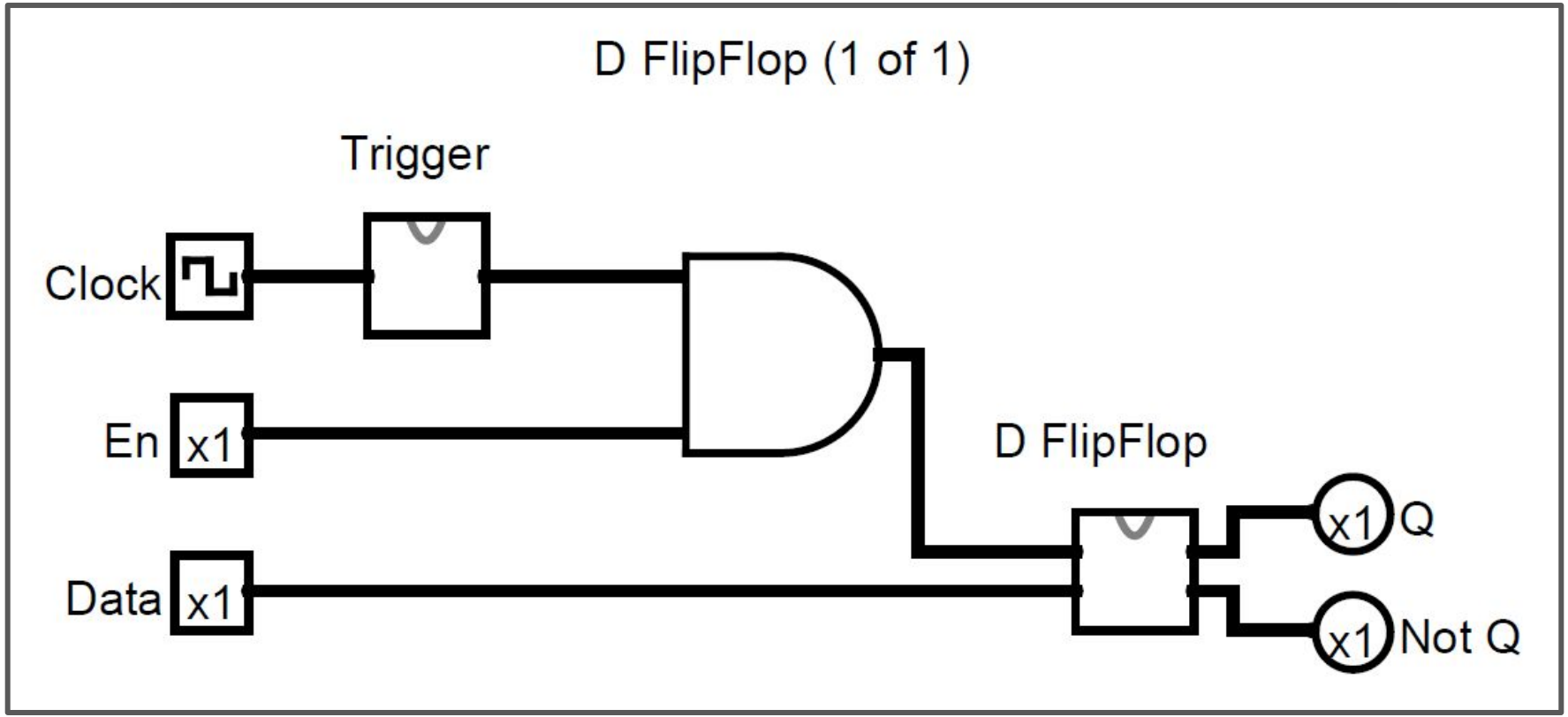


Ben Eater's 8 Bit Computer

ADD	A and B are summed
ADD with CARRY	A and B and a Carry-In bit are all summed
SUBTRACT	B is subtracted from A (or vice versa)
SUBTRACT with BORROW	B is subtracted from A (or vice versa) with borrow (carry-in)
NEGATE	A is subtracted from zero, flipping its sign (from - to +, or + to -)
INCREMENT	Add 1 to A
DECREMENT	Subtract 1 from A
PASS THROUGH	All bits of A are passed through unmodified

