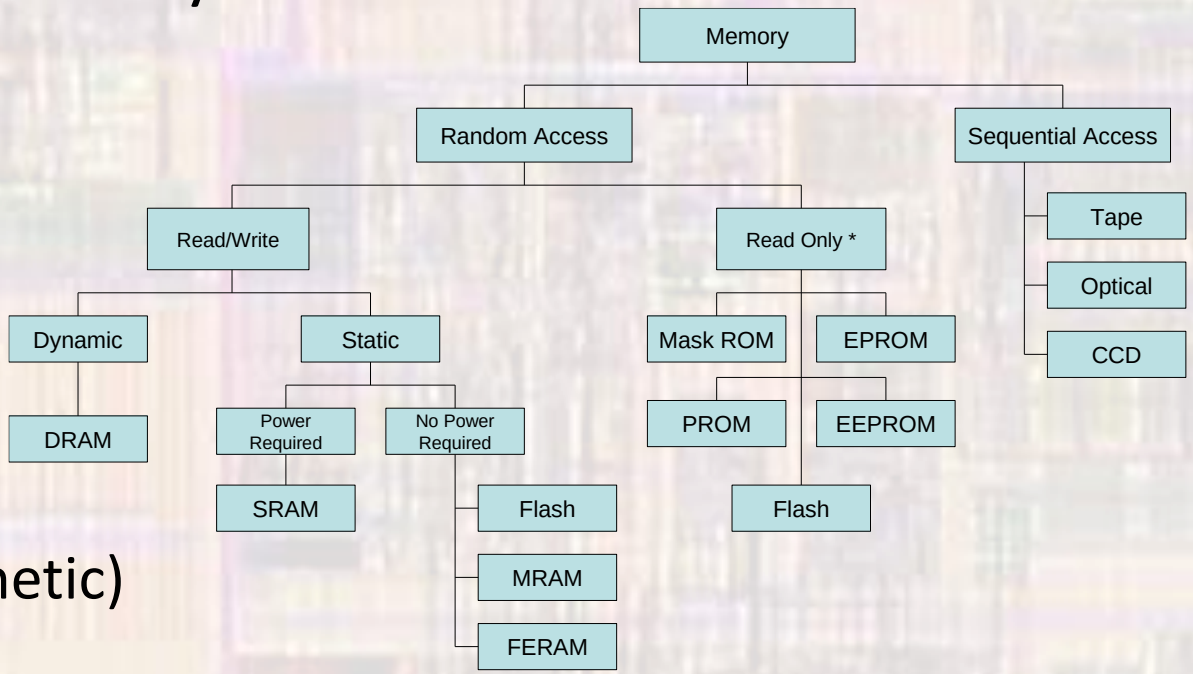
Memory Overview

Last updated 6/13/23

These slides introduce semiconductor memories

Memory Overview

- Many Types of memory
  - Paper tape
  - Cards
  - Magnetic Tape
  - Floppy Disk
  - Hard Drive (Magnetic)
  - Optical Drive
  - Integrated Circuit Memory



Memory Overview

- 2 Key Concepts for Integrated Circuit memory
  - ROM
    - ROM – read only memory
    - Fixed values - memory cannot be changed
  - RAM
    - RAM – random access (really Read/Write = R/W)
    - Memory can be changed

Memory Overview

- Integrated Circuit Memory
  - Non – Volatile
    - Retains its values even when power is removed
    - ROM
    - NAND and NOR Flash
    - EPROM, EEPROM
  - Volatile
    - Loses its values when power is removed
    - Static – When powered, retains value without any extra effort
      - Registers
      - SRAM – Static RAM
    - Dynamic – When powered, requires periodic refresh or values will degrade
      - DRAM – Dynamic RAM
      - SDRAM – Synchronous DRAM (DDR, DDR2, DDR3, DDR4, …)

