BetterMemory Peripheral

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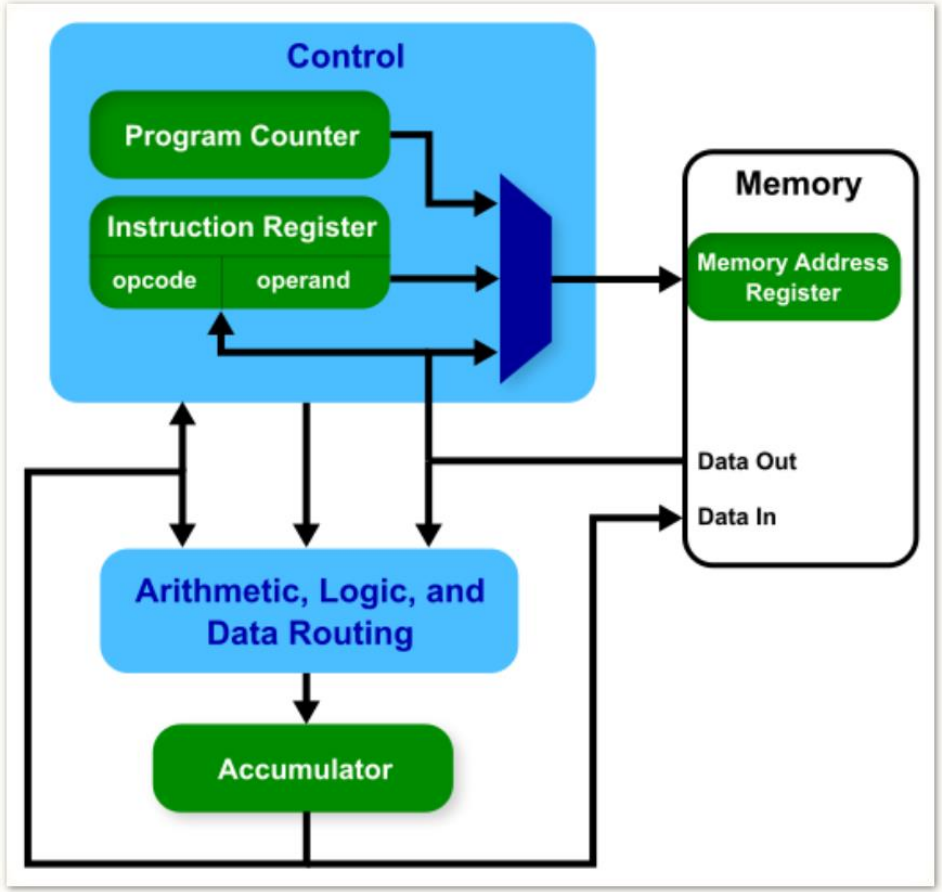
Addressing the Issue of Limited Memory

SCOMP Only Stores 2048 Words of Memory

- Some data-intensive processes require significantly more memory than SCOMP provides
- We have external memory available from the FPGA, but not an easy way to access it
- A peripheral would enable programmers to make use of this additional memory with simple "IN" and "OUT" commands in SCOMP assembly



