Memory types

CMPE 311
General Concepts

- A memory is an array of storage locations
  - Each with a unique address
  - Like a collection of registers, but with optimized implementation
- Address is unsigned-binary encoded
  - $n$ address bits $\Rightarrow 2^n$ locations
- All locations the same size
  - $2^n \times m$ bit memory
Memory Sizes

- Use power-of-2 multipliers
  - Kilo (K): $2^{10} = 1,024 \approx 10^3$
  - Mega (M): $2^{20} = 1,048,576 \approx 10^6$
  - Giga (G): $2^{30} = 1,073,741,824 \approx 10^9$

- Example
  - 32K x 32-bit memory
  - Capacity = 1,024K = 1Mbit
  - Requires 15 address bits

- Size is determined by application requirements
Basic Memory Operations

- **a inputs:** unsigned address
- **d_in and d_out**
  - Type depends on application
- **Write operation**
  - \( \text{en} = 1, \text{wr} = 1 \)
  - \( \text{d_in} \) value stored in location given by address inputs
- **Read operation**
  - \( \text{en} = 1, \text{wr} = 0 \)
  - \( \text{d_out} \) driven with value of location given by address inputs
- **Idle:** \( \text{en} = 0 \)
Synchronous SRAM (SSRAM)

- Clocked storage registers for inputs
  - address, data and control inputs
  - stored on a clock edge
  - held for read/write cycle

- Flow-through SSRAM
  - no register on data output
Memory Types

• Volatile and non-volatile
  • Volatile: only maintains its data while the device is powered, Ex: RAM
  • Non volatile: can maintain stored information even after having been power cycled (turned off and back on), Ex: ROM, Flash

• Random-Access Memory (RAM)
  • Can read and write
  • Static RAM (SRAM)
    • Stores data so long as power is supplied
    • Asynchronous SRAM: not clocked
    • Synchronous SRAM (SSRAM): clocked
  • Dynamic RAM (DRAM)
    • Needs to be periodically refreshed

• Read-Only Memory (ROM),
• Programmable read only memory (PROM)
• Erasable PROM (EPROM)
• Electronically Erasable PROM (EEPROM)
Electrically erasable programmable read-only memory (EEPROM)

• remove the biggest drawbacks of EPROMs: ease of programmability.
• The chip does not have to removed to be rewritten.
• The entire chip does not have to be completely erased to change a specific portion of it.
• Changing the contents does not require additional dedicated equipment.
• EEPROM chips are too slow to use in many products that make quick changes to the data stored on the chip.
Flash

- **Flash memory**, a type of EEPROM that uses **in-circuit wiring** to erase by applying an electrical field to the entire chip or to predetermined sections of the chip called **blocks**. Flash memory works much faster than traditional EEPROMs because it writes data in chunks, usually 512 bytes in size, instead of 1 byte at a time.
## Memory Comparison table

<table>
<thead>
<tr>
<th>Memory type</th>
<th>Read speed</th>
<th>Volatility</th>
<th>density</th>
<th>rewrite</th>
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<td>+++</td>
<td>-</td>
<td>-</td>
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<tr>
<td>DRAM</td>
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