Memory Overview

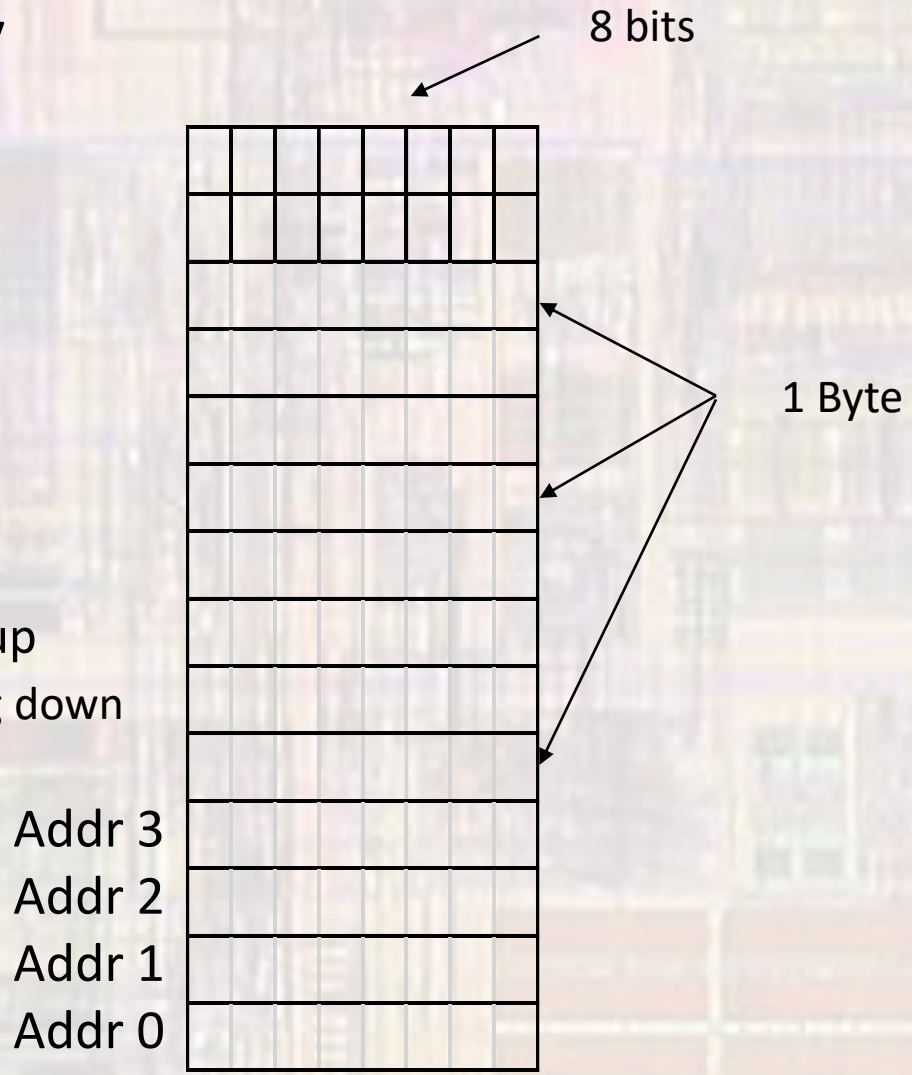
- Key Measures
  - Density
    - Amount of storage in a given area
  - Speed
    - Read or Write speed
    - Can be different for first access vs. follow on accesses
  - Power
    - Static – powered up but not doing anything
    - Dynamic – reading or writing
  - Cost / bit
    - Function of complexity and density

Memory Overview

- Integrated Circuit Memory
  - Minimum logical element
    - 1 – bit (b)
    - Has a logical value of ‘0’ or ‘1’
    - Has a physical value of “vdd” or “gnd”
      - 5v, 3.3v, 2.4v, 1.8v, 1.2v
  - Minimum accessible storage element
    - 1- Byte (B)
    - 8 bits
  - Minimum Addressable element
    - 1 – Word
    - Situational dependent length
    - 1B, 2B, 4B, 8B, 16B, …