8 Operations Circuits:

Ben Eater's 8 Bit Computer
Latches and Memory



Ben Eater’s 8 Bit Computer

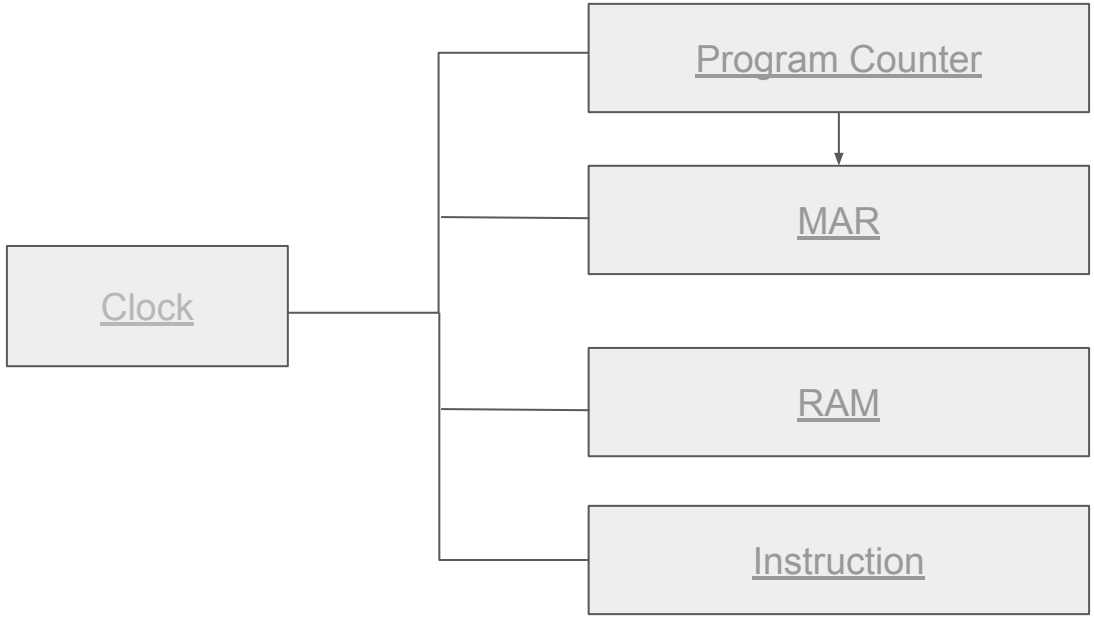
Write to memory
Read from memory

Registers ia a group of latches, which holds a single number, and the number of bits in a register is called its width.

