In the Name of God

Digital Circuit Design

Chapter 7:

Memory and Programmable Logic

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✓Memories

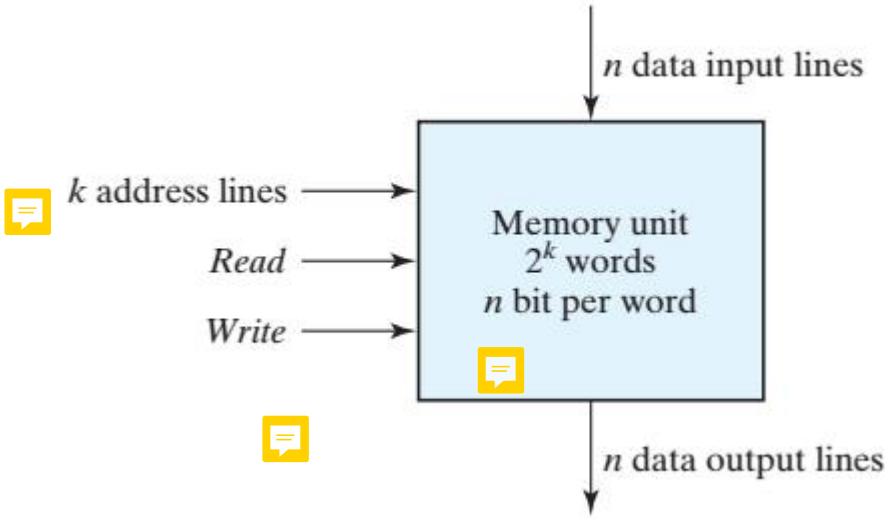
- A device to which binary information is transferred for storage and from which information is retrieved when needed for processing
- When data processing takes place, information from memory is transferred to selected registers in the processing unit and then, the final results are transferred back in memory
- *Write* operation: The process of storing new information into memory
- *Read* operation: The process of transferring the stored information out of memory
- **Types of memories:**
  - ✓*Random-Access Memory (RAM)*: Perform both write and read operations
  - ✓*Read-Only Memory (ROM)*: Perform only the read operation

✓Random-Access Memory (RAM)

- A collection of storage cells, together with associated circuits needed to transfer information into and out of a device
- The information can be selectively retrieved from any of its internal location
- The times it takes to transfer data to or from any desired random location is always the same
- A memory unit stores binary information in group of bits called *word*
- A group of 8 bits is called a *byte*
- Most computer memories use words that are multiples of 8 bits in length
- The capacity of a memory unit is usually stated as the total number of bytes that the unit can store

✓Random-Access Memory (RAM)

- The memory unit is specified by the number of words it contains and the number of bits in each word
- Each word in memory is assigned an identification number, called *address*
- An internal decoder accepts this address and opens the paths needed to select the word specified



- Number of words (or bytes) in memory can be referred with one of the letters K (equals to 2^{10}), M (equals to 2^{20}), G (equals to 2^{30})
  - ✓ *1K×16 memory has 10 bits in the address and 16 bits in each word*
  - ✓ *64K×10 memory has 16 bits in the address and 10 bits in each word*

✓Random-Access Memory (RAM)

- *Write Operation*
  - ✓Apply the binary address of the desired word to the address lines
  - ✓Apply the data bits that must be stored in memory to the data input lines
  - ✓Activate the write input
- *Read Operation*
  - ✓Apply the binary address of the desired word to the address lines
  - ✓Activate the read input
- Most ICs provide two other control inputs: one input selects the unit (Chip Select) and the other determines the operation

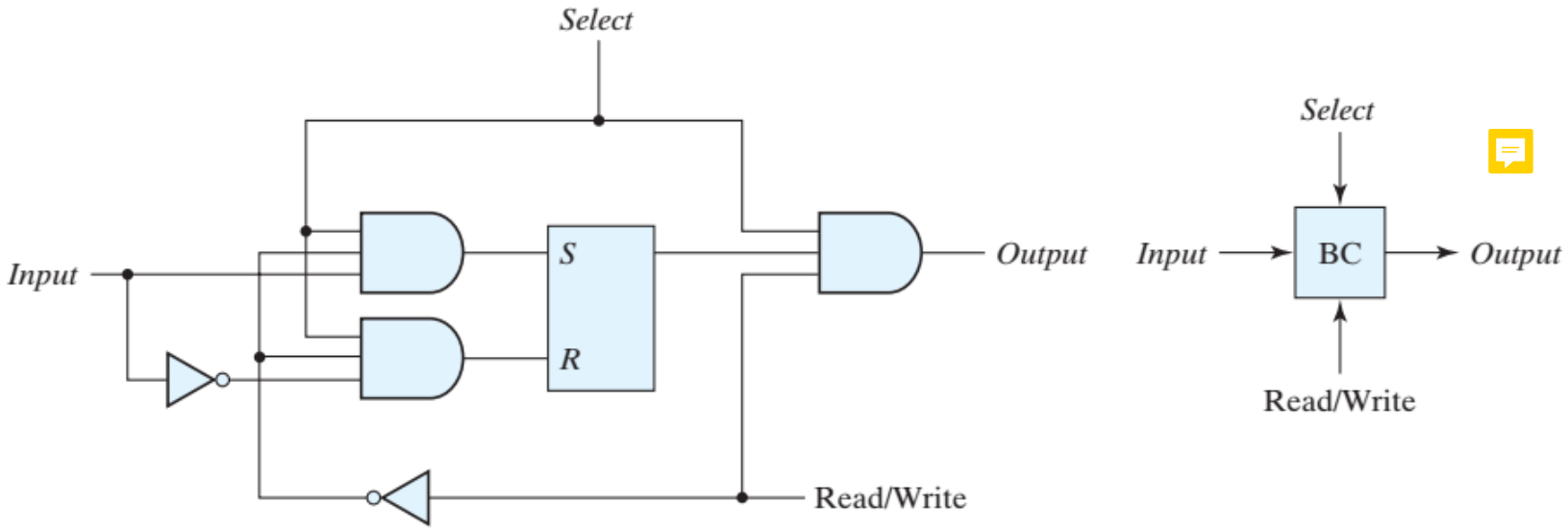
Control Inputs to Memory Chip

Memory Enable	Read/Write	Memory Operation
0	X	None
1	0	Write to selected word
1	1	Read from selected word

✓Random-Access Memory (RAM)

❖ *Internal construction*

✓A binary storage cell is the basic building block of a memory unit



✓The binary cell (BC) stores one bit in its internal latch

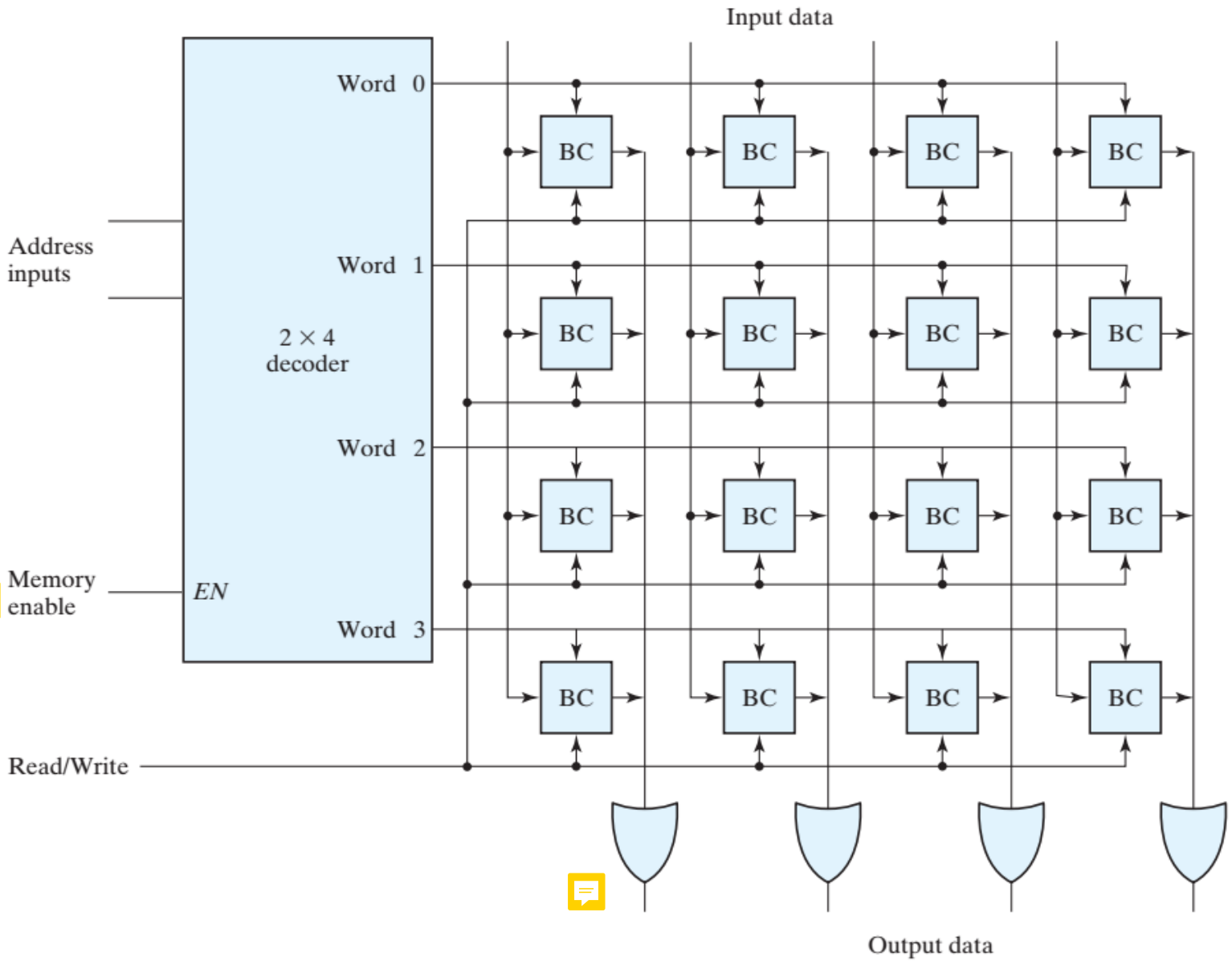
✓The select input enables the cell for reading or writing

✓A "1" in the read/write input provides (فراهم کردن) the *read* operation (عملیات) and a "0" provides the *write* operation

✓Random-Access Memory (RAM)

❖ *Internal construction*

✓4×4 RAM



✓Random-Access Memory (RAM)

- Types of RAM

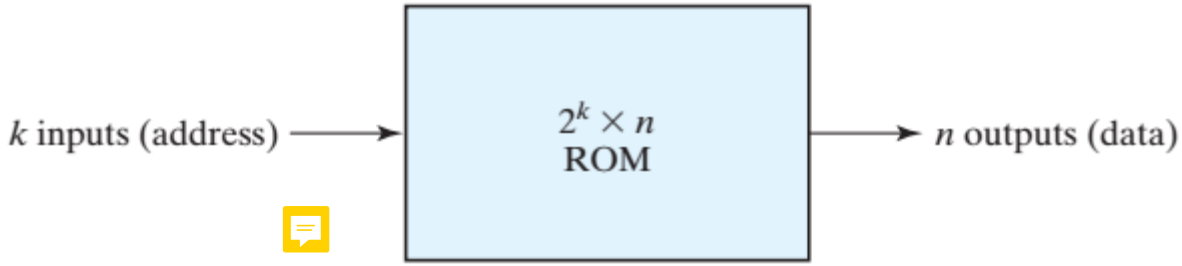
  ✓SRAM: Consists of internal latches that stores the binary information

  ✓DRAM: Stores the binary information in the form of electric charges on capacitors provided inside the chip by MOS transistors

- DRAM offers reduced power and larger storage capacity, while SRAM is easier to use
- In a Sequential-Access Memory (SAM), the information is not immediately accessible (a magnetic tape) and the time it takes to access a word depends on the position of the word
- In RAMs, the stored information are removed when power is turned off

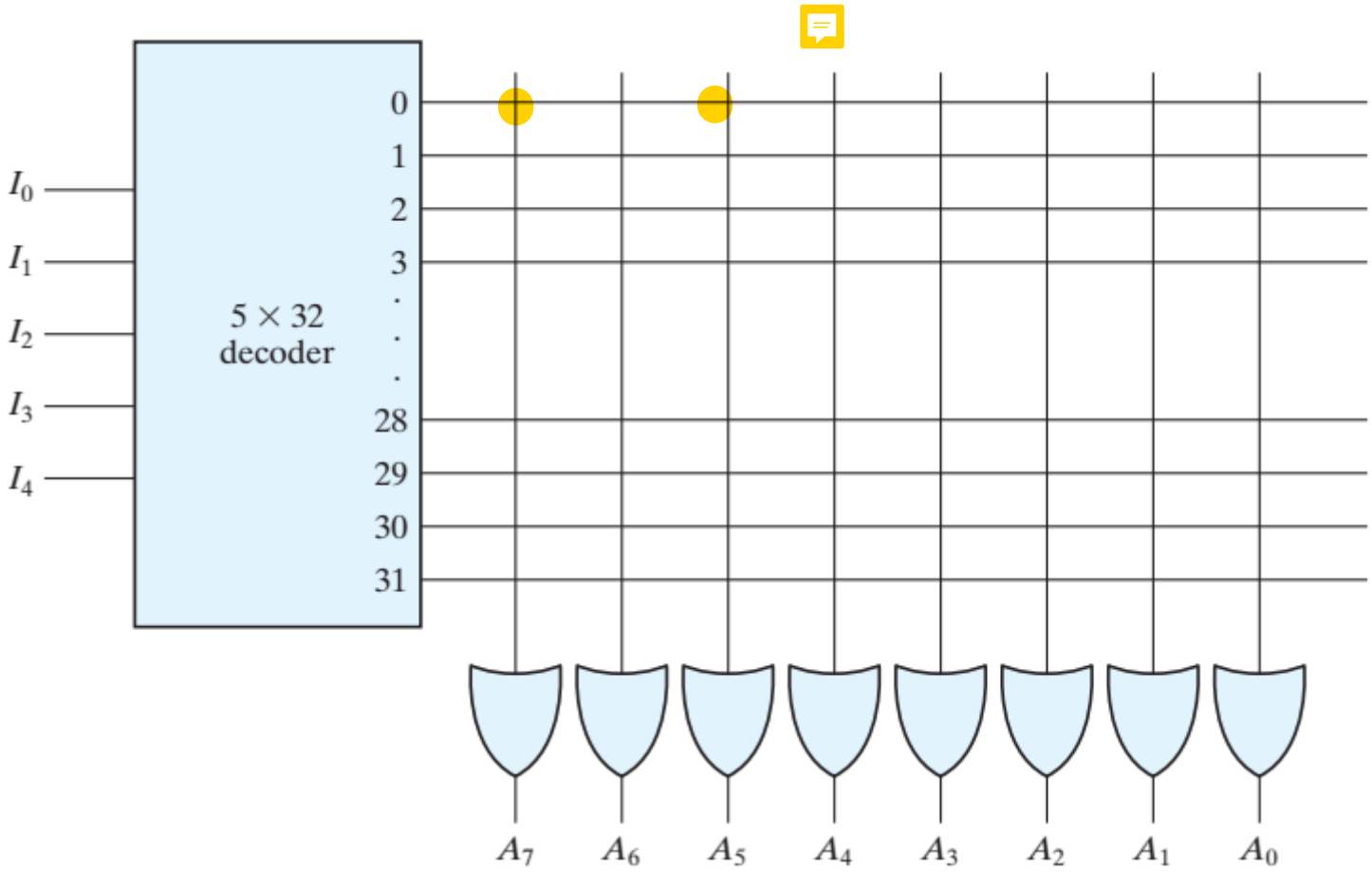
✓Read-Only Memory (ROM)

- A memory device in which permanent binary information is stored
- Performs only read operation
- The binary information stays within the unit even when power is turned off and on again
- ROM does not have data inputs



✓Read-Only Memory (ROM)

- A 32×8 ROM
- The 32 outputs of the decoder are connected to each of the eight OR
- Each OR gate must be considered as having 32 inputs
- The ROM contains 32×8 = 256 internal connections
- In general, a 2^k×n ROM will have an internal k×2^k decoder and *n* OR gates



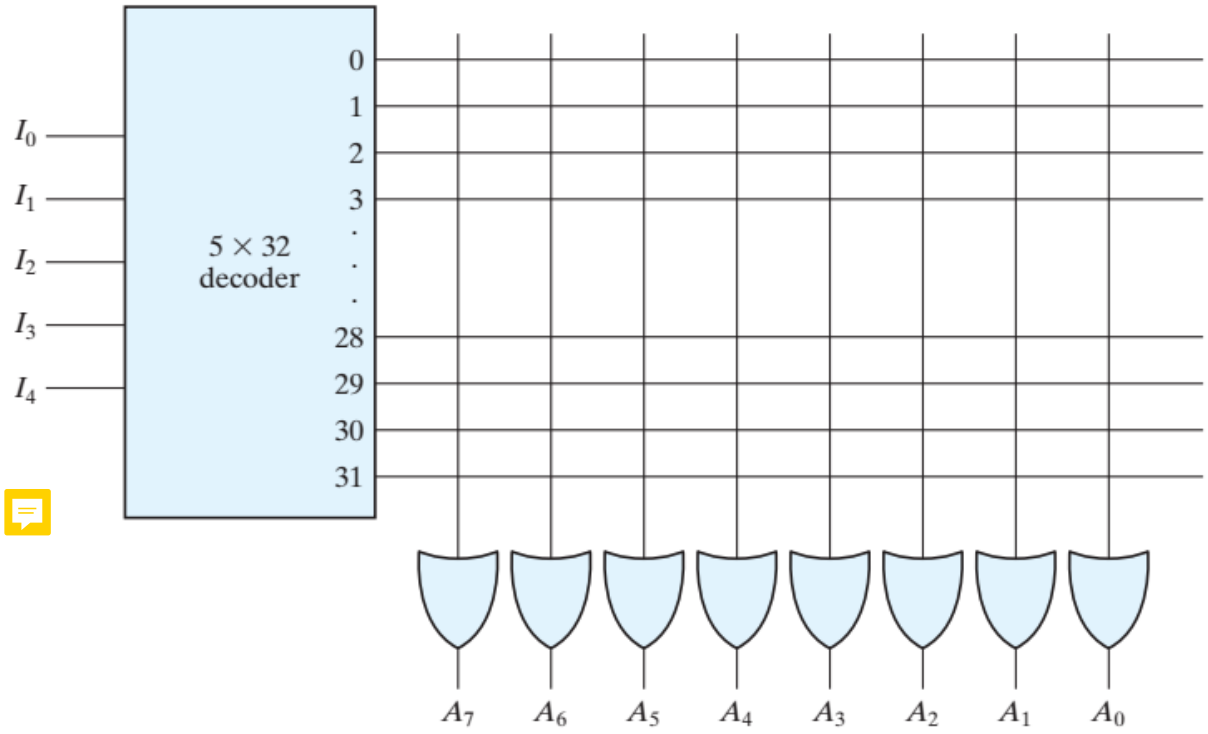
✓Read-Only Memory (ROM)

❖ The 256 intersections are programmable

❖ A programmable connection between two lines is logically equivalent to a switch

✓Closed: meaning that two lines are connected

✓Opened: meaning that two lines are disconnected



❖ One of the simplest technology employs a *fuse*

✓ Normally connects two points

✓ Is opened (blown) by the application of a high-voltage pulse into the fuse

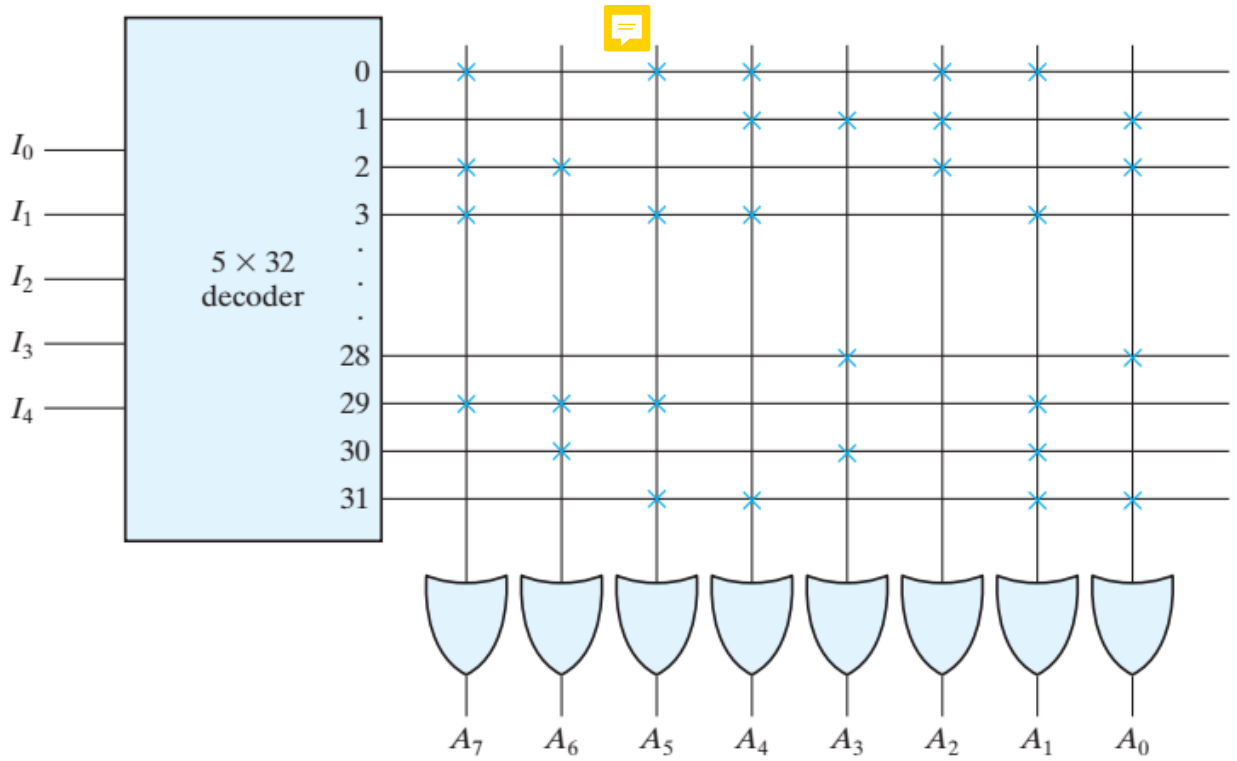
✓Read-Only Memory (ROM)

- The internal binary storage of a ROM is specified by truth table
- The hardware procedure that programs the ROM, blows fuse links in accordance with a given truth table

ROM Truth Table (Partial)

Inputs					Outputs							
I_4	I_3	I_2	I_1	I_0	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0
0	0	0	0	0	1	0	1	1	0	1	1	0
0	0	0	0	1	0	0	0	1	1	1	0	1
0	0	0	1	0	1	1	0	0	0	1	0	1
0	0	0	1	1	1	0	1	1	0	0	1	0
		⋮							⋮			
1	1	1	0	0	0	0	0	0	1	0	0	1
1	1	1	0	1	1	1	1	0	0	0	1	0
1	1	1	1	0	0	1	0	0	1	0	1	0
1	1	1	1	1	0	0	1	1	0	0	1	1

$$A_7(I_4, I_3, I_2, I_1, I_0) = \Sigma(0, 2, 3, \ldots, 29)$$



✓Read-Only Memory (ROM)

➢ **Types of ROMs:** *The required paths in ROM may be programmed in four different ways*

❖Mask programming:

✓Done by the semiconductor company during the fabrication

✓This procedure is costly, thus is economical only for a large quantity of the same ROM

❖PROM (Programmable ROM):

✓Contain all the fuses intact and can be blown by the application of a high-voltage pulse

❖EPROM (Erasable PROM):

✓Can be restructured to the initial state by placing under a special ultraviolet light

❖EEPROM (Electrically Erasable PROM):

✓The previously programmed connections can be erased with an electrical signal

✓The device can be erased without removing it from its socket