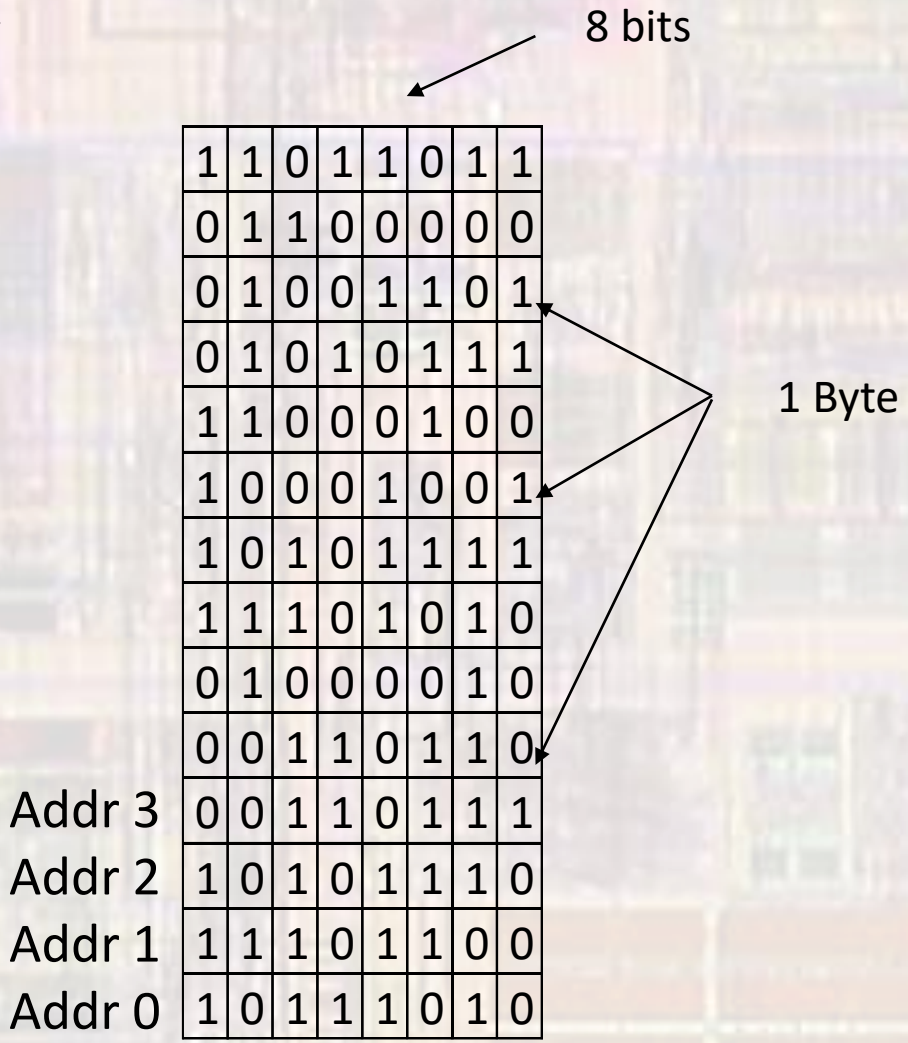
Memory Overview

- Integrated Circuit Memory
  - Logical configuration
    - Long column of bytes
    - 1st address is "0"
    - Typically thought of as growing up
      - Sometimes thought of as growing down



Memory Overview

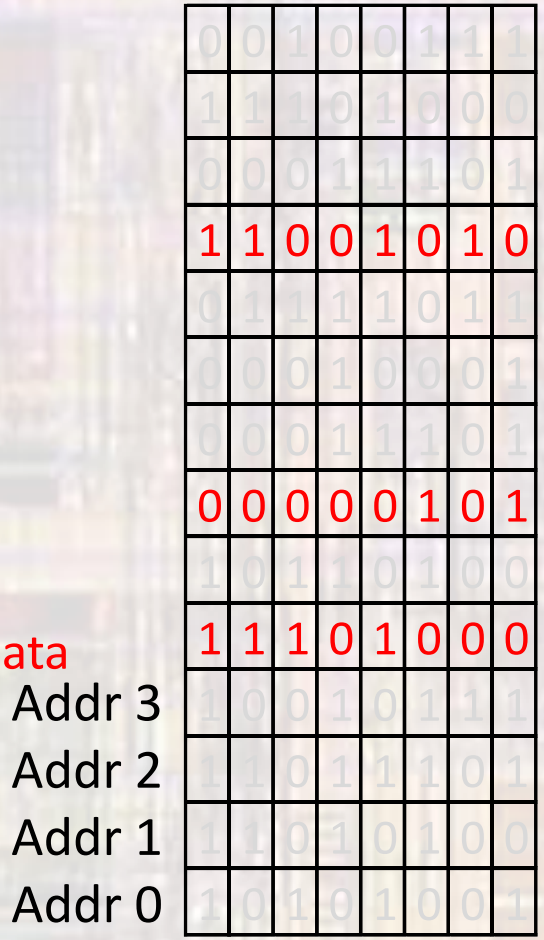
- Integrated Circuit Memory
  - Even though we may not have stored anything in a specific memory location
    - It has a value
    - The value is likely random



	1	1	0	1	1	0	1	1
	0	1	1	0	0	0	0	0
	0	1	0	0	1	1	0	1
	0	1	0	1	0	1	1	1
	1	1	0	0	0	1	0	0
	1	0	0	0	1	0	0	1
	1	0	1	0	1	1	1	1
	1	1	1	0	1	0	1	0
	0	1	0	0	0	0	1	0
	0	0	1	1	0	1	1	0
Addr 3	0	0	1	1	0	1	1	1
Addr 2	1	0	1	0	1	1	1	0
Addr 1	1	1	1	0	1	1	0	0
Addr 0	1	0	1	1	1	0	1	0

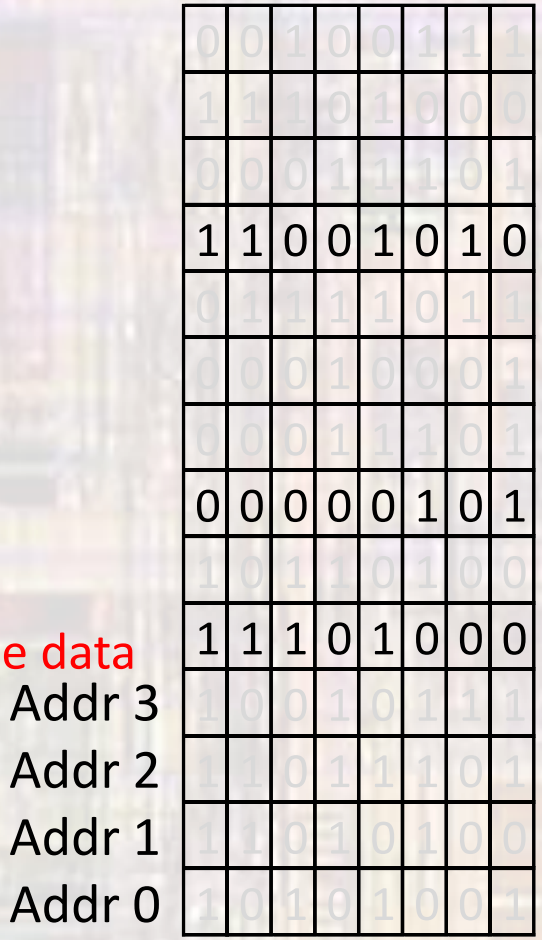
Memory Overview

- Integrated Circuit Memory
  - Write
    - Provide Address and Data
    - Write (addr 4, 11101000)
    - Write (addr 6, 00000101)
    - Write (addr 10, 11001010)
  - Note: Writing overwrites existing data



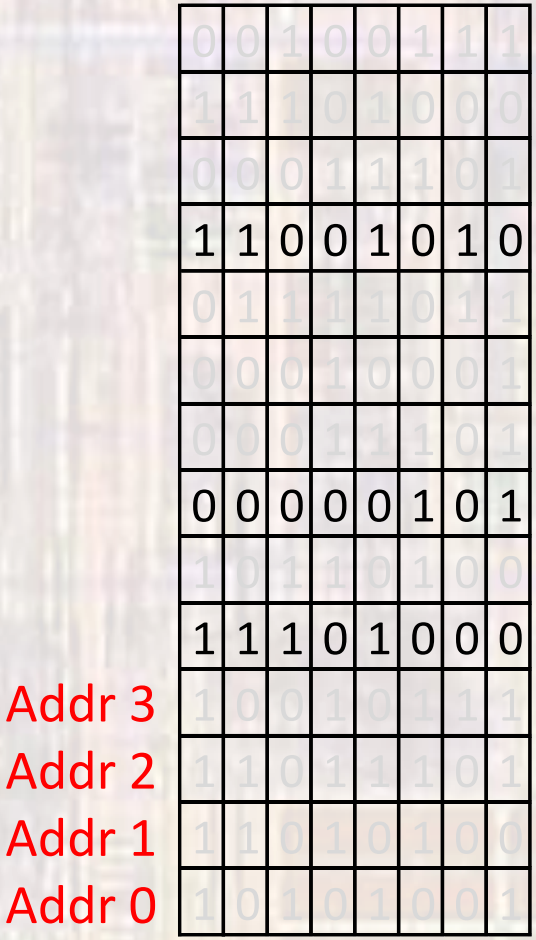
Memory Overview

- Integrated Circuit Memory
  - Read
    - Provide Address
    - Read (addr 4) → 11101000
    - Read (addr 6) → 00000101
    - Read (addr 8) → ????????
  - NOTE: Reading does not destroy the data



Memory Overview

- Integrated Circuit Memory
  - Addresses
    - Addresses are NOT part of the memory array
    - Addresses are logic circuits to choose which part of the array to read from or write to – decoders determine the location