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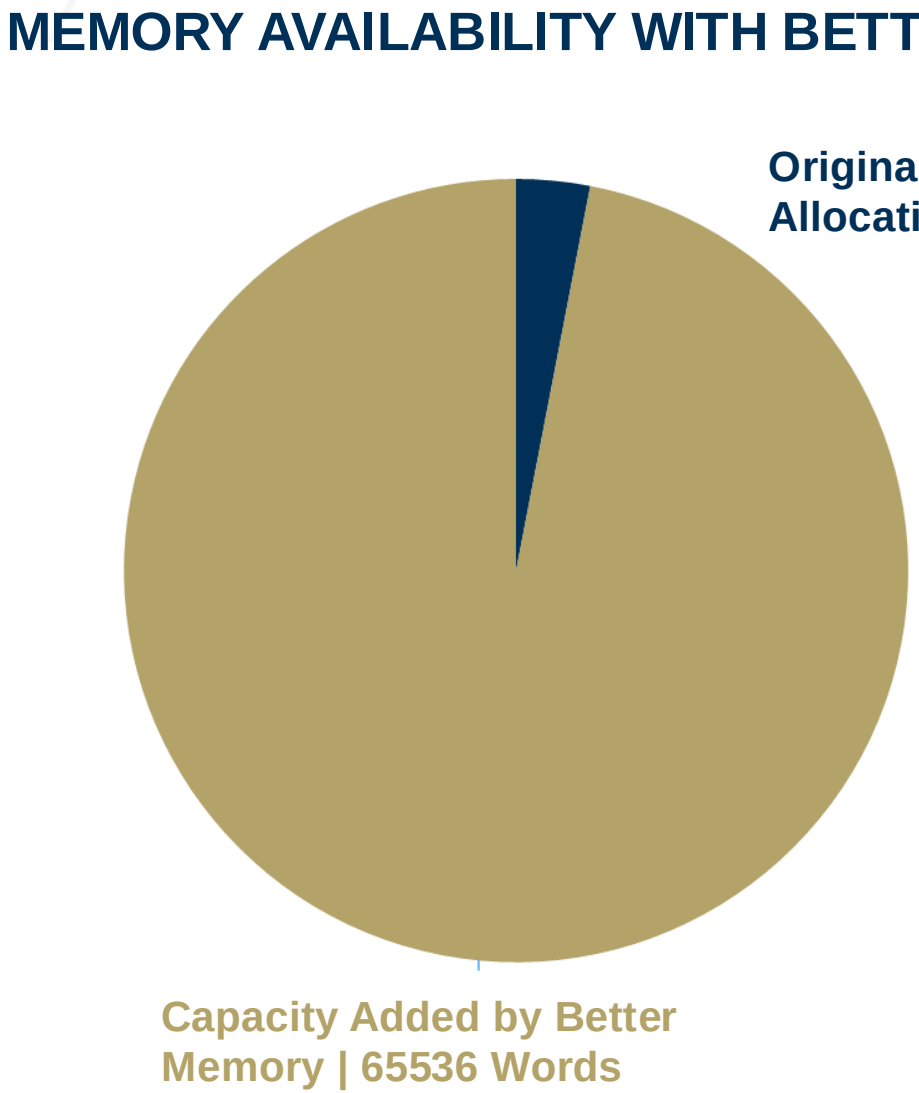
The BetterMemory Peripheral Expands SCOMP Storage



- BetterMemory utilizes Intel's altsyncram memory
  - Preconfigured IP that allocates FPGA resources for memory
- This allows us to hold a **megabit** of memory
- That is enough memory to hold:
  - A space invaders game
  - A dictionary
  - A basic voice processing model
  - The BEE MOVIE SCRIPT

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How We Spice Up Memory Use

Auto-Incrementing Memory

- Pick a place in memory, and either read or write at consecutive memory addresses without specifying the address for each use
- Makes assembly code easier to understand and write
- Eliminates confusion and mix-ups with multiple data filled memory addresses
- Allows easy implementation of repeated commands interacting with memory, such as summing multiple variable, saving files, holding instructions or lists, etc.