RAM or Random Access Memory
Persistent Memory

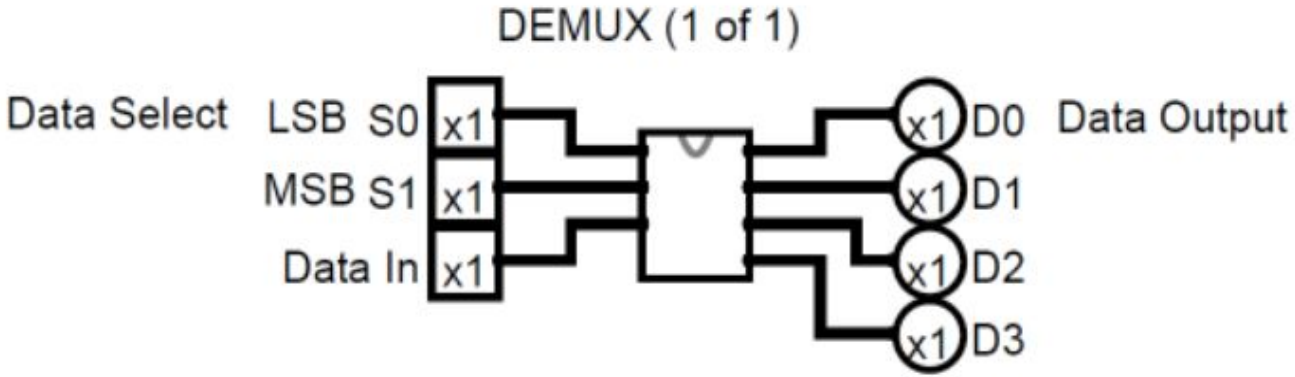
Ben Eater's 8 Bit Computer

Memory, Address Instructions



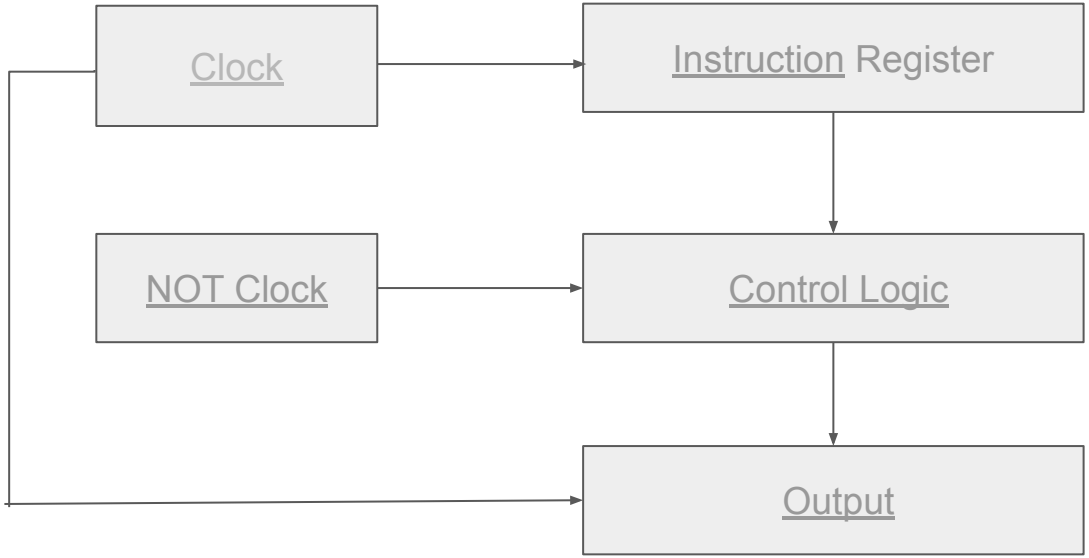
Run Mode And Program Mode

Ben Eater's 8 Bit Computer
DeMUX

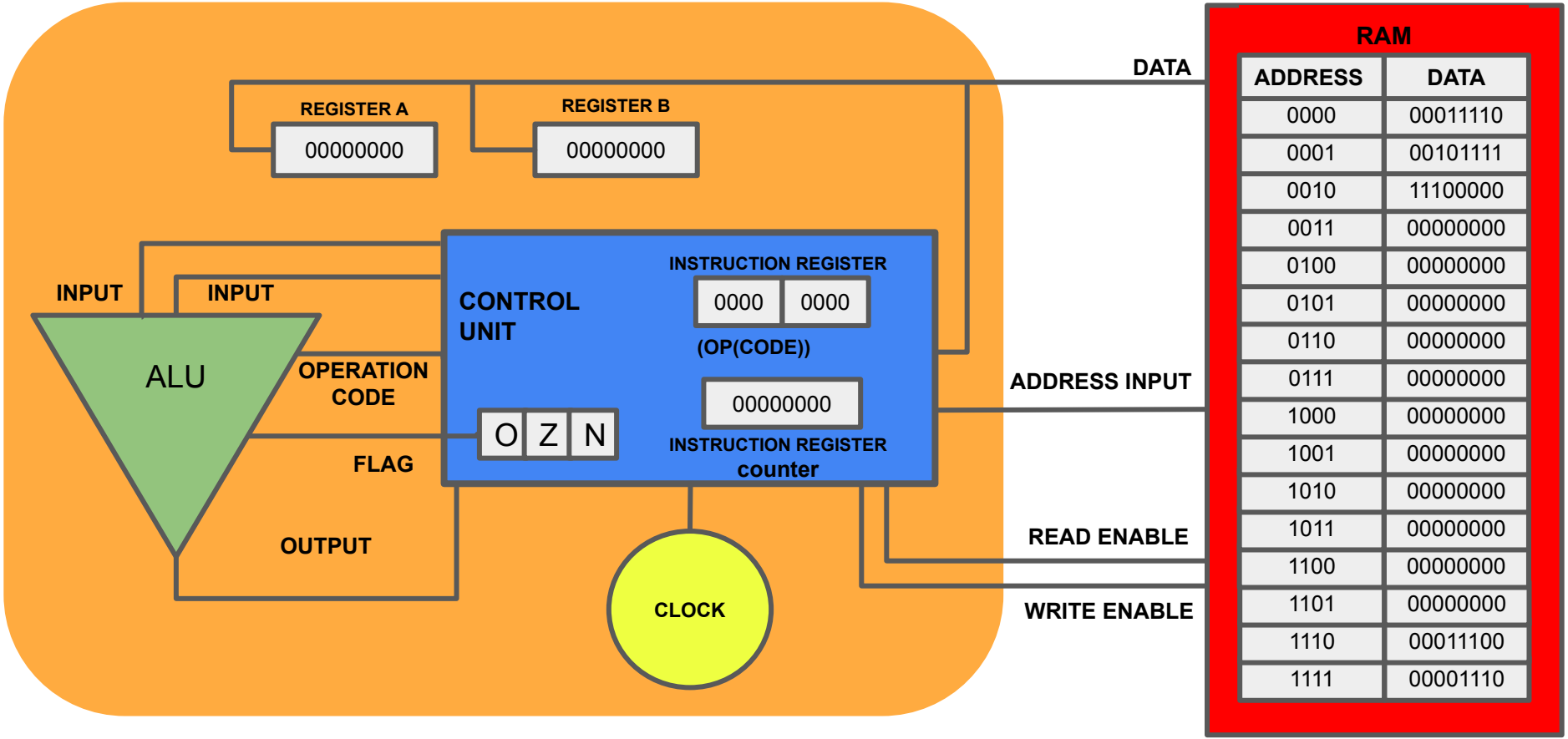


Ben Eater's 8 Bit Computer

Control Logic



CENTRAL PROCESSING UNIT(CPU)