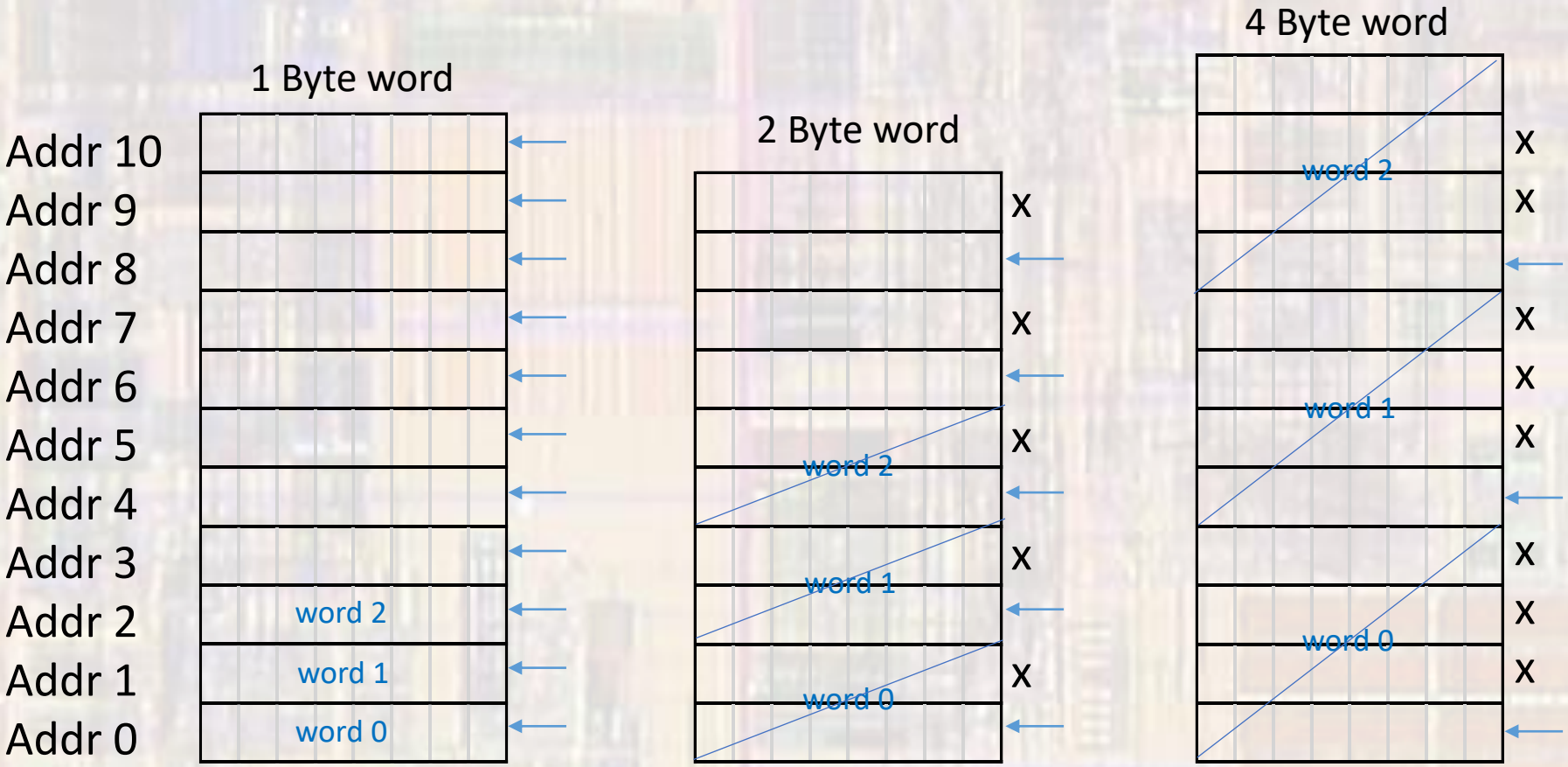
Memory Overview

- Integrated Circuit Memory
  - Word Alignment
    - Processors work with data WORDS
    - Size of the internal registers
      - 1 Byte – 8 bit processor
      - 2 Bytes – 16 bit processor
      - 4 Bytes – 32 bit processor
      - 8 Bytes – 64 bit processor
    - Memory is word aligned
      - Must access the entire word
      - Not allowed/possible to access inside a word*

        * exceptions exist

Memory Overview

- Integrated Circuit Memory
  - Word Alignment
    - Allowed addresses indicated by ←



Memory Overview

- Integrated Circuit Memory
  - Big-Endian vs Little-Endian – the order words > 1B are stored in memory
  - data value 01110111 10111011 11011101 01110111 in a 4 byte word