

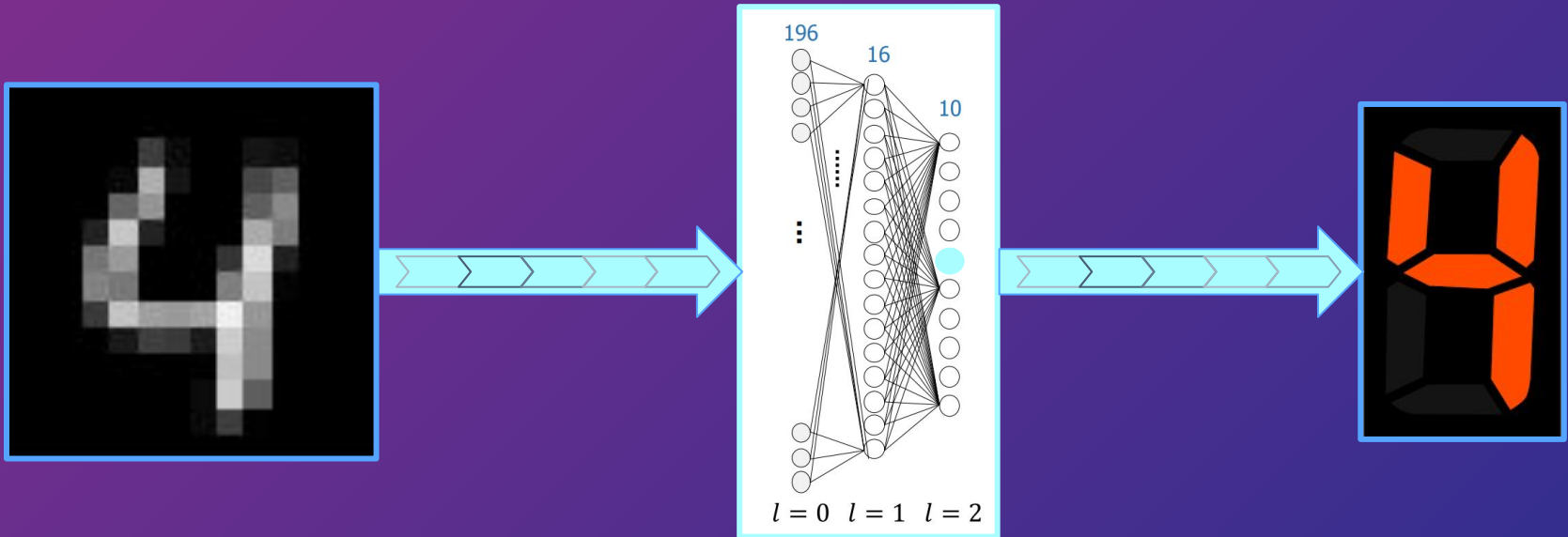


ARTIFICIAL NEURAL NETWORK

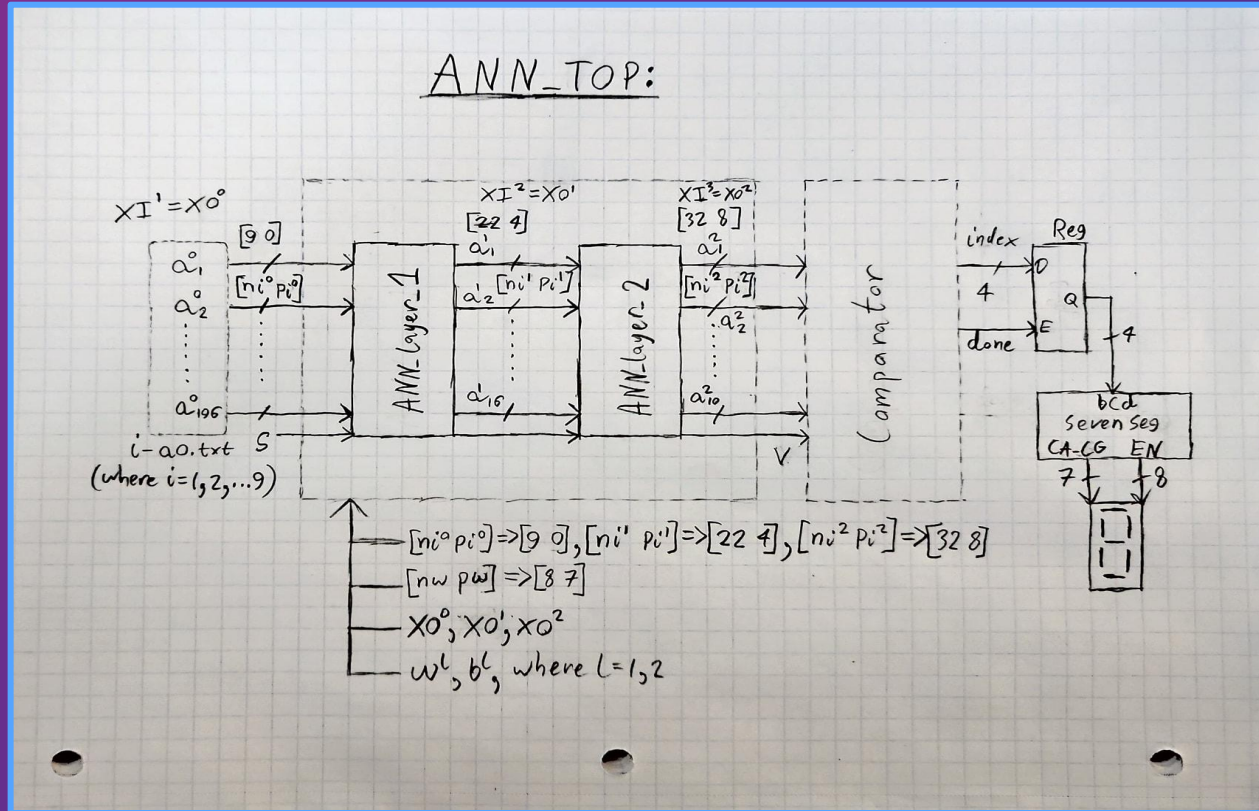
David Kosa, Polly Jane Bates, Gerard Griest

Circuit Operation

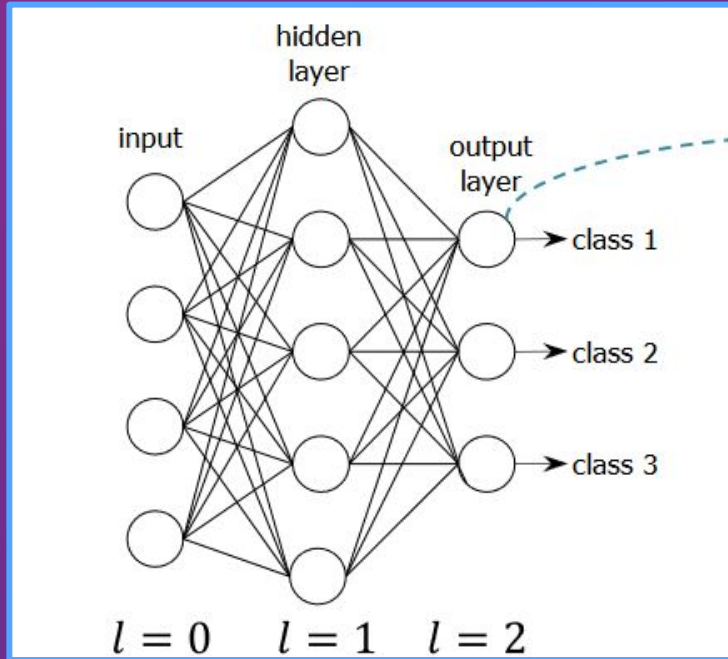
1. Receives 14x14 gray scale image as a vector
2. Feeds forward values through neural network to determine the digit
3. Deciphers the output
4. Displays guessed digit on seven segment display



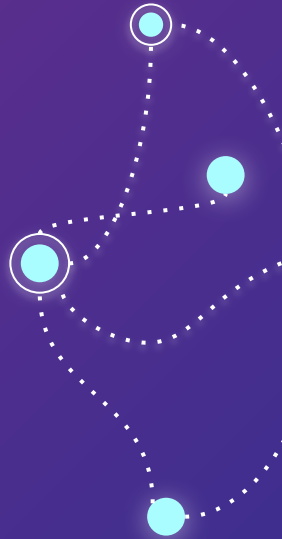
ANN Top File Block Diagram



What is a Neural Network?



