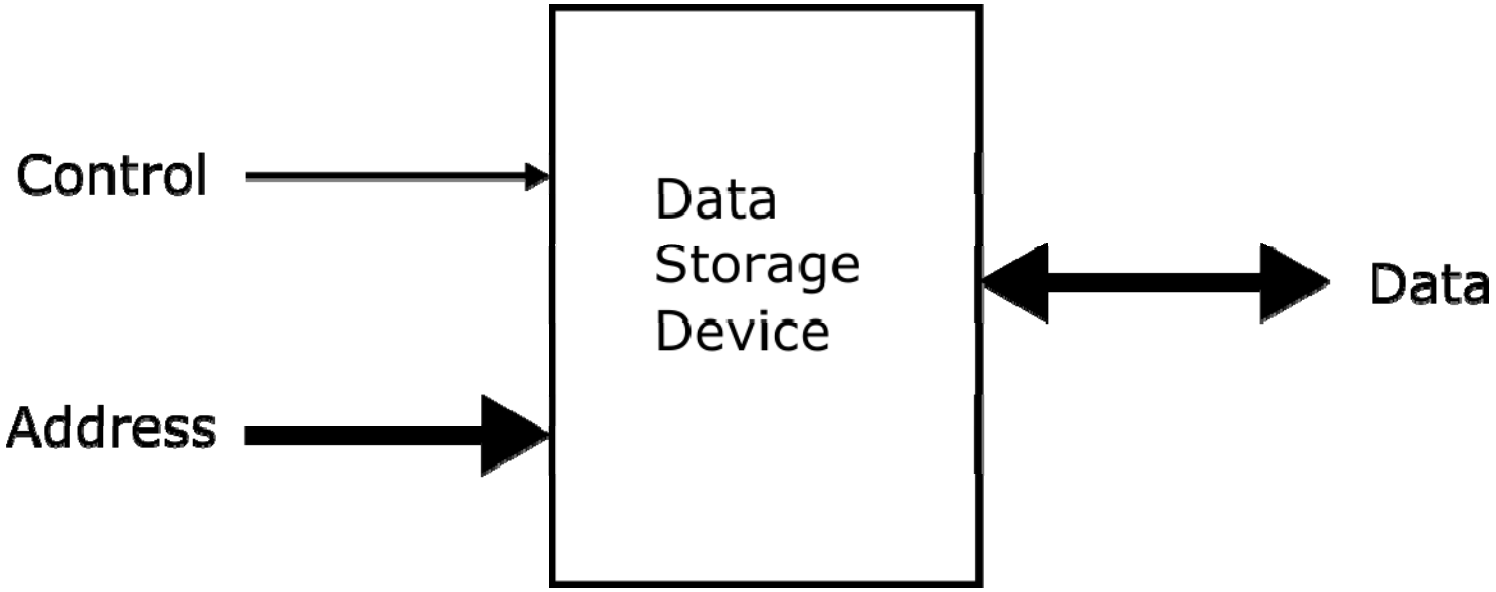
Memories Overview

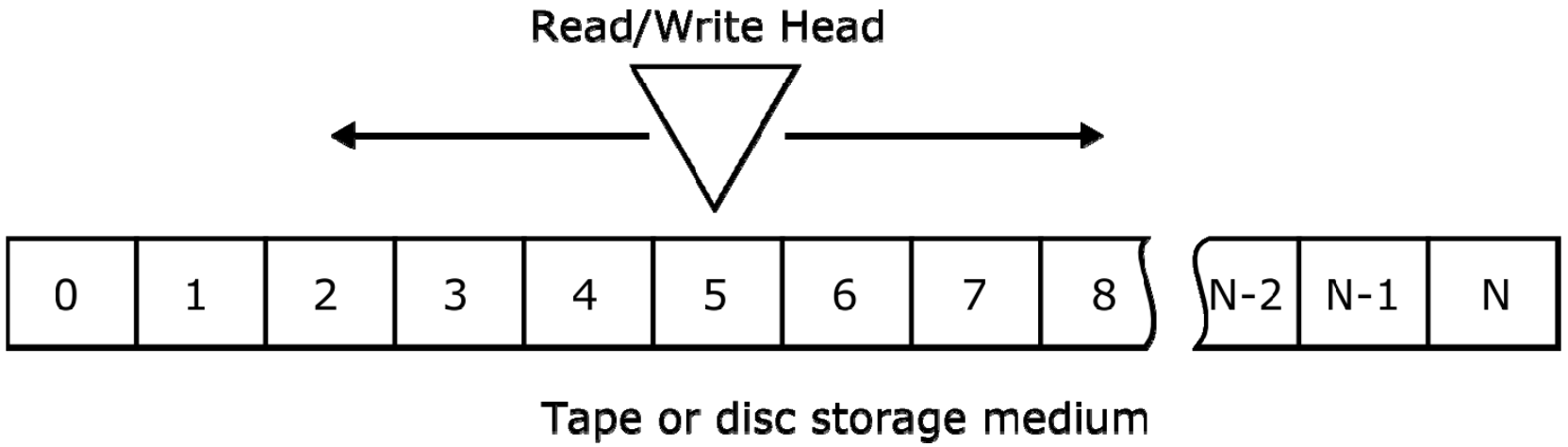
Memory Devices

- Data Storage Devices
- Classification:
  - Serial Access (Disc, Tape)
  - Random Access (ICs)
- Volatile vs. non-volatile
- Read-Only vs. Read/Write

General Model



Serial Access

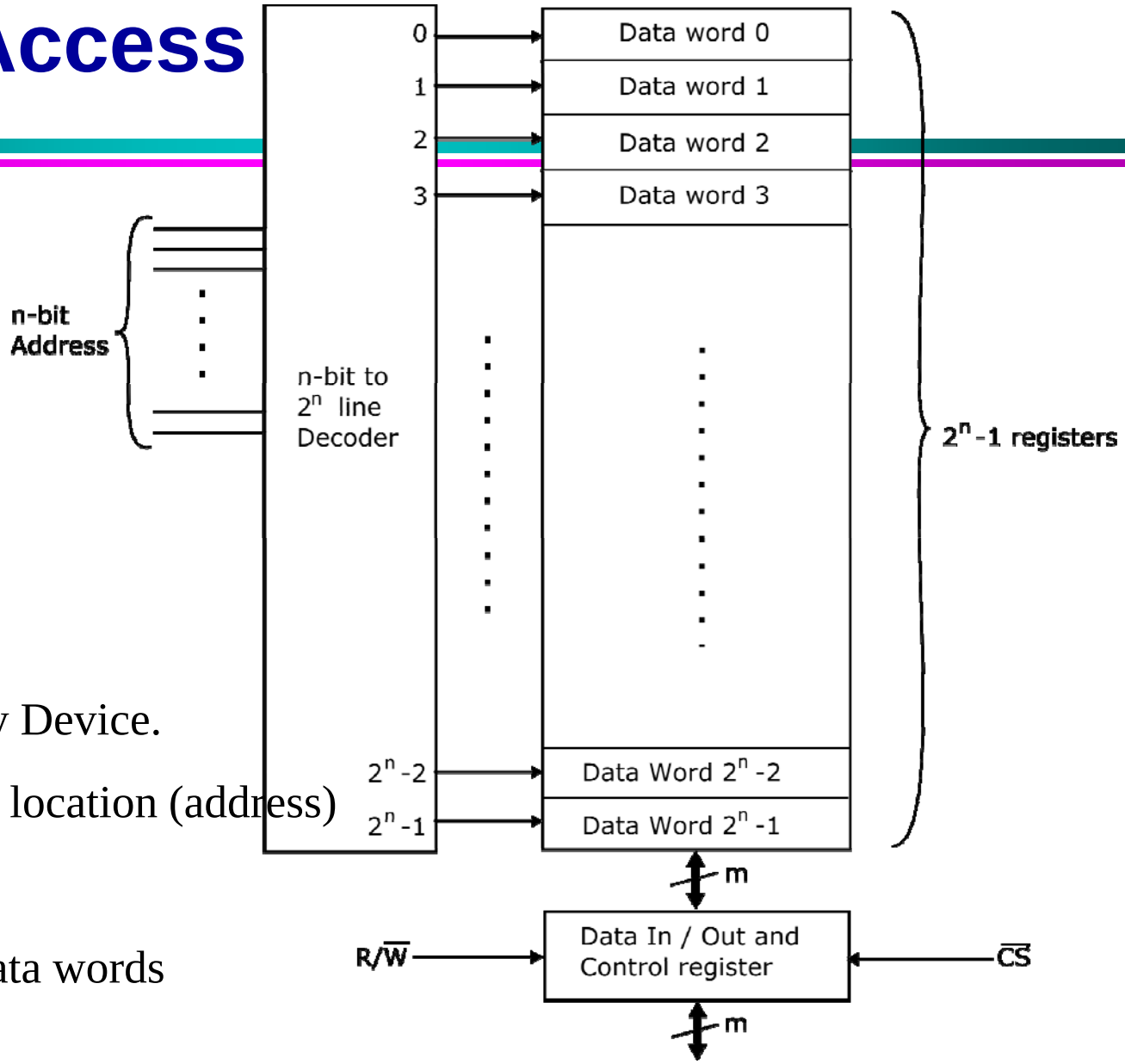


Stores data bits in series

Head must travel from current position to new address passing the other addresses in between – time consuming

Can store large amounts of data

Random Access



Random Access Memory Device.

Equal time to access any location (address)

n-bit address

Device stores 2^n m-bit data words

Volatile/Non-volatile

- Volatile memory loses its contents when the power is switched off
- Non-volatile memory keeps its contents even if there is no power to the device
- Volatile memory is commonly called RAM. Often used as “working memory”
- Non-volatile memory is commonly called ROM
- Both RAM and ROM are random-access
- Some types of ROM can be written to by the user (programmable)

RAM (RWM): Random Access Memory

There are 2 types of RWM (RAM):

- **Static RAM (SRAM):** Uses transistors to store a single bit of information and does not need to be refreshed periodically.

- **Dynamic RAM (DRAM):** Uses a capacitor to store the data bit and needs to be periodically refreshed to maintain the charge in the capacitors.

RAM (RWM): Random Access Memory

SRAM:

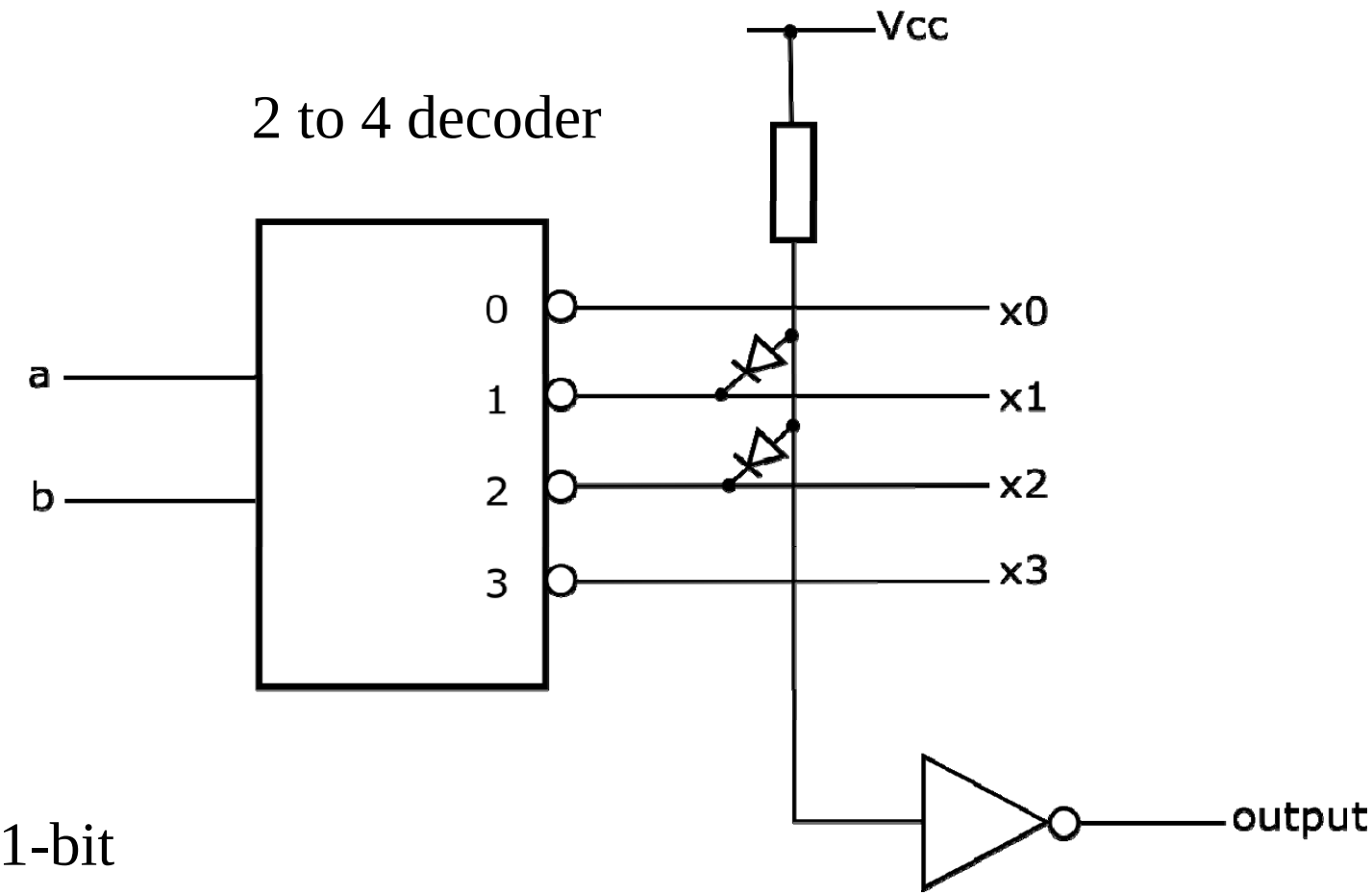
- Uses bistable latching circuit to store data (perhaps 6 to 8 transistors).
- It is volatile (although a non-volatile version is available nvSRAM). Batteries internal to the computer can be used to maintain power when the main computer power is switched off.
- It is more expensive and less dense that DRAM. So it is not used for low cost, high capacity applications such as the main memory devices in personal computers.
- It uses little power at low speeds.

RAM (RWM): Random Access Memory

DRAM:

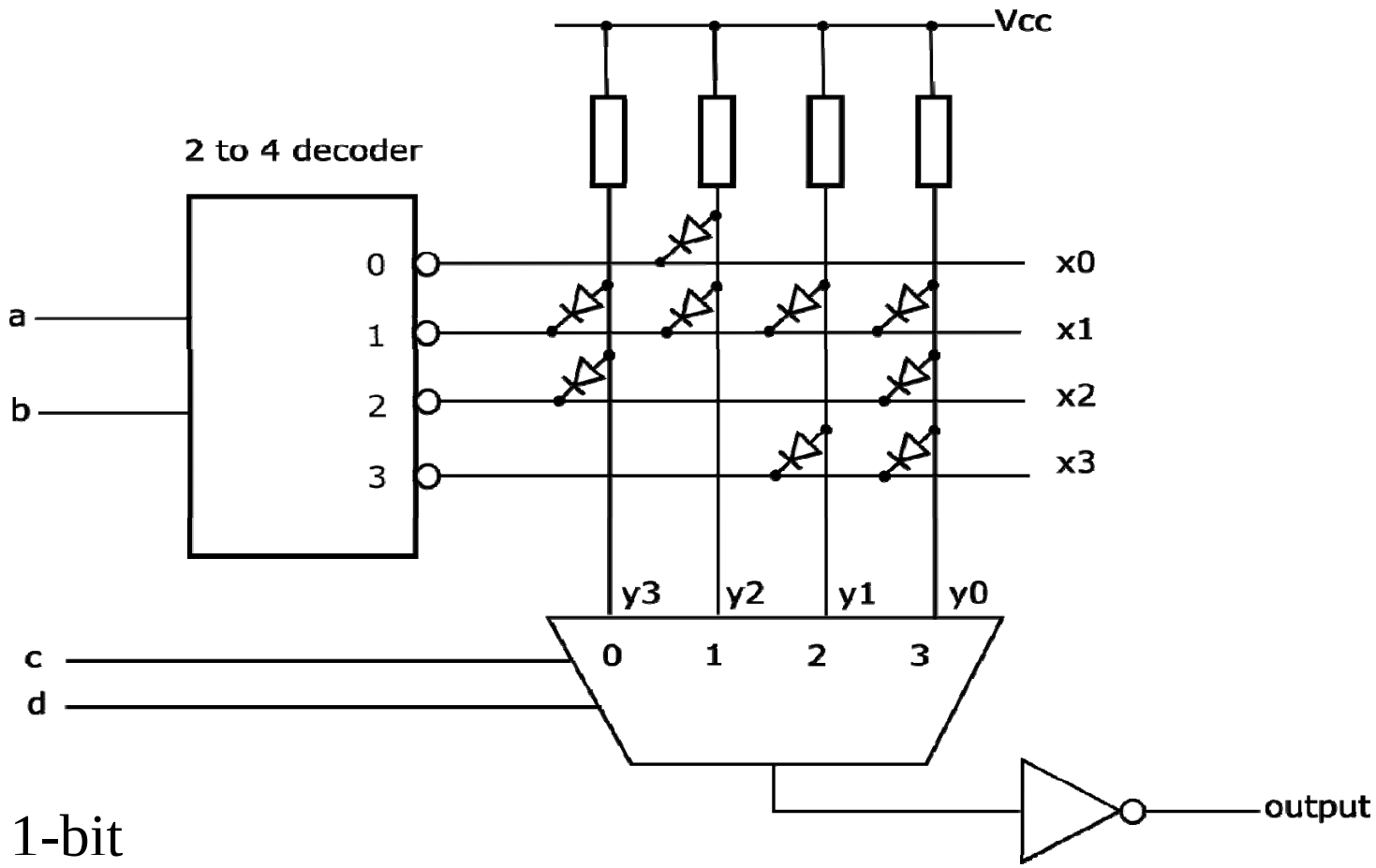
- Uses a capacitor and a single transistor for each bit.
- It is volatile and quickly loses its data when the power is removed.
- Because capacitors leak charge, DRAM has to be continually refreshed.
- It is slower than SRAM.
- Because of the small cell size, DRAM can have very high densities.
- It is the main memory in personal computers.

ROM: Read Only Memory



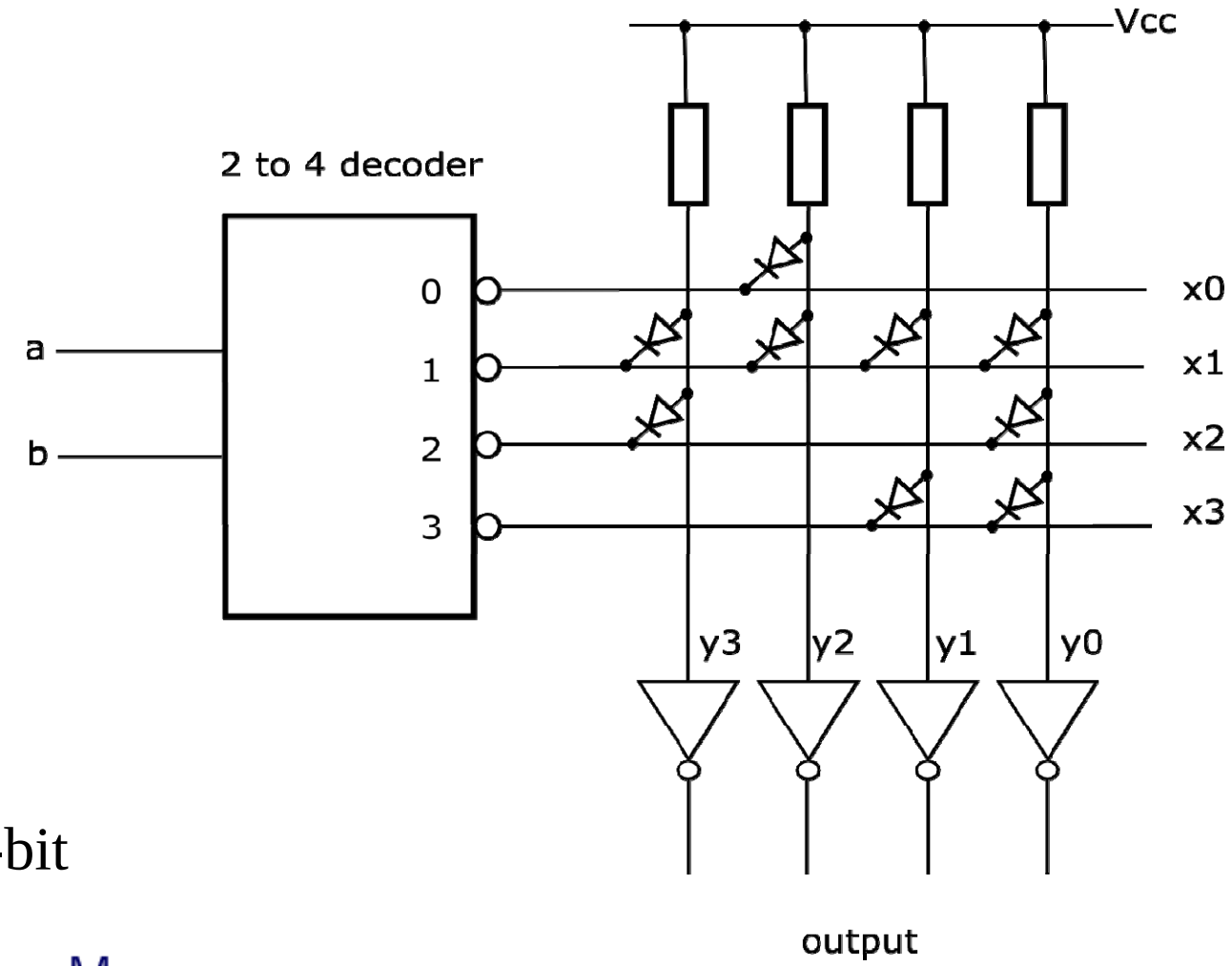
4 × 1-bit

ROM: Read Only Memory



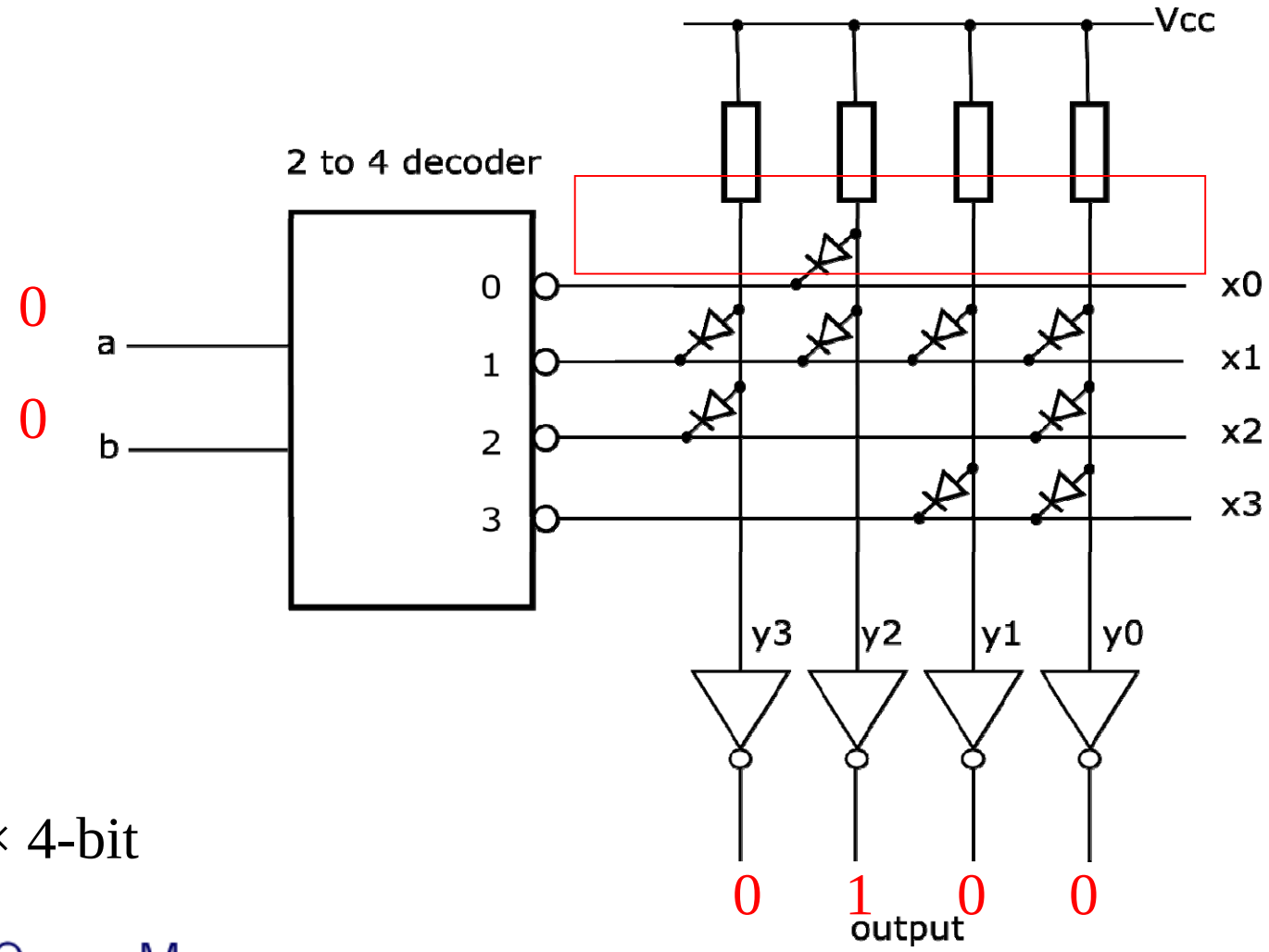
16 × 1-bit

ROM: Read Only Memory



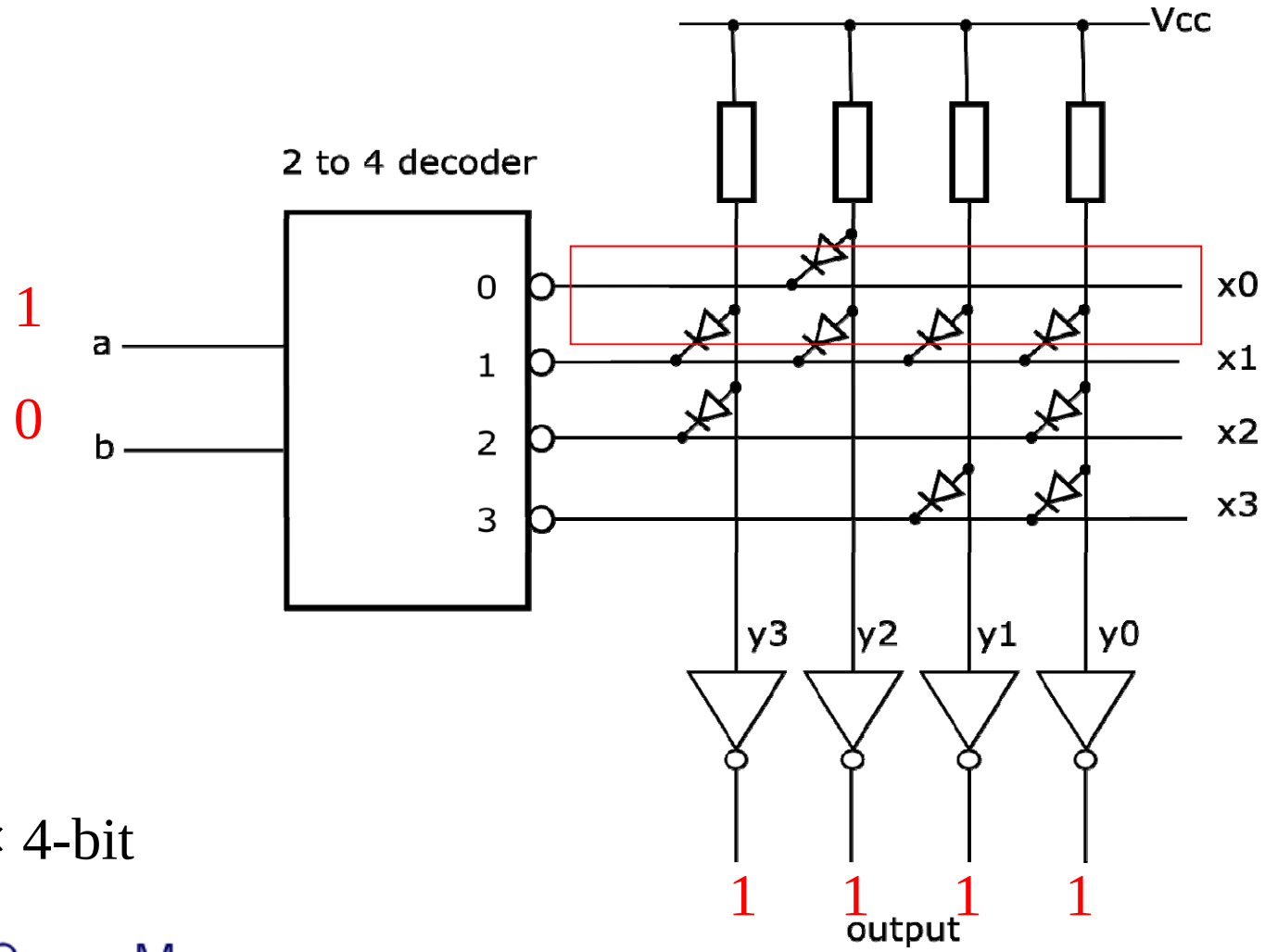
4 × 4-bit

ROM: Read Only Memory



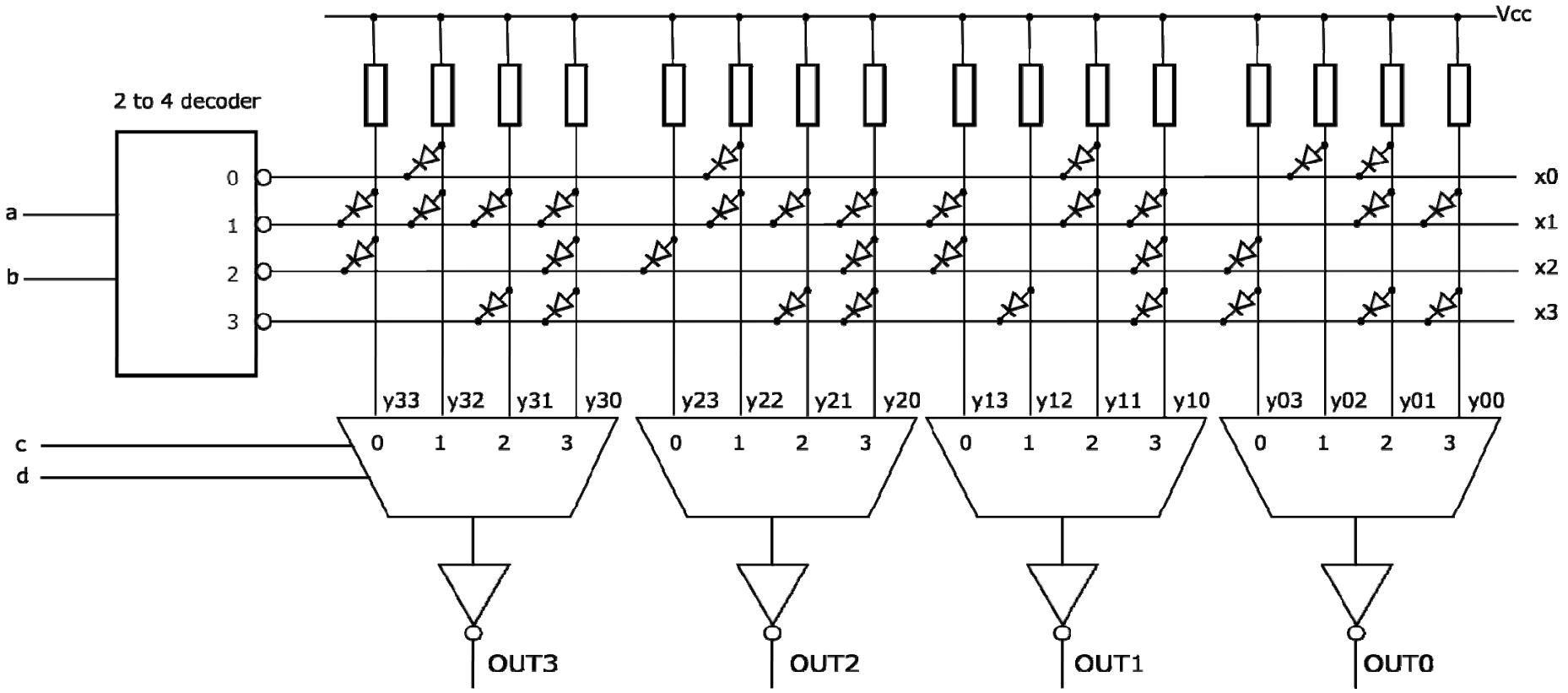
4 × 4-bit

ROM: Read Only Memory



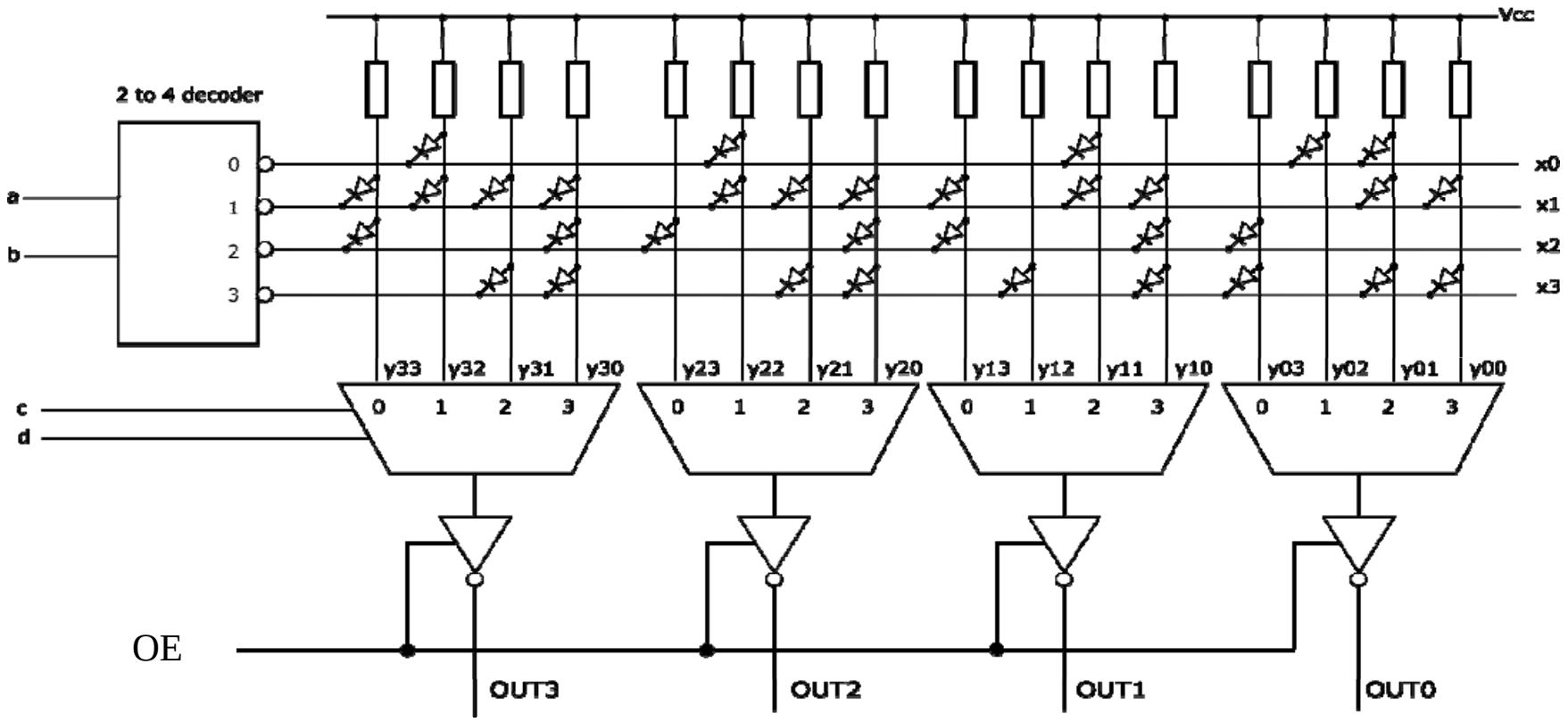
4 × 4-bit

ROM: Read Only Memory



16 × 4-bit

ROM: Read Only Memory



Tristate Outputs

enable output to be connected to a bus

ROM Technologies

- Mask ROM – programmed in manufacture
- PROM – Programmable ROM
- EPROM – Erasable PROM
- EEPROM – Electrically Erasable PROM

Memory Sizes

- Have dealt so far with very small memory sizes
- What about bigger memory devices?

Memory Sizes

- **Careful!**
- For memory sizes:

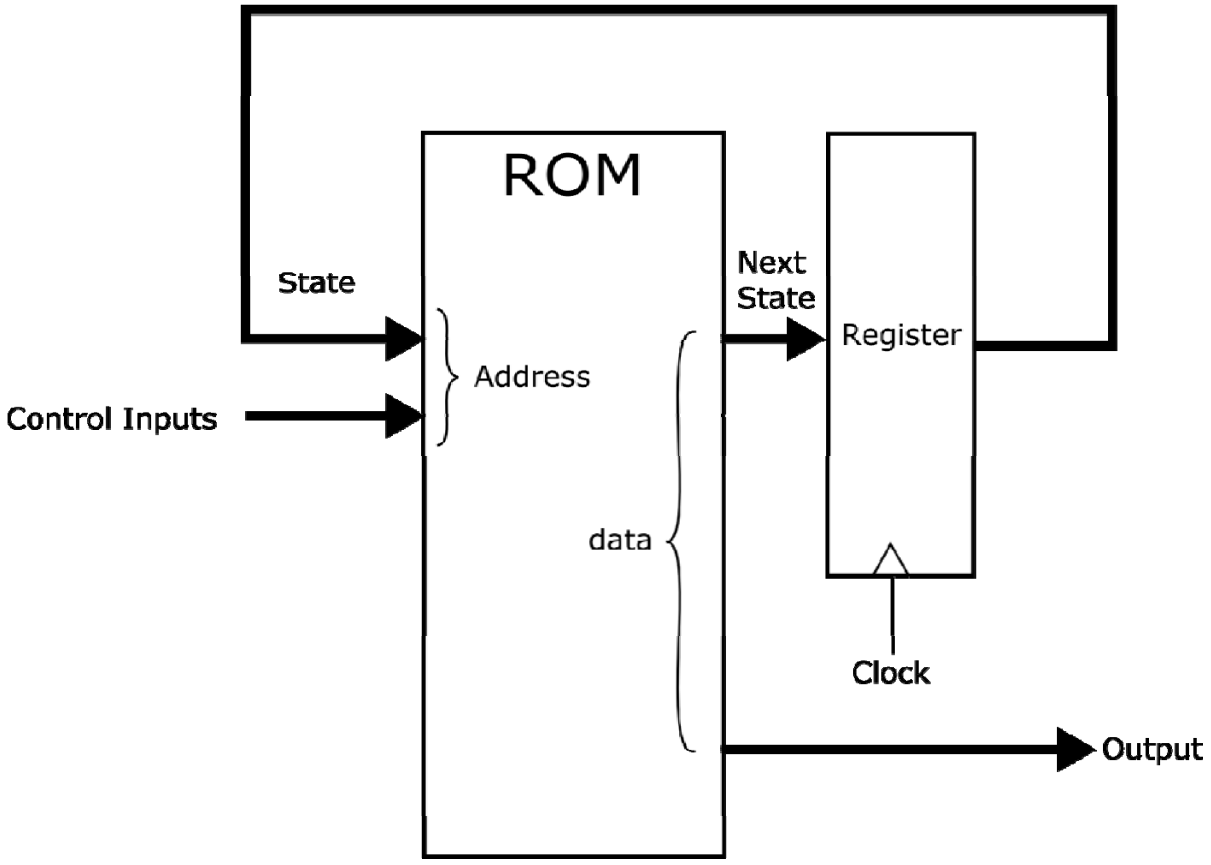
$$1k = 1024 = 2^{10}$$

- Not 1000 as with SI units

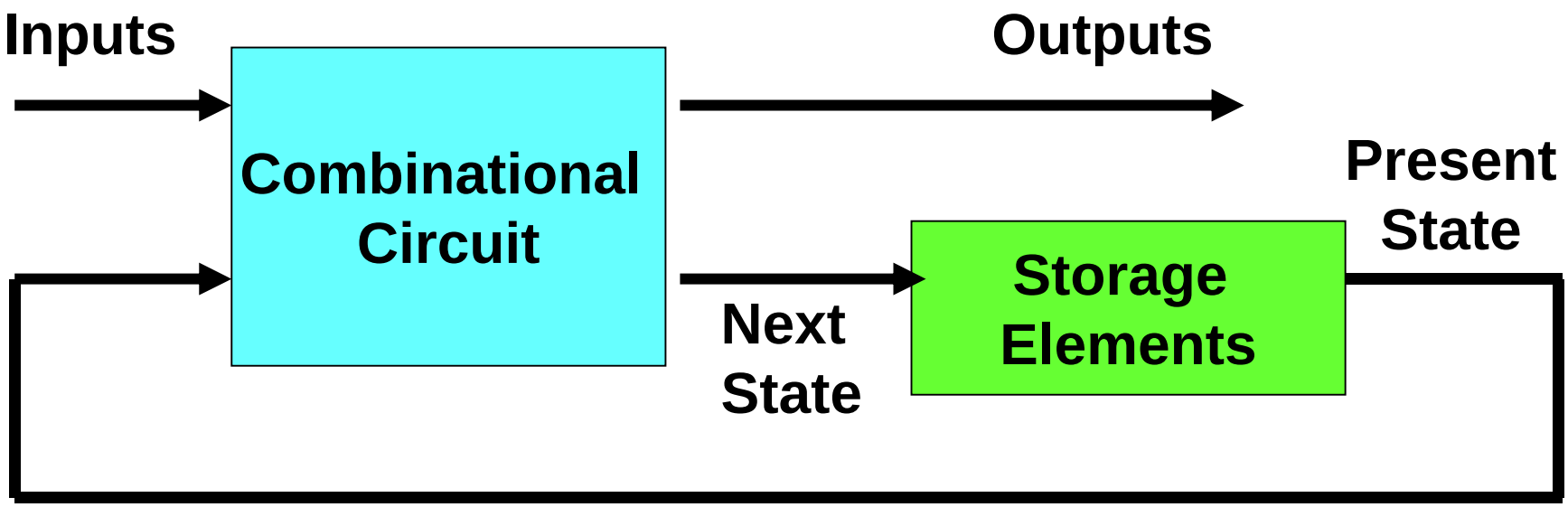
Term	Popular Usage	SI
Kilobyte (KB)	2^{10}	10^{3}
Megabyte (MB)	2^{20}	10^{6}
Gigabyte (GB)	2^{30}	10^{9}
Terabyte (TB)	2^{40}	10^{12}
Petabyte (PB)	2^{50}	10^{15}
Exabyte (EB)	2^{60}	10^{18}
Zettabyte (ZB)	2^{70}	10^{21}
Yottabyte (YB)	2^{80}	10^{24}

ROM Example Application

Provide next-state feedback and output for State Machine



Sequential Circuits



Sequential Circuit

ROM Example Application

Lookup table – Digital Attenuator (Wakerly Chapter 9)