How BetterMemory Works

BetterMemory API – End User's Perspective

STORING Data

- Load 16-bit address into SCOMP Accumulator
- Write OUT to BetterMemory's ADDRESS_EN
- Load 16-bit value into SCOMP Accumulator
- Write OUT to BetterMemory's VALUE_EN

SCOMP Assembly Example

```
1  ORG 0
2
3      LOADI   &H00A0      ;load 160 into AC
4      OUT     ADDRESS_EN  ;set BEtterMemory's Address ptr to 160
5
6      LOADI   &H00D3      ;load some value into AC
7      OUT     VALUE_EN    ;store value from AC into memory at address 160
8
9  ; Addresses of Better Memory peripheral enable pins
10 ADDRESS_EN  EQU &H0070
11 VALUE_EN    EQU &H0071
12 INCR_EN     EQU &H0072
```

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BetterMemory API – End User's Perspective

RETRIEVING Data

- Load 16-bit address into SCOMP Accumulator
- Write out to BetterMemory's ADDRESS_EN
- Read in from BetterMemory's VALUE_EN

SCOMP Assembly Example

```
1  ORG 0
2
3      LOAD    AddressOfSomeData   ;load address into ac
4      OUT     ADDRESS_EN          ; set peripheral address to be ac
5
6      IN      VALUE_EN            ;read & latch data at address
7
8  ;Arbitarary variables
9  AddressOfSomeData:  DW  &HFC9A
10
11 ; Addresses of Better Memory peripheral enable pins
12 ADDRESS_EN  EQU &H0070
13 VALUE_EN    EQU &H0071
14 INCR_EN     EQU &H0072
```

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BetterMemory API – Auto-Increment Feature

STORING Data

- Load 16-bit address into SCOMP Accumulator to set initial address
- Write out to BetterMemory's ADDRESS_EN
- Write out to BetterMemory's INCR_EN
- Load 16-bit value into SCOMP AC
- Write out to BetterMemory's VALUE_EN

SCOMP Assembly Example

```
1  ORG 0
2
3      LOAD    InitialAddress      ;load address into ac
4      OUT     ADDRESS_EN          ; set peripheral address to be ac
5
6      OUT     INCR_EN             ; set to autoincrement mode
7
8      LOADI   &H0001
9      OUT     ADDRESS_EN          ; stored at address
10
11     ADDI    1
12     OUT     ADDRESS_EN          ;value stored at 2nd address
13     ADDI    1
14     OUT     ADDRESS_EN          ;value stored at 3rd address
15     ADDI    1
16     OUT     ADDRESS_EN          ;value stored at 4th address
17
18
19 ;Arbitarary variables
20 InitialAddress: DW  &HFC9A
21
22 ; Addresses of Better Memory peripheral enable pins
23 ADDRESS_EN  EQU &H0070
24 VALUE_EN    EQU &H0071
25 INCR_EN     EQU &H0072
```