ADDRESS	DATA
0000	00011110
0001	00101111
0010	11100000
0011	00000000
0100	00000000
0101	00000000
0110	00000000
0111	00000000
1000	00000000
1001	00000000
1010	00000000
1011	00000000
1100	00000000
1101	00000000
1110	00011100
1111	00001110

Ben Eater's 8 Bit Computer Instructions

NAME	INSTRUCTION				STEP	HLT	MI	RI	RO	IO	II	AI	AO	EO	SU	BI	OI	CE	CO	J	FL
FETCH	X	X	X	X	0 0 0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	
	X	X	X	X	0 0 1	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	
LDA	0	0	0	1	0 1 0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	
	0	0	0	1	0 1 1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	
	0	0	0	1	1 0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
ADD	0	0	1	0	0 1 0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	
	0	0	1	0	0 1 1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	
	0	0	1	0	1 0 0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	
OUT	1	1	1	0	0 1 0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	
	1	1	1	0	0 1 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	1	1	1	0	1 0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Control Logic and Programing

VAR NAME: CHNGBASE

```
ClrHome
Input "DIGITS: ",D
Input "NUMBER: ",A
Input "IN BASE: ",B
Input "TO BASE: ",F
Ø→T
Ø→C
For(J,Ø,D-1)
int(A/(1Ø^(D-1-J)))→C
C*B^(D-1-J)+T→T
A-C*1Ø^(D-1-J)→A
End
1→P
Ø→E
For(K,Ø,15)
int(T/(F^(15-K)))→E
Output(5,P,E)
T-(E*F^(15-K))→T
P+1→P
End
Disp "
```

Ben Eater's 8 Bit Computer

Testing and TroubleShooting

Testing:

Run a Functional Module Check. You may Need to hookup the required INPUTS and OUTPUTS to see if the Module is operational.

Running the subsystem checks before networking them together or through the BUS will help isolate for troubleshooting.

ADD another module Test operations if good then add one more and Test. Do this until they Master System is completed.

TroubleShooting:

Problem

Clock has an inverter OUTPUT and only lights if the LED is place in circuit with Cathode to pin 8 of the 74LS08 AND Gate and Anode to VCC.

Solution

Maksure the ICs have VCC and Ground connected

Power distribution Problems

Why does an LED light when the INPUT is 0?

APA Citation

Eater, B. (n.d.). *8 Bit Computer*. Eater.Net. https://eater.net/8bit

8bit-computer.jpeg image

X,B.(n.d). Using the 555 Timer. *DroneBot Workshop*.https://dronebotworkshop.com/555-timer/

Miscellaneous image

Eater,B. [Ben Eater]. (Year, Month Day). *Clock logic - 8-bit computer clock - part 4* [Video]. YouTube. https://www.youtube.com/watch?v=SmQ5K7UQPMM

Ben Eater 8 Bit Computer

USER MANUAL

All projects should include a user manual that will explain how your electronic system works from the perspective of the end user. This can include relevant illustrations, instructions and safety information. Your instructor is likely to try operating your finished product using your user manual and make an evaluation on that basis.

Ben Eater’s 8 Bit Computer

THEORY REQUIREMENTS

ELTR 100 – Electrical Network Analysis

This might include the use of discrete passive components such as resistors, capacitors, inductors, potentiometers, and/or specific component configurations such as voltage dividers, current dividers, filters, time-constant delays, and/or some combination thereof.

ELTR 130 – Digital Logic Systems

This might include the use of discrete basic logic ICs, discrete combinational logic ICs, memory devices, counters, timers, and/or some combination thereof.

ELTR 150 – Solid State Semiconductor Devices

This might include the use of discrete semiconductor components such as diodes or transistors, transistor amplifier circuits, operational amplifiers, and/or some
combination thereof.

Ben Eater 8 Bit Computer
Project Contents

MATERIAL REQUIREMENTS

Sketches and/or illustrations
Block diagrams
Schematic diagrams
Logic diagrams
Concept art
Journals
Graphs
Test results
Research materials
Anything else you think is relevant to your project

Ben Eater’s 8 Bit Computer

Check List

MATERIAL REQUIREMENTS

- Design materials
- Diagrams and schematics
- Documentation and information
- A functional prototype
- A functional final product
- An audio-visual presentation