- Is a machine learning program that makes decisions similar to a human brain
- Each neuron communicates with each other
- If the output of a neuron threshold is surpassed the neuron sends its information to the next layer
- Neural Networks require data training to help it detect patterns



[illegible][illegible][illegible]

Final Evaluation

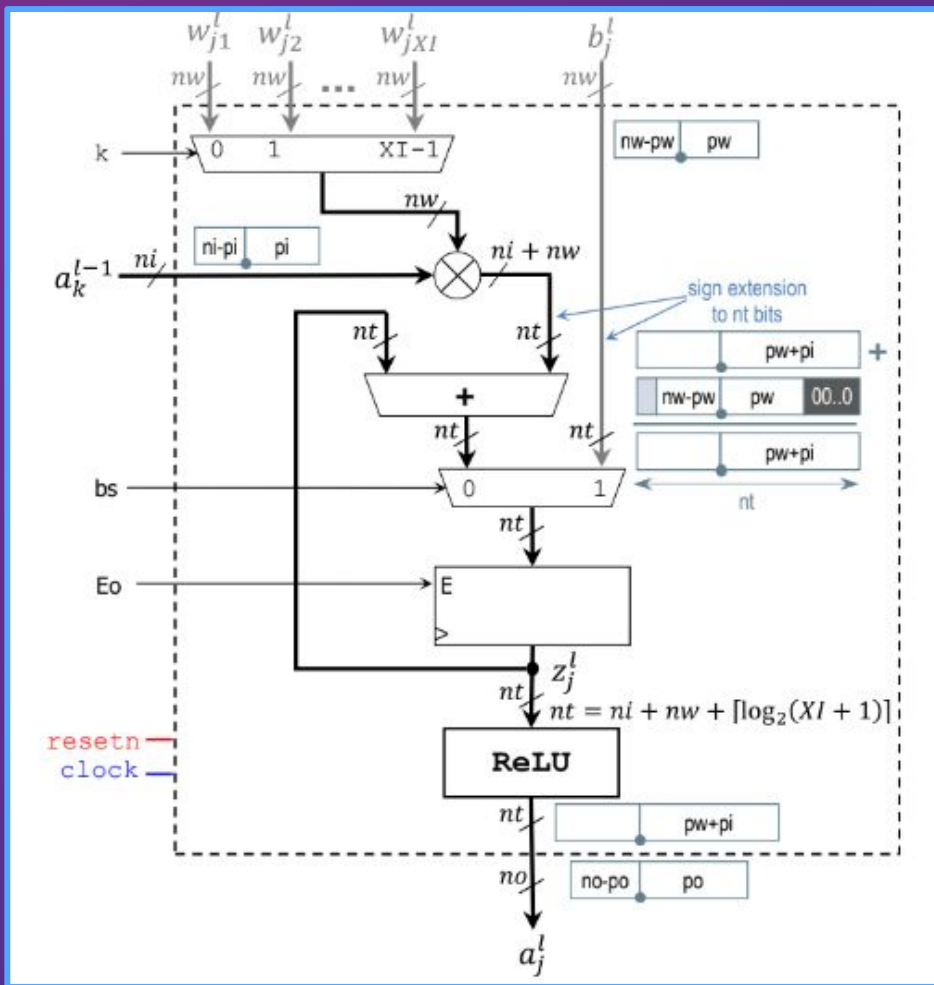
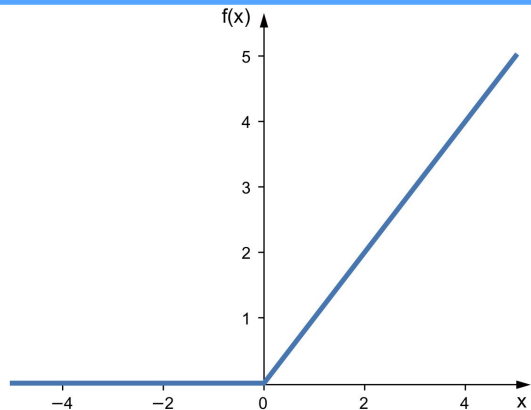
Neuron

Multiply-and-accumulate architecture
Weights & biases: [8 7]

Activations:

- [9 0]
- [22 4]
- [32 8]

ReLU





Layer

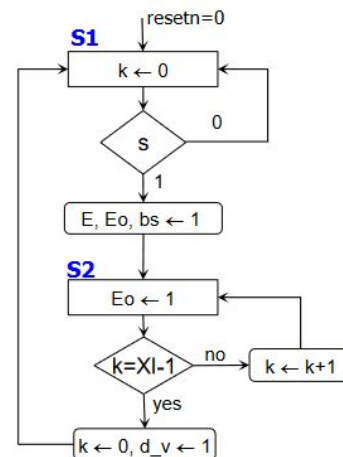
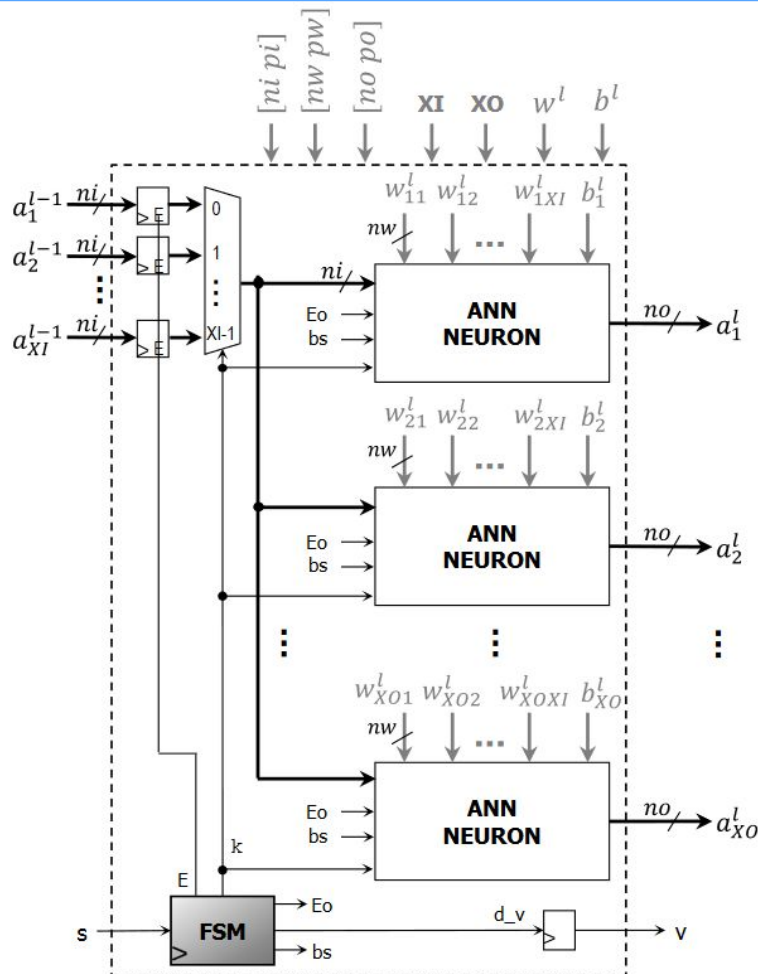


Layer 1:

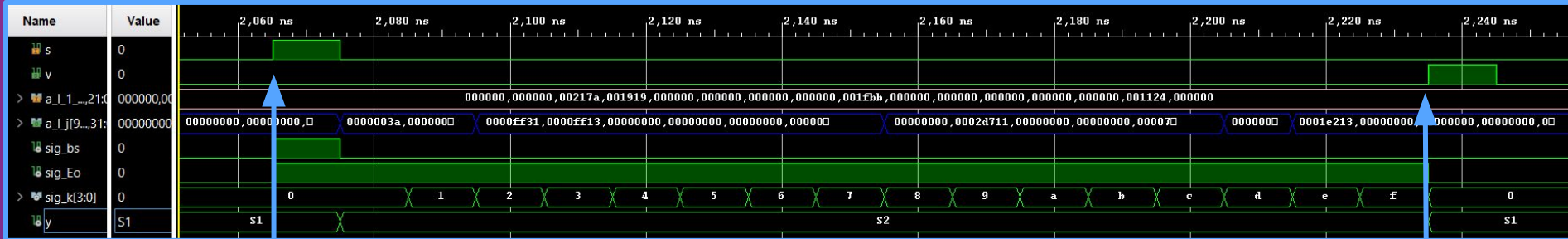
- $XI = 196$
- $X0 = 16$
- $W = 16 \times 196$
- $B = 16$

Layer 2:

- $XI = 16$
- $X0 = 10$
- $W = 10 \times 16$
- $B = 10$



Layer 2 Simulation



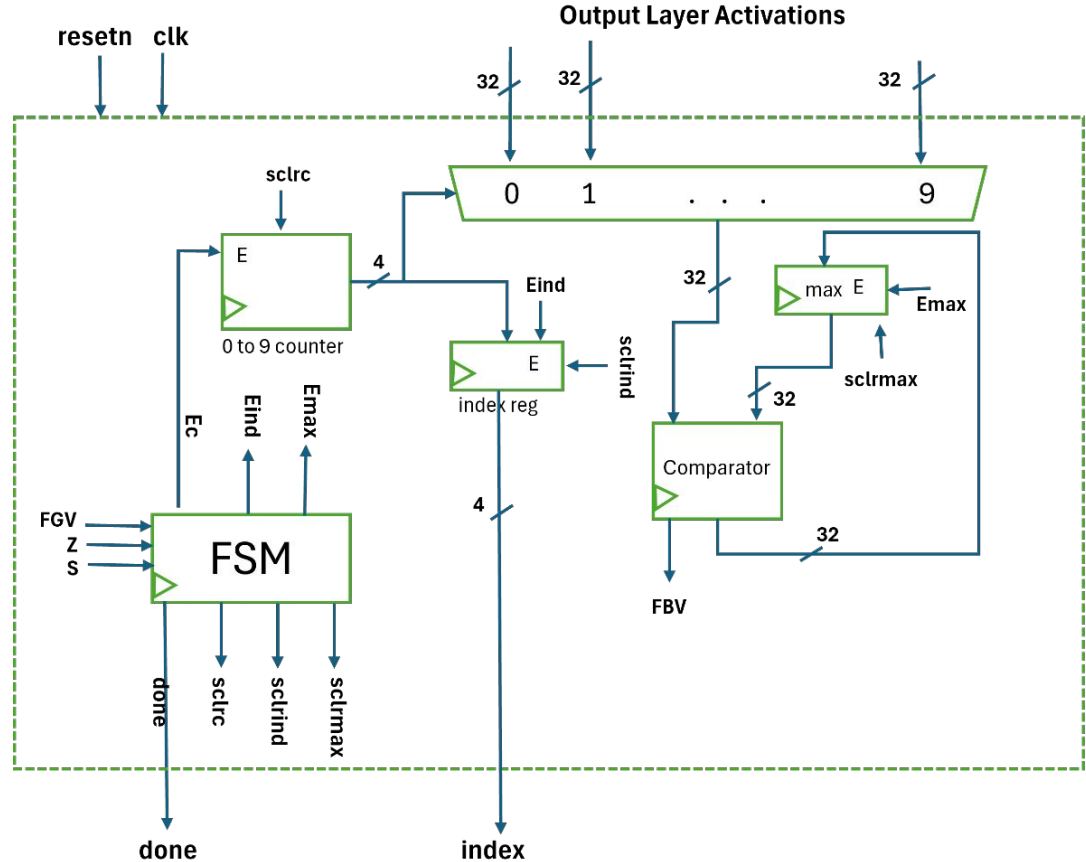
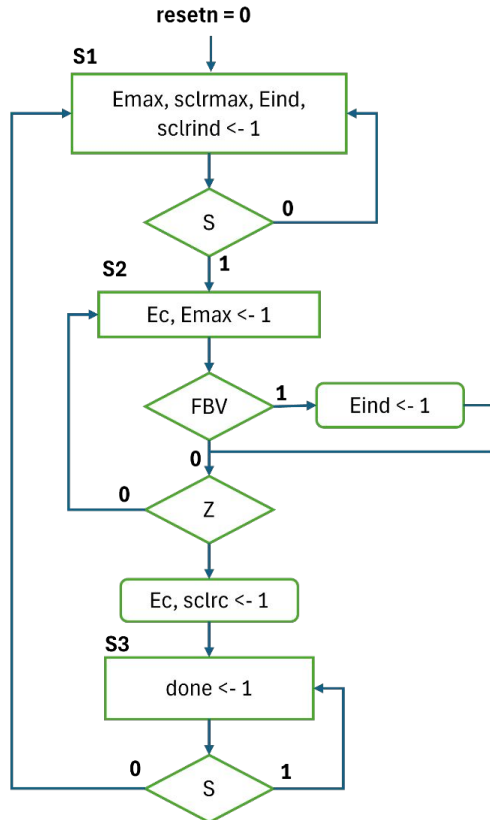
- K iterates through all input neurons (16 total)
- Enable accumulator register
- Choose add bias first clock cycle

start

done

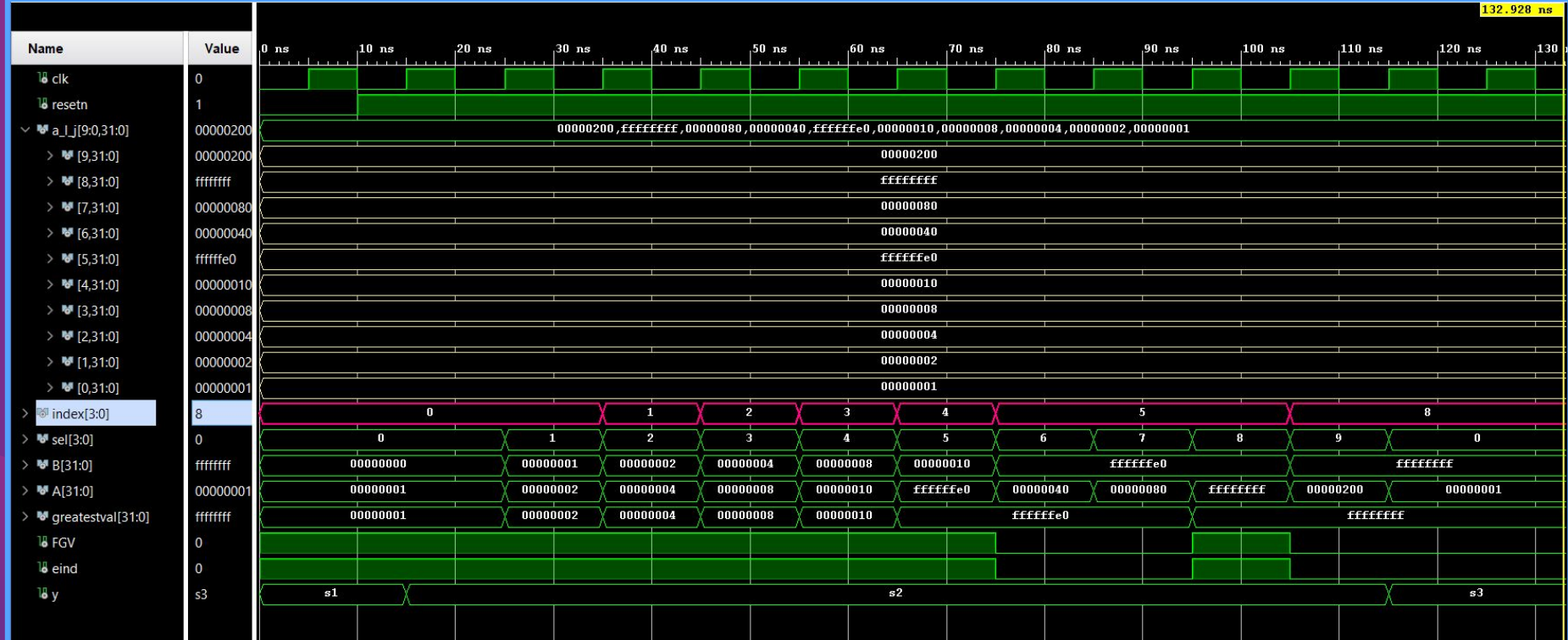


Comparator

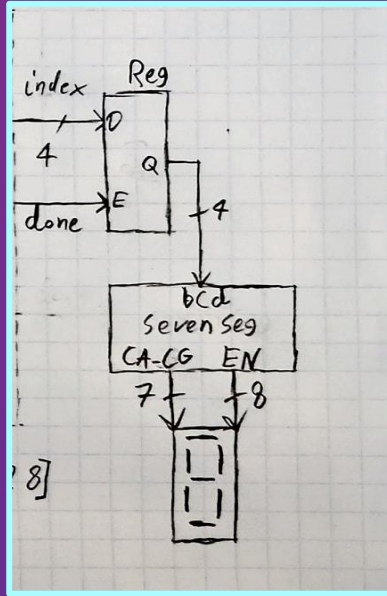




Comparator Testbench



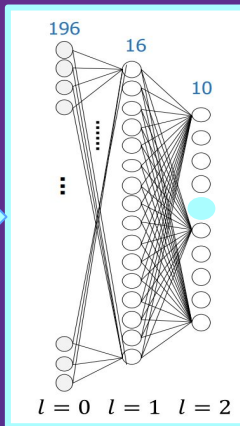
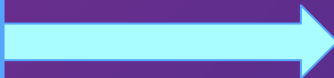
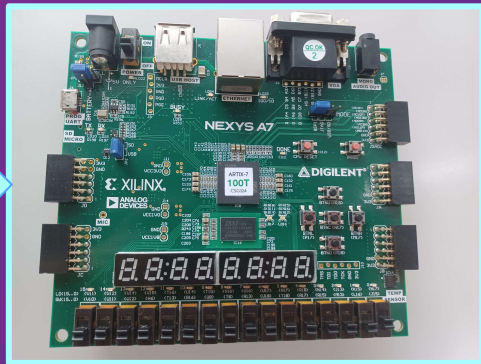
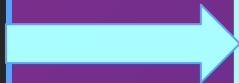
Index Capture & Seven Seg Display



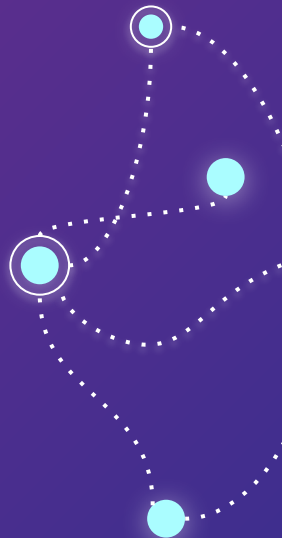
- Register - captures the ANN's guess once the 'done' signal goes high
- Seven Segment Decoder - convert BCD to Seven Segment decoding; this displays on a single Seven Segment Display

Synthesizing Text Files

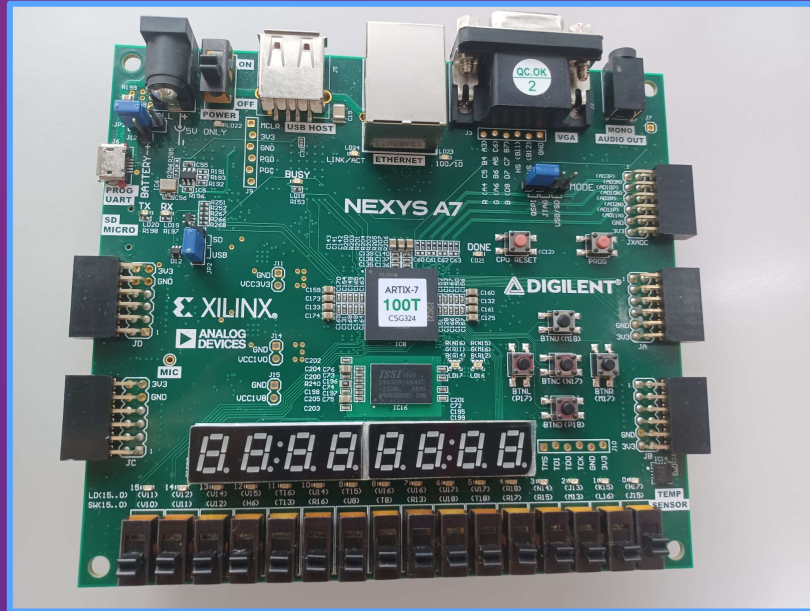
```
000000000
000000000
000000011
000010001
000011001
000010100
000000011
000000000
```



- Utilized an Impure Function to synthesize text files in VHDL
- The function itself is NOT part of the hardware
- Essentially reads a text file and stores them as constant values (weights, biases, activation input)



Bitstream / Hardware



- The Nexys A7 100T board was required for this project as the program was too big for the 50T board
- Outputs are put on the 7 Segment Display

Project Demo for the Number 8

```
1(i));  
  
gusActivation:= ReadFromFile("8-a0.txt"); -- edit the # to cha  
  
ray of inputs read from the txt file  
2d (195 downto 0, 8 downto 0);
```

