

Unit VI

Memory

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Memory and Programmable Logic

Memory Device:

- Device to which binary information is transferred for storage, and from which information is available for processing as needed.

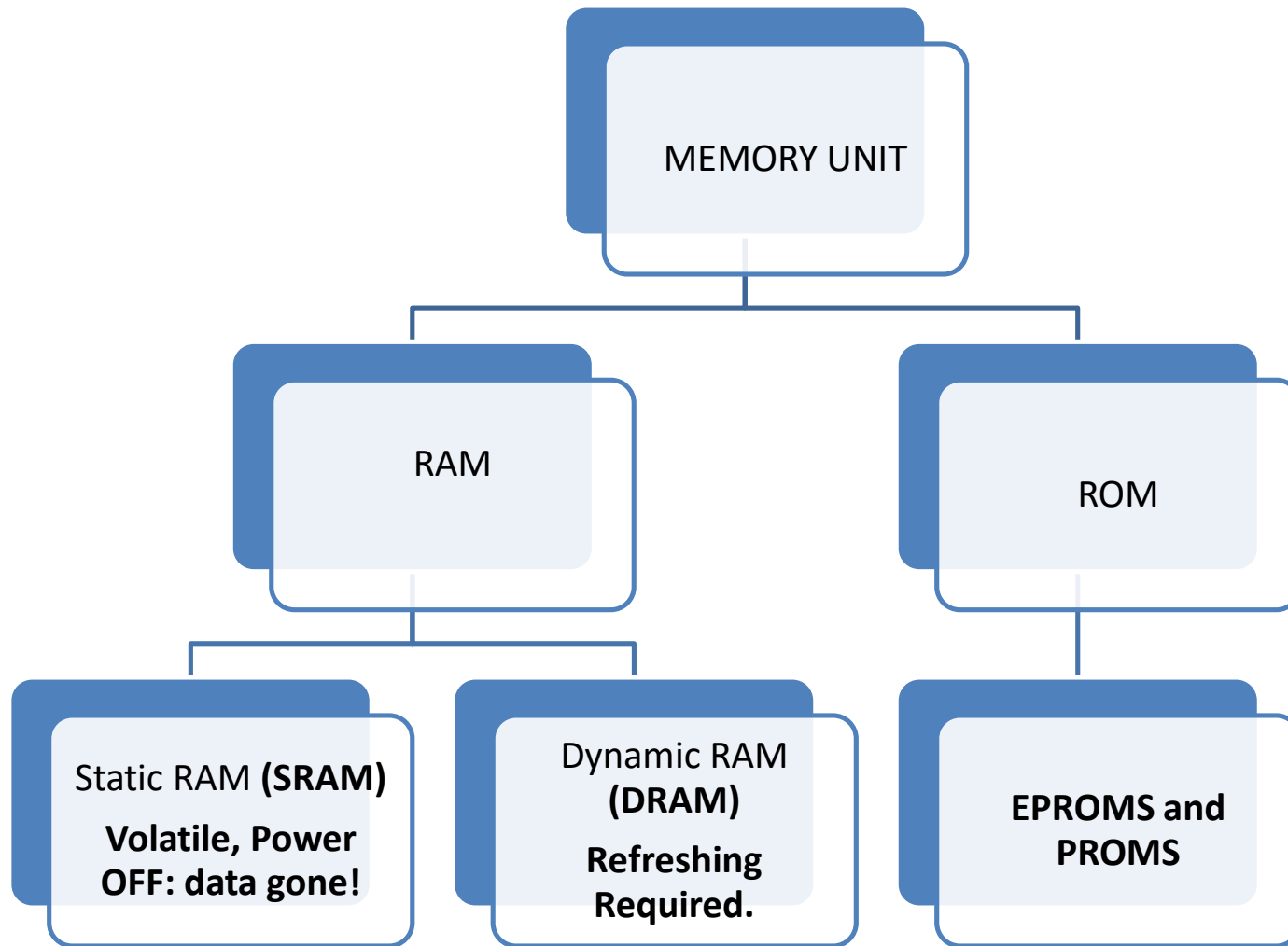
Memory Unit:

It is a collection of cells capable of storing a large quantity of binary information.

In digital systems, there are two types of memories:

1. RAM
2. ROM

MEMORY UNIT



Random-Access Memory (RAM)

- RAM is the place in a computer where the operating system , application programs, and data in current use are kept so that they can be quickly reached by the computer's processor.

Read-Only Memory (ROM)

- ROM is a type of memory that is as fast as RAM, but has two important differences: It can not be changed, and it retains its contents even when the computer is shut off. It is generally used to start your computer up and load the operating system.

Using a ROM as a PLD

- A programmable logic device or PLD is an electronic component used to build digital circuits . Before the PLD can be used in a circuit it must be programmed.
- Examples of PLDs: programmable logic array (PLA), programmable array logic (PAL), and *field-programmable logic gate array (FPGA)*.
(PAL: Program. AND, fixed OR, PLