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Science and Engineering

EBU4202: Digital Circuit Design
Memories Overview & Microcomputer

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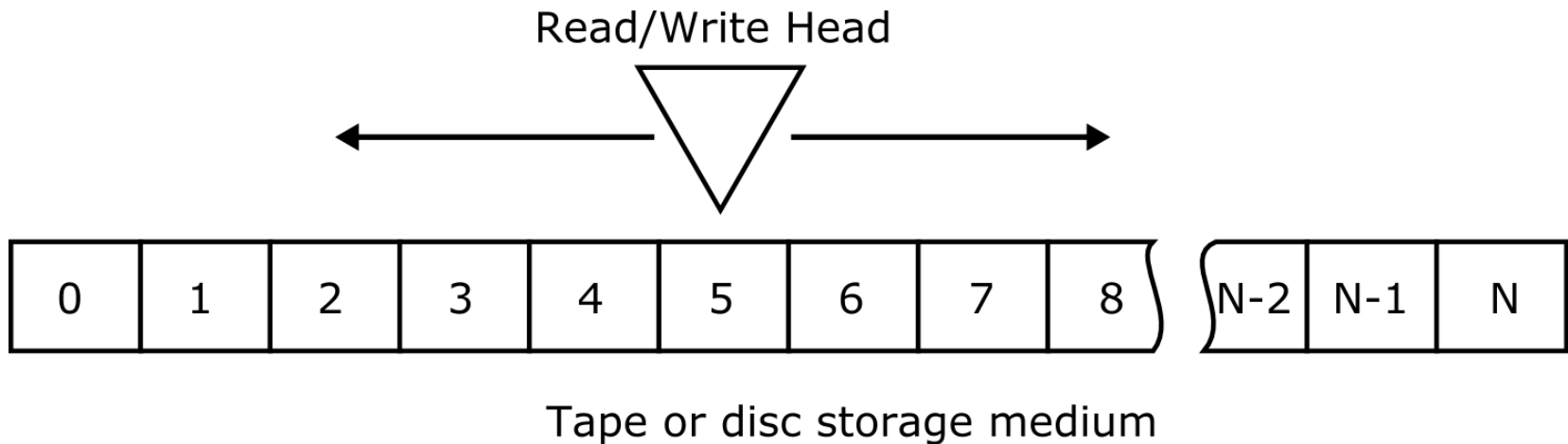London, United Kingdom.

Memory Devices

- Data Storage Devices

- Classification:

  - Serial Access (Disc, Tape)

  - Random Access (ICs)

- Volatile vs. non-volatile

- Read-Only vs. Read/Write

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General Model

Serial Access

Read/Write Head

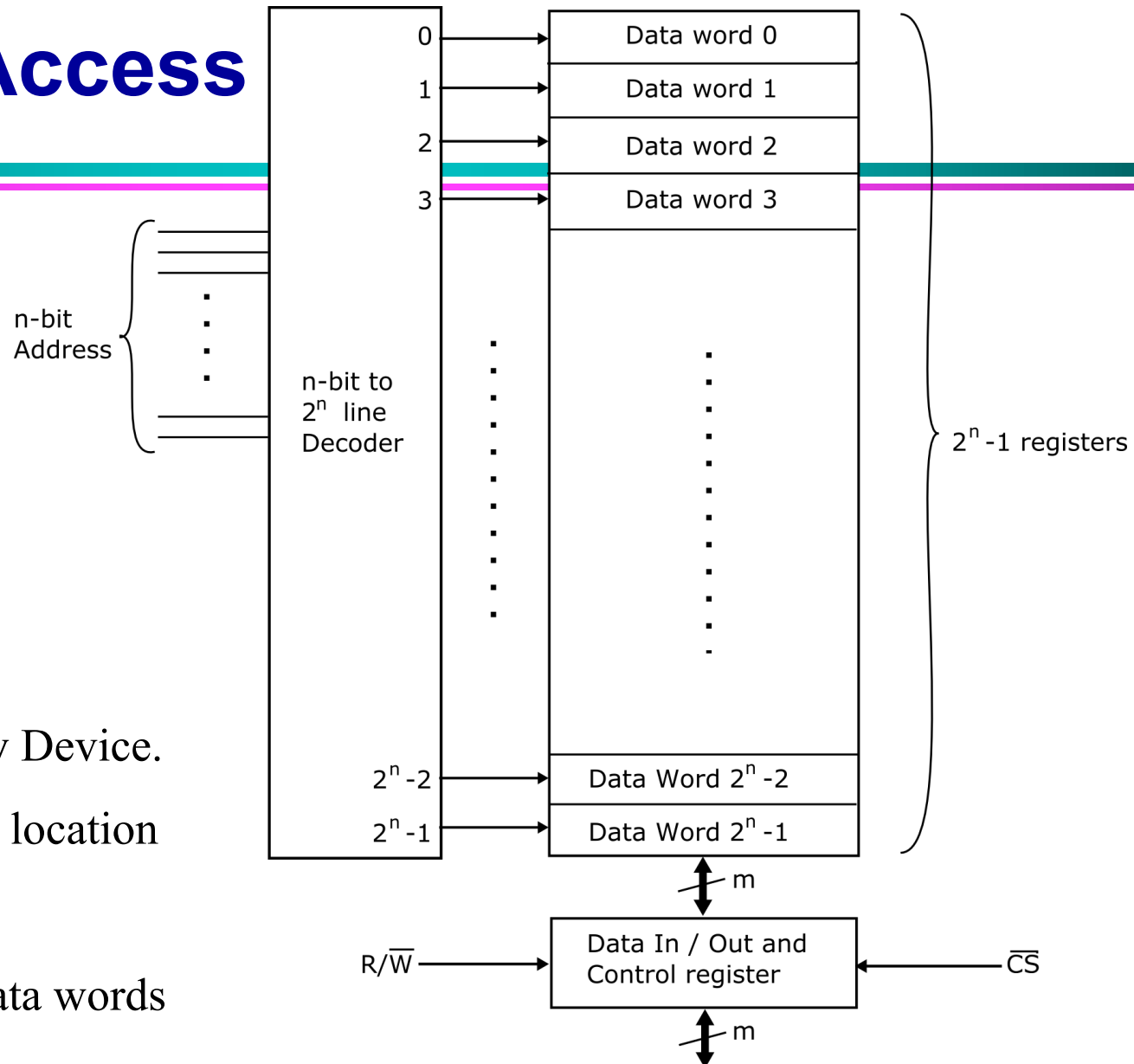| 0	1	2	3	4	5	6	7	8	N-2	N-1	N

Tape or disc storage medium
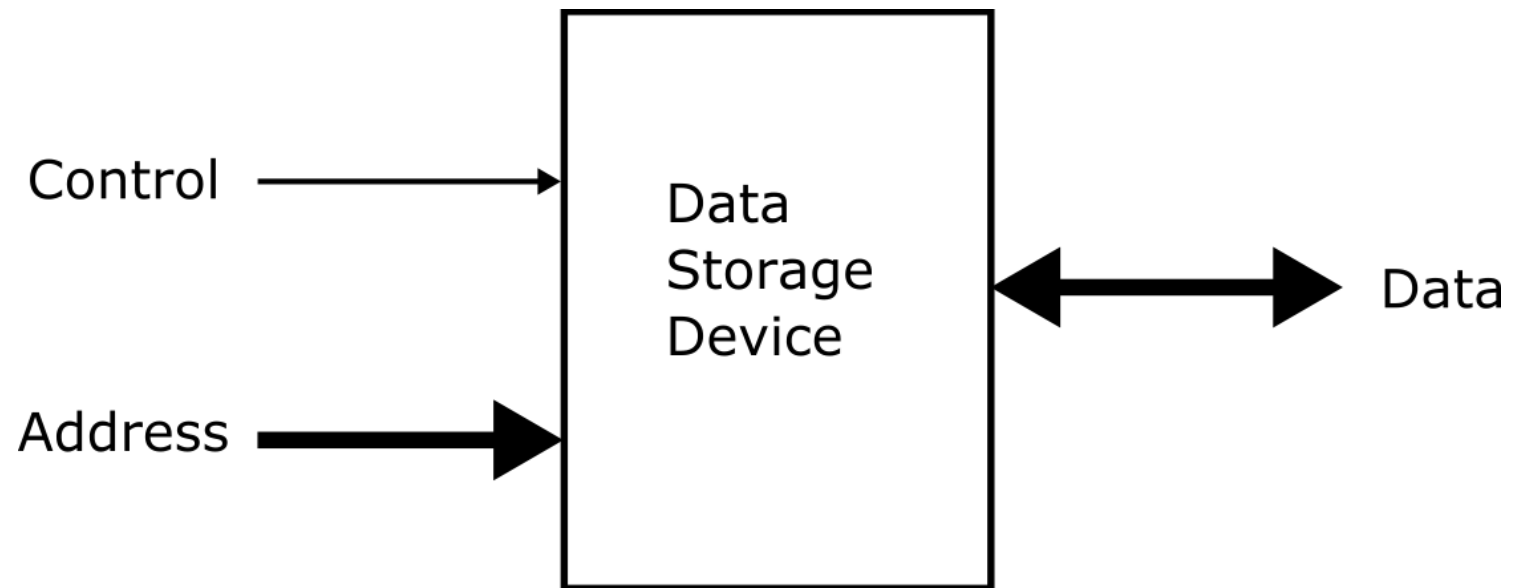
Stores data bits in series

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

n-bit address

Device stores 2^n m-bit data words

n-bit Address

n-bit to 2^n line Decoder

	Data word 0
0	Data word 0
1	Data word 1
2	Data word 2
3	Data word 3

2^n-1 registers

2^n-2	Data Word 2^n-2
2^n-1	Data Word 2^n-1

m

Data In / Out and Control register

$R/\overline{W}$

$\overline{CS}$

m

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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 as ROM

- Both RAM and ROM are random-access

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.

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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 than 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.
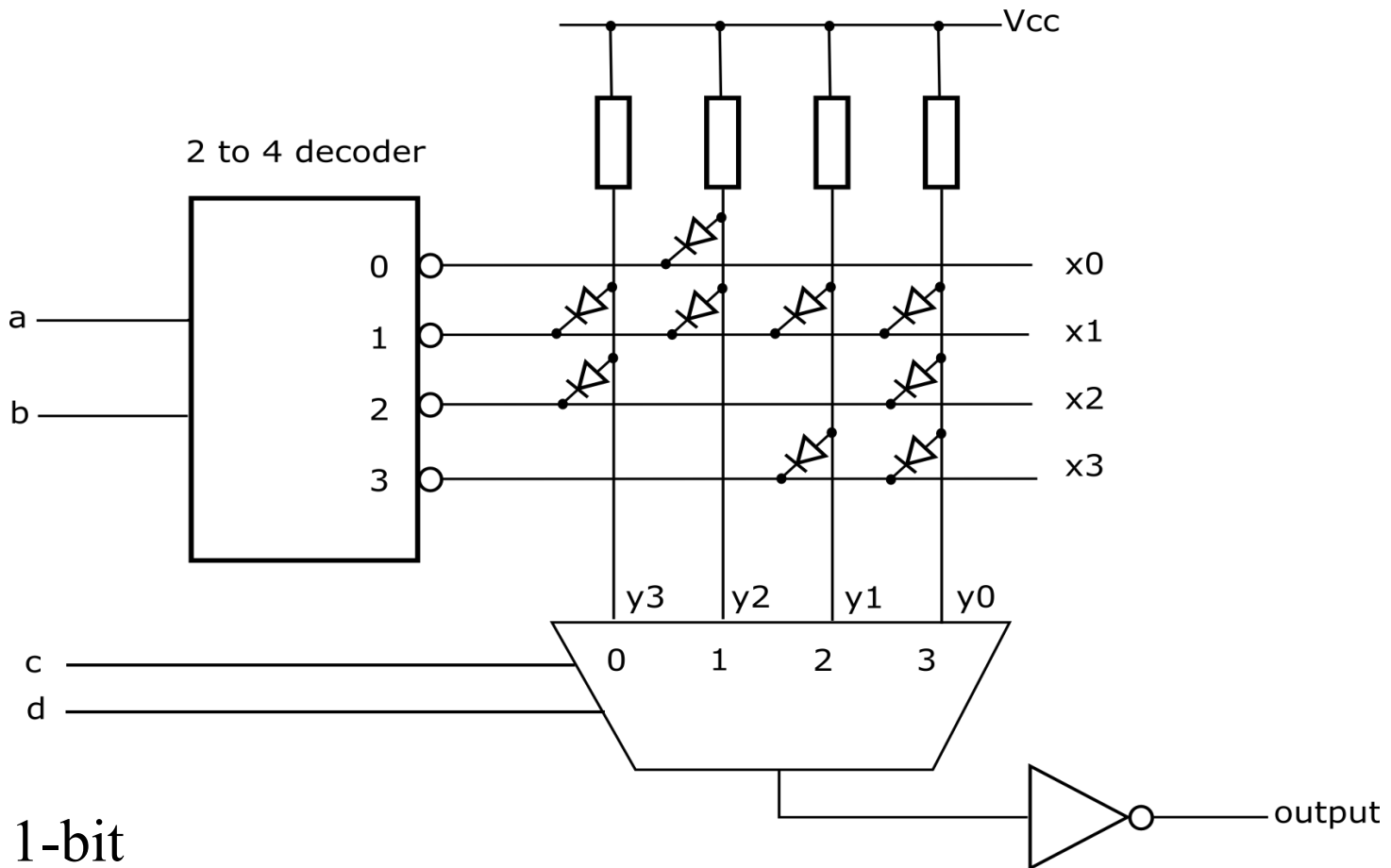
ROM: Read Only Memory

ROM:

- ROM is Read-Only Memory where the contents cannot be changed by normal CPU operations.

- They are used to store fixed data or information.

- The contents of ROM are usually set by manufacturer, but some types of ROM can be written to by the user (programmable)

- For example, PROM (Programmable ROM), which uses a special device called a PROM Programmer.
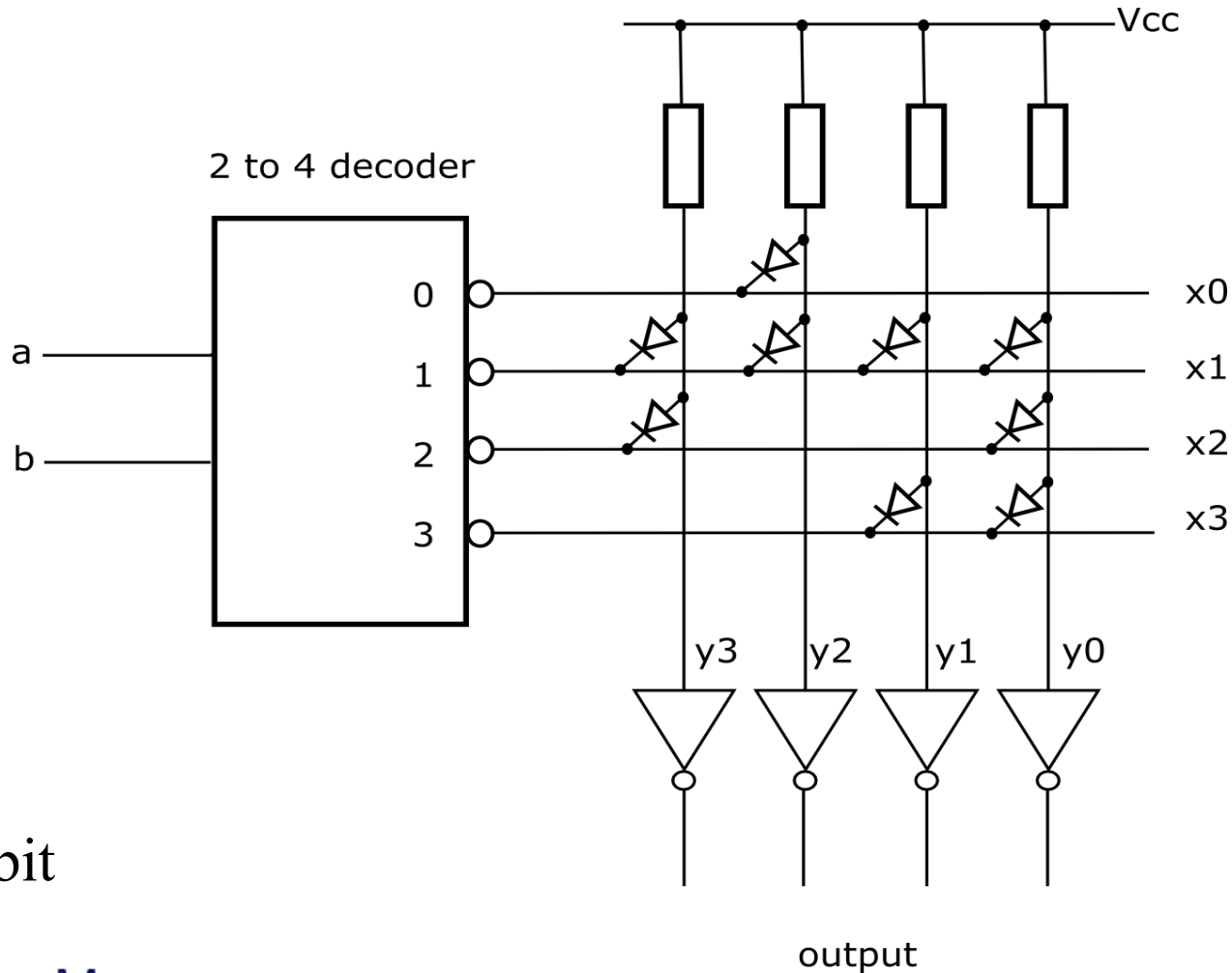
ROM: Read Only Memory

2 to 4 decoder
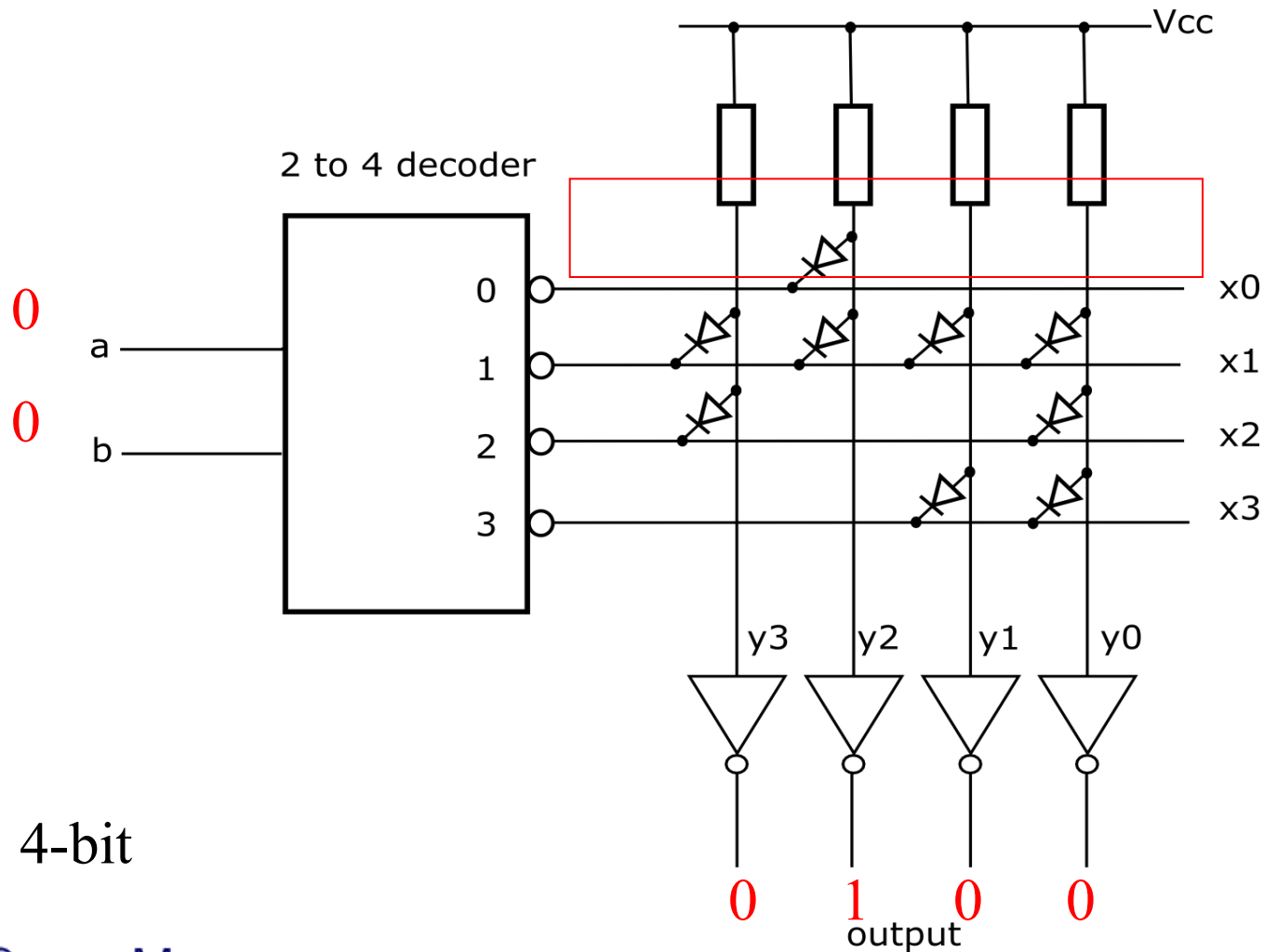
4 × 1-bit
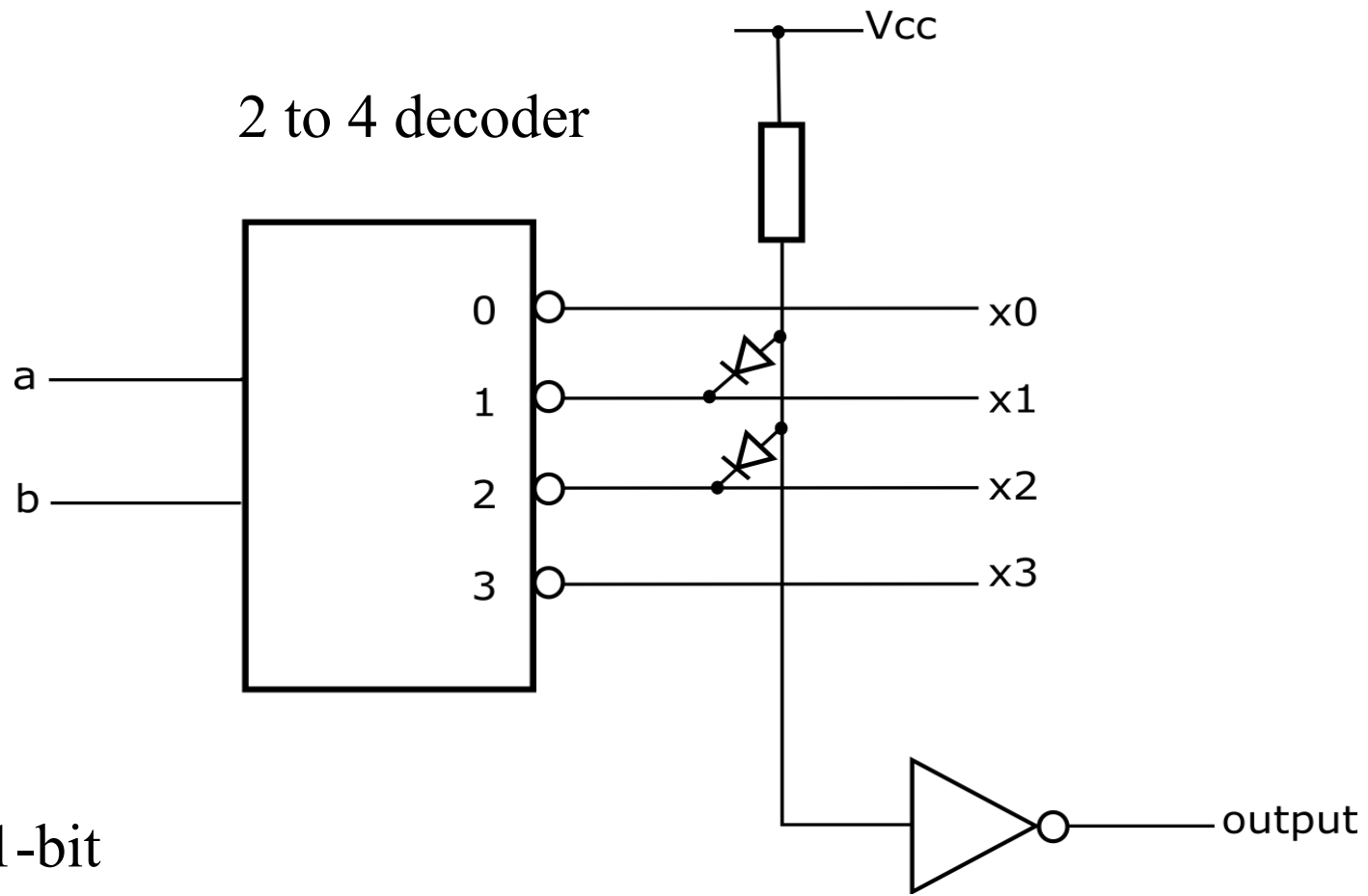
ROM: Read Only Memory
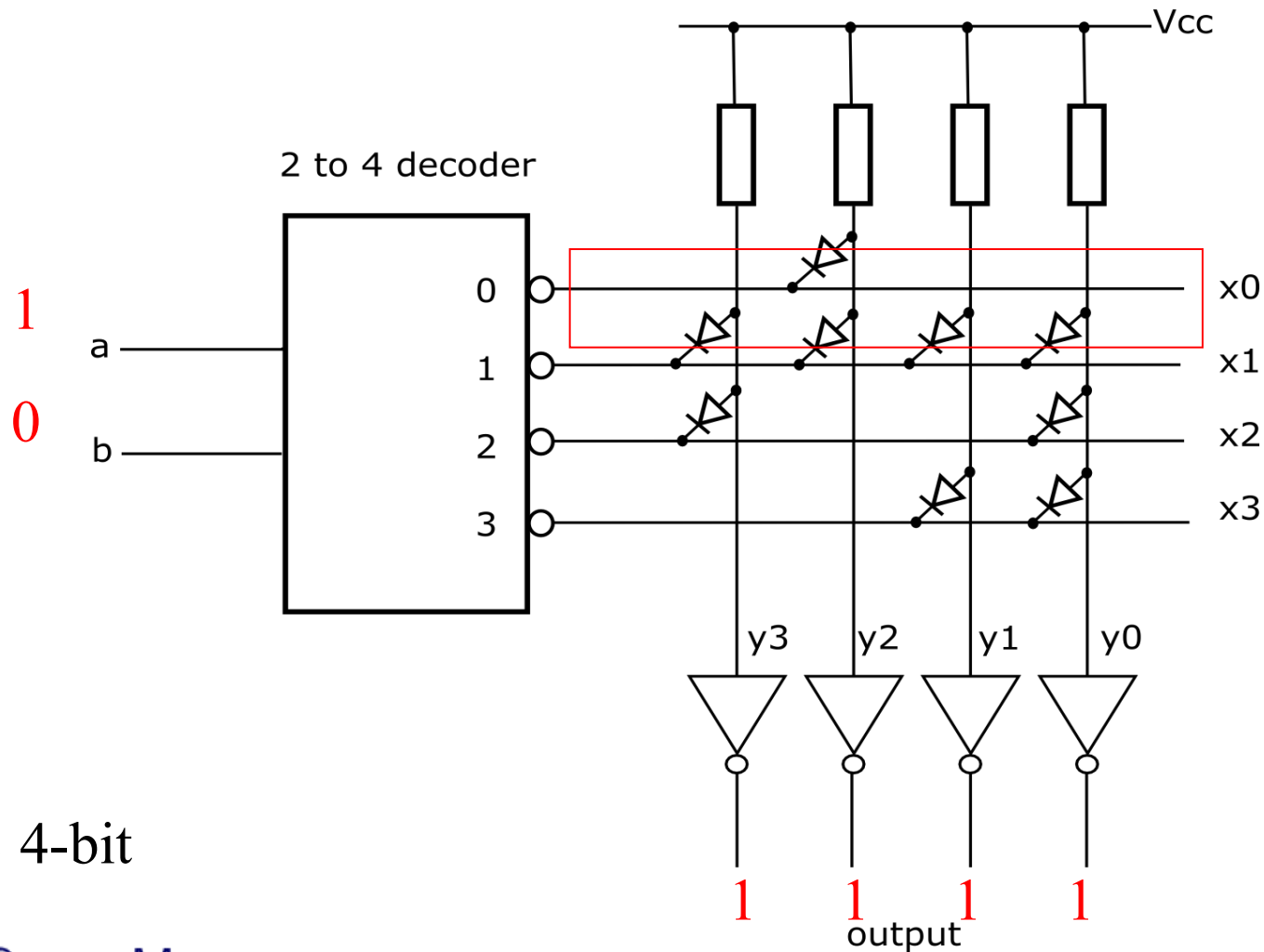

16×1-bit

ROM: Read Only Memory

2 to 4 decoder

4 × 4-bit

output

ROM: Read Only Memory

2 to 4 decoder

Vcc

0

a

1

0

b

2

3

x0

x1

x2

x3

y3 y2 y1 y0

4 × 4-bit

0 1 0 0

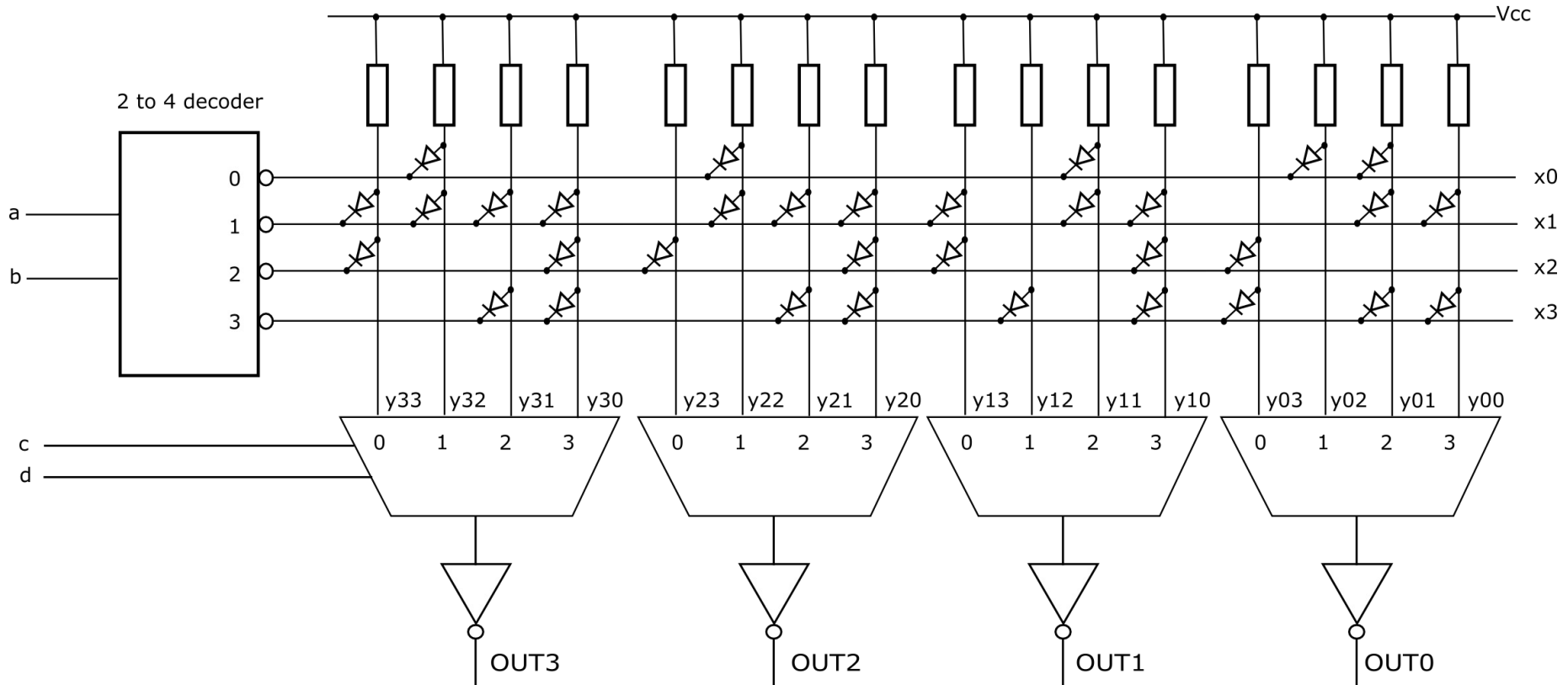output

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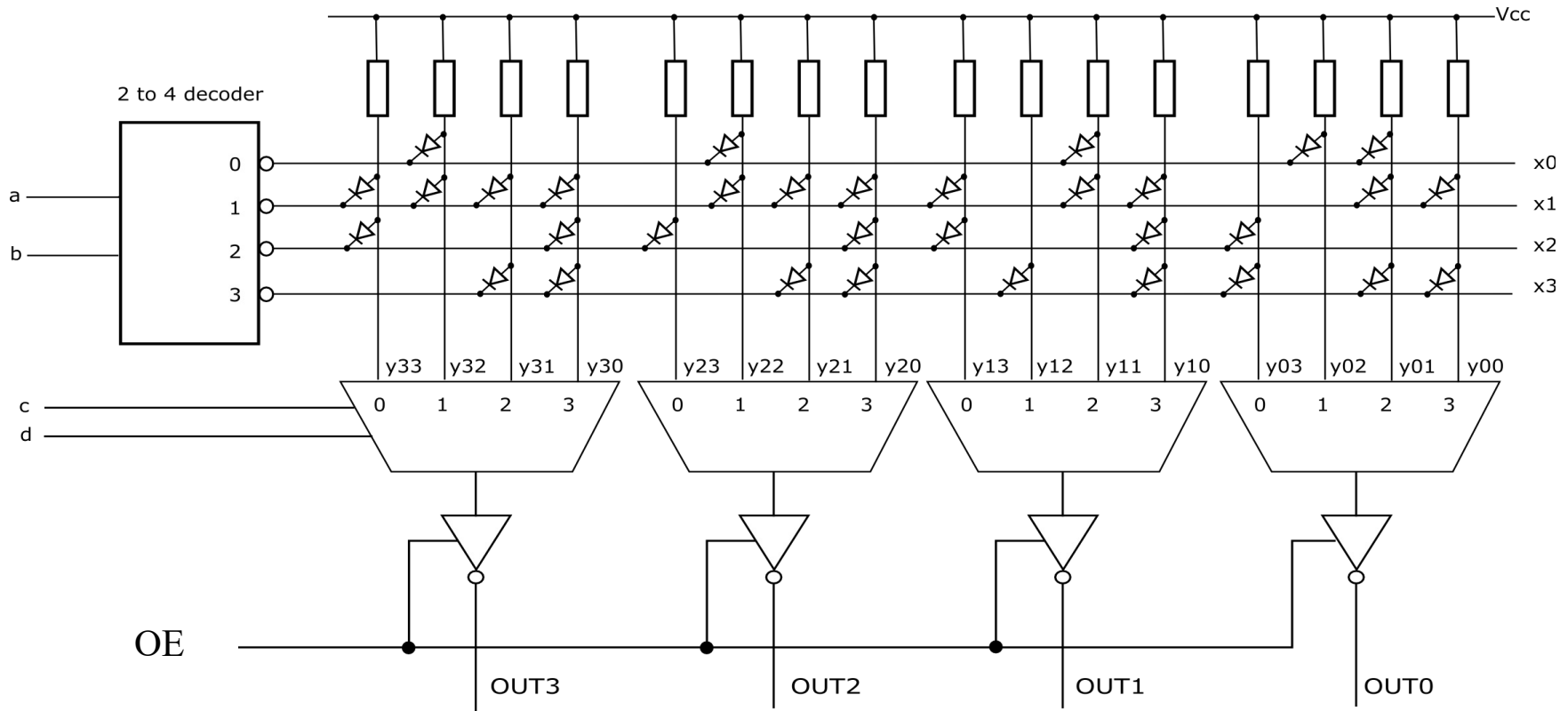# ROM: Read Only Memory

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

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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}

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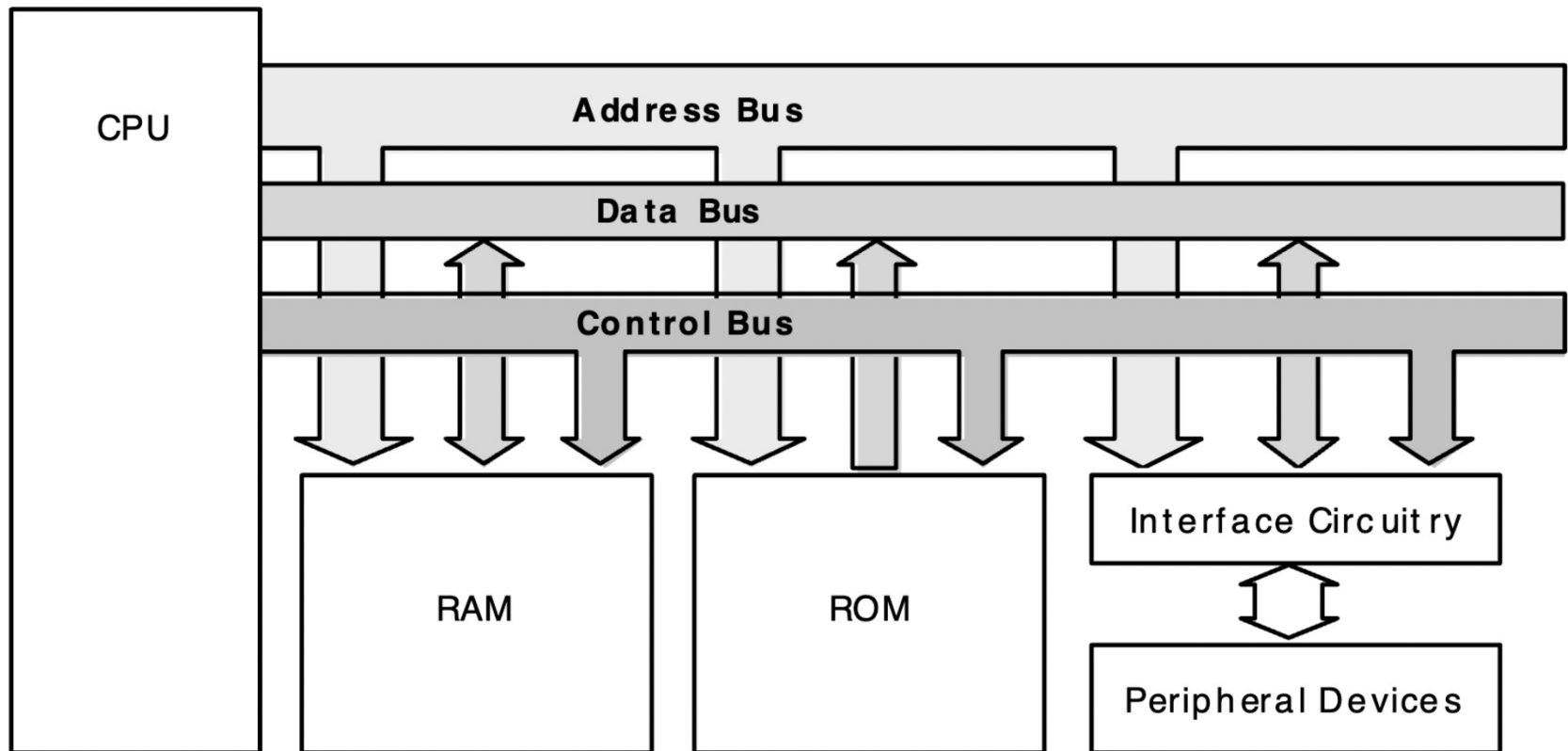# ROM Example Application

Provide next-state feedback and output for State Machine
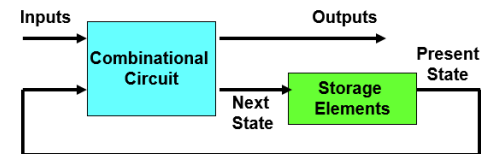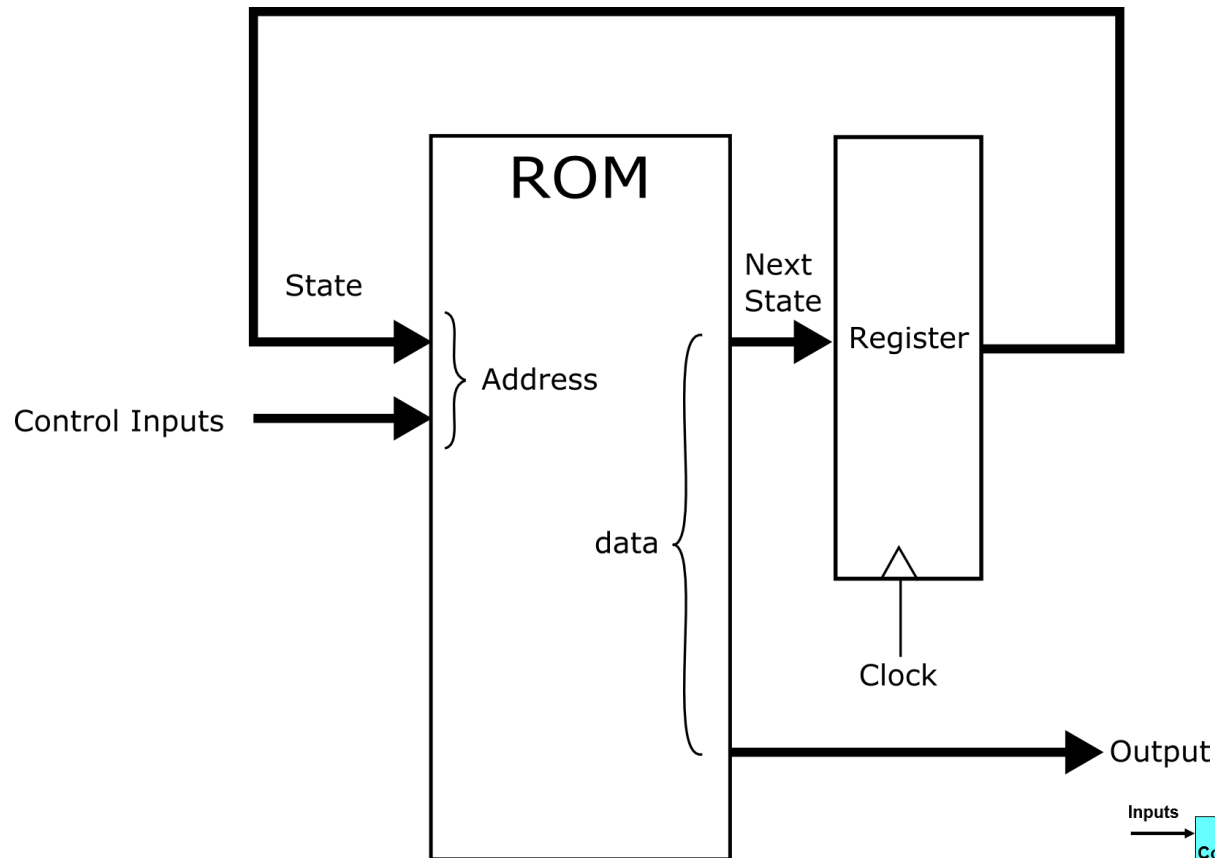
Microcomputer Block Diagram

Microcomputer

- Examples of Control signals are:
  - Read/Write
  - Chip Select
  - Output Enable, etc.

- RAM can be a combination of volatile and non-volatile (SRAM/DRAM) as "working memory" and temporary storage.

- ROM is non-volatile, storing the operating system (e.g. Windows 10, iOS12, Linux, etc) and other permanent firmware.