Repeat => Values stored in consecutive addresses

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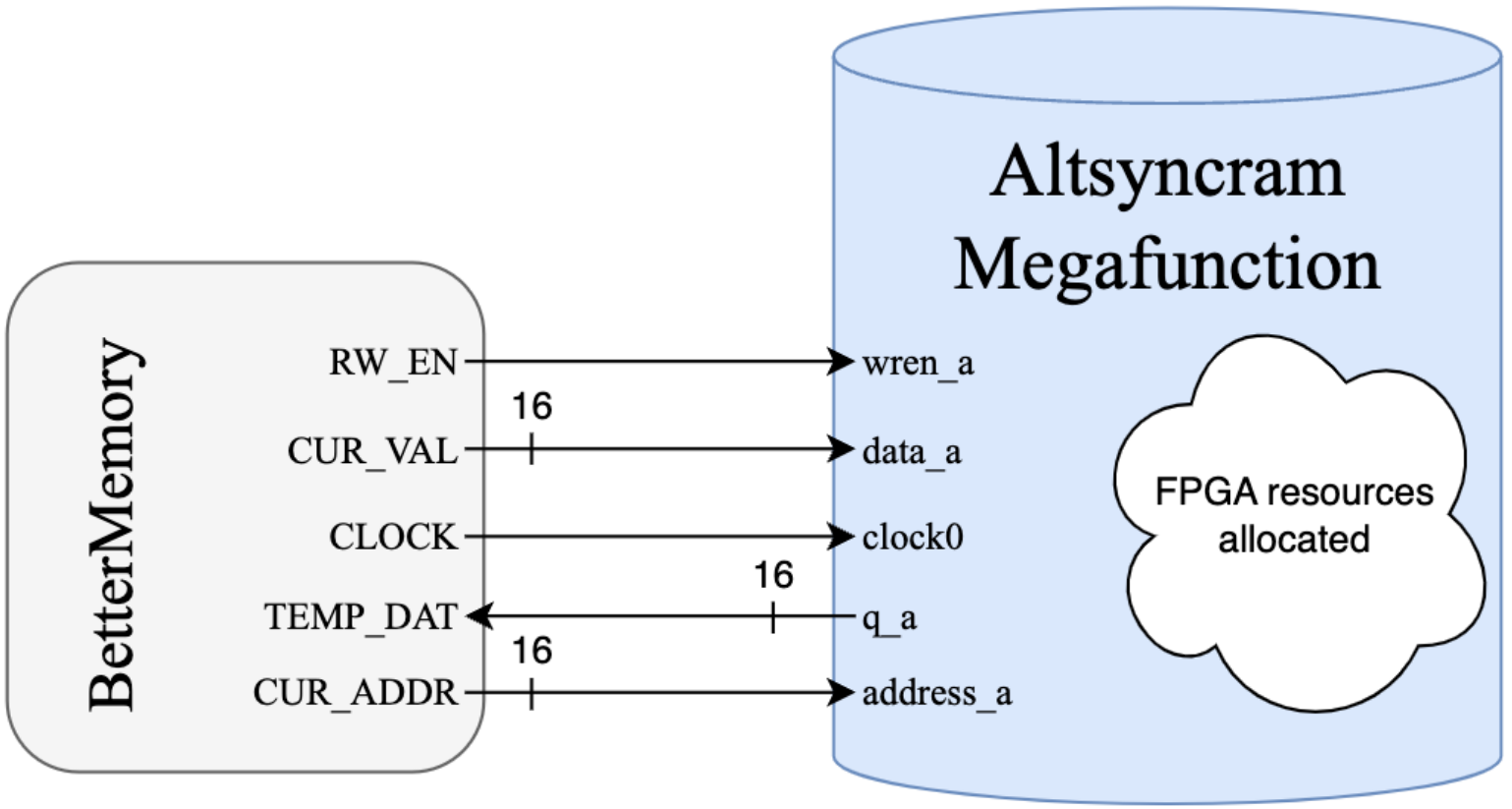
BetterMemory uses ALTSYNCRAM megafunction



- 16-bit value and address space
- Same 50MHz clock signal

- Utilize Altsyncram as a 'component' instantiation in peripheral VHDL

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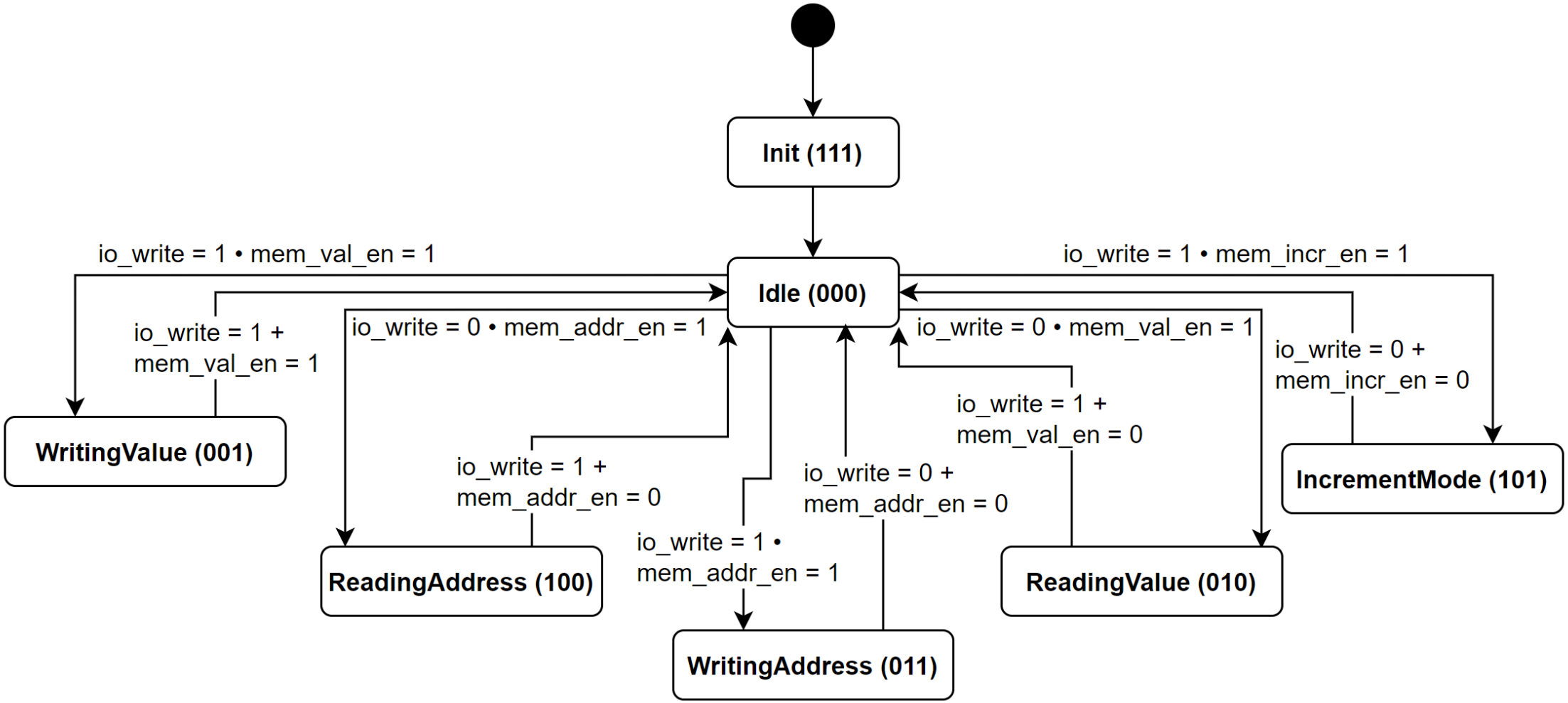
State Machine Diagram



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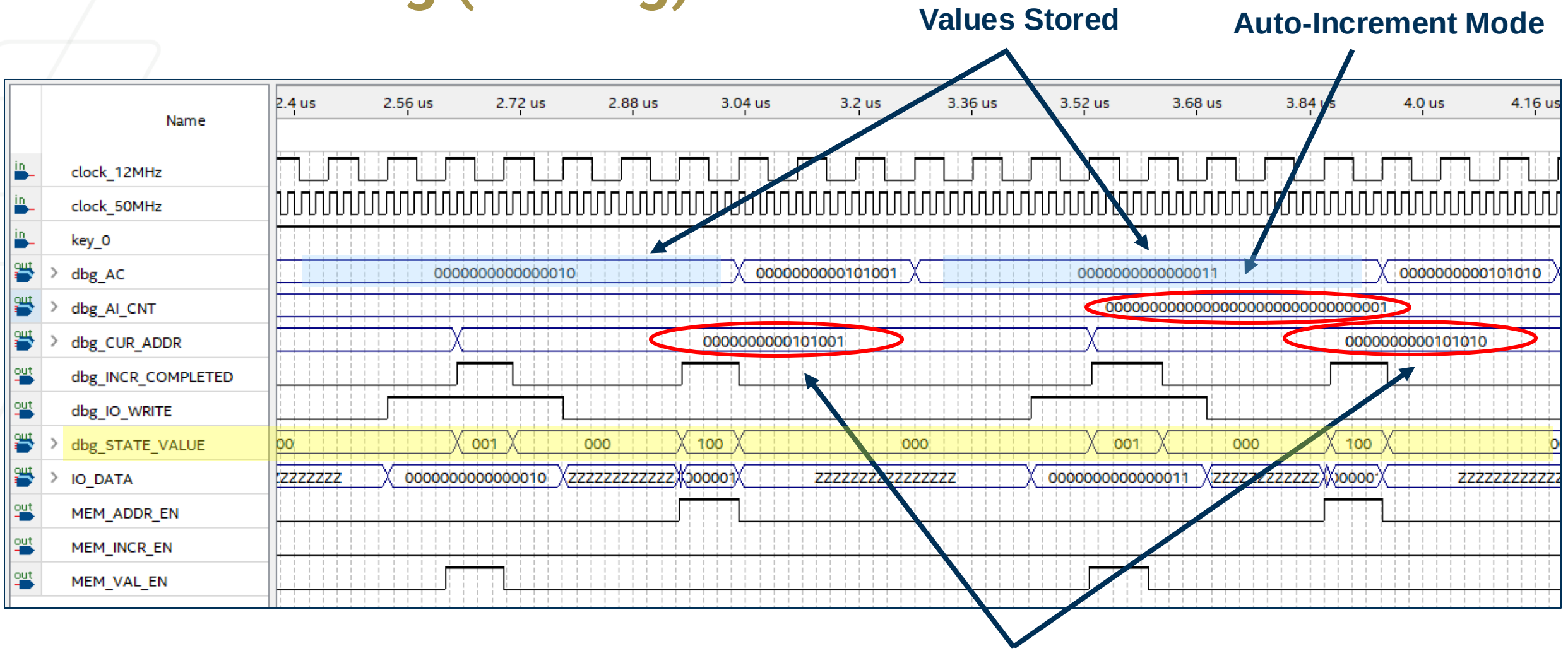
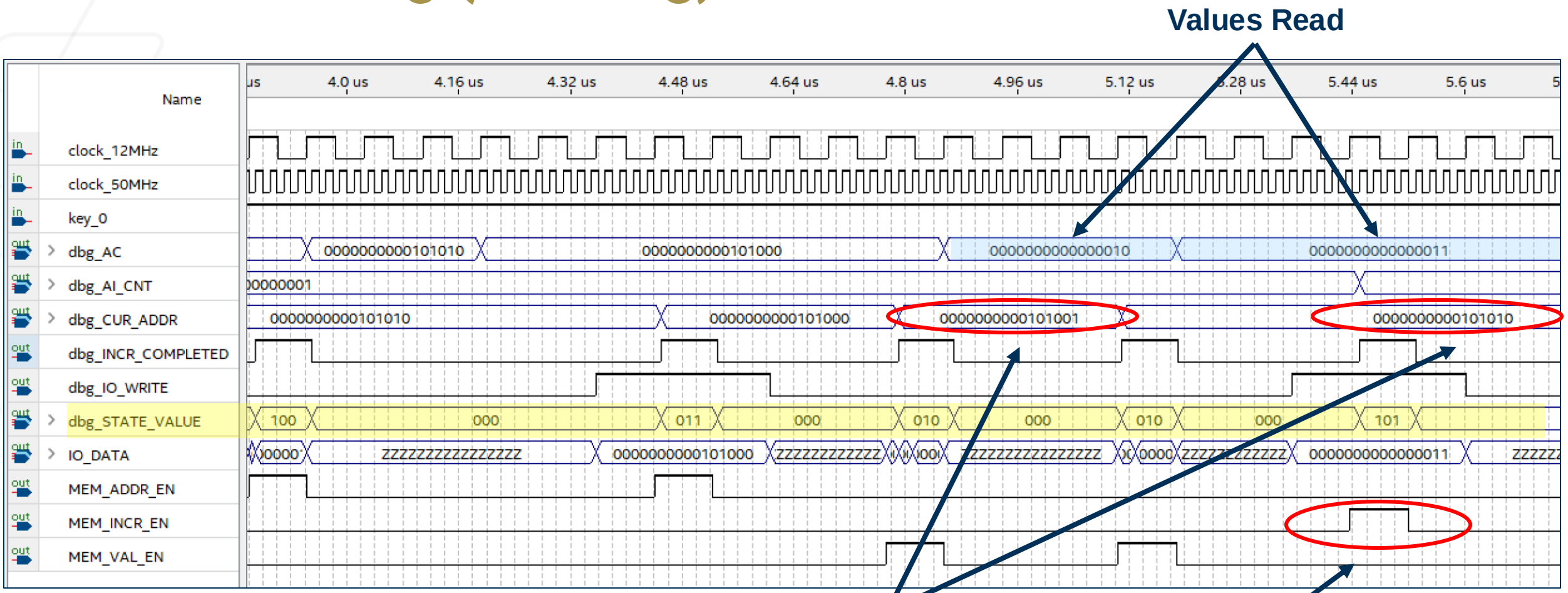
Current Testing (Writing)



State: 000 = Idle
001 = WritingValue
100 = ReadingAddress

Current Testing (Reading)



State: 000 = Idle
010 = ReadingValue
011 = WritingAddress

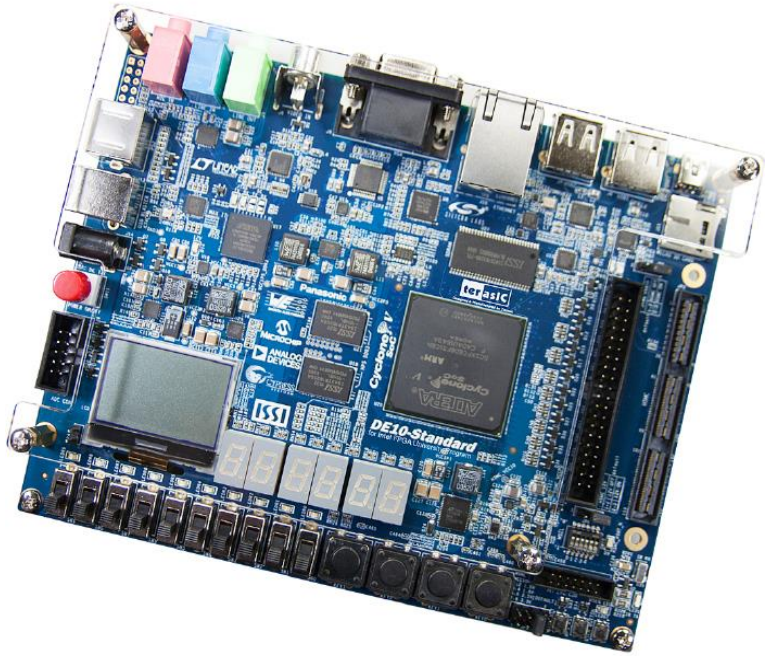
Current Testing and Results

Programming DE-10 Board with Counter Assembly Program

- Program start => write value 0x0001 at address 0x0001, then value 0x0002 at address 0x0002, then 0x0003 @ address 0x0003...
- Stop writing to memory when any switch is active
- Use 10 switches to write 10bit address and display value on 7seg display

The Demonstration

- GT Football Record for 2024-2025 Season
- Score on 7-Segment Display
- LED's Indicate Win



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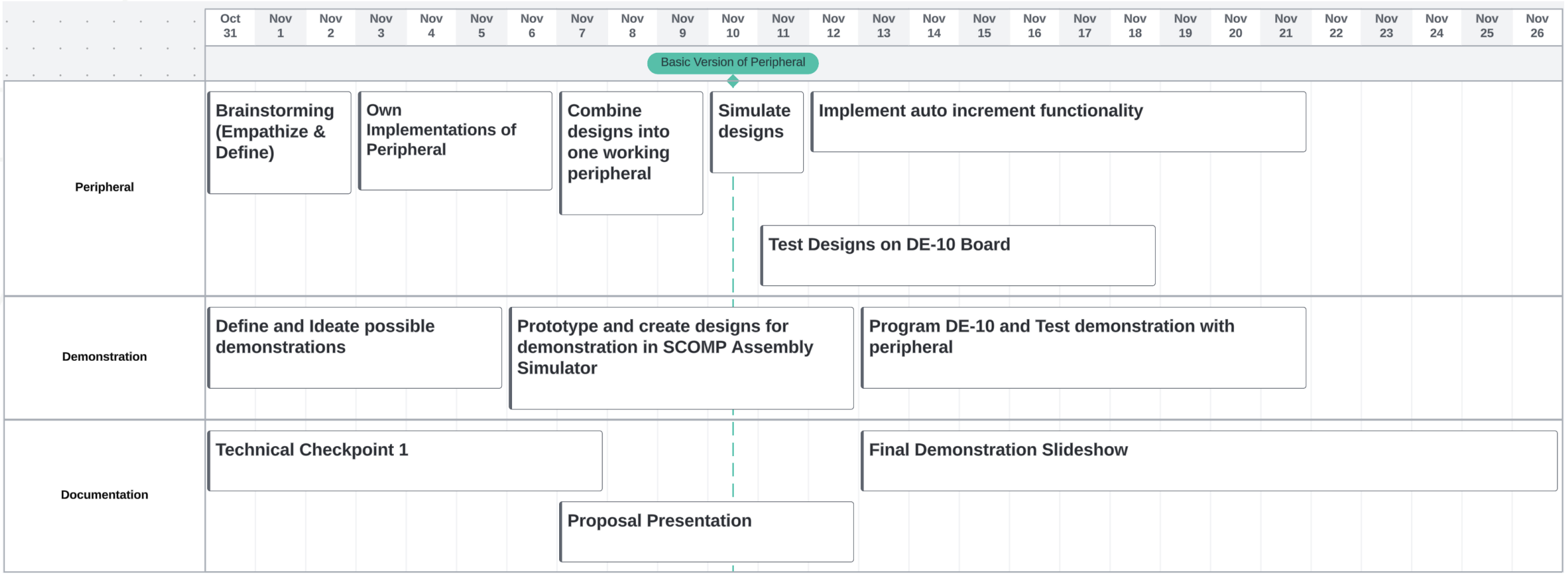
Timeline and Feasibility

BetterMemory Project Timeline

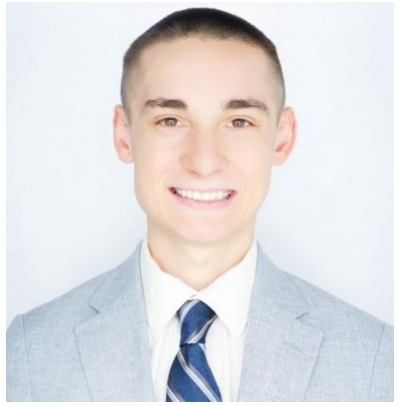


Contingencies

Potential Problem	Course of Action
Altsyncram Integration Failure	Resort to other available RAM ports (ex: Dual Port RAM)
Timing Inconsistencies	Operate memory off SCOMP clock, allowing reliable function at the cost of efficiency
Misuse in Assembly	Sounder API documentation, and variables to force proper state at all times.

Organization

- Noah – VHDL superstar
  - Figured out how to use Altsyncram
- Femke – Incrementer (Co-Pres of VHDL superstardom)
  - Made our memory system special with incrementing feature
- Rudra and Cody – Demonstrators
  - Wrote the assembly code to show off our product to attract customers
- Evan – Documenter
  - API, Testing , and Presentation



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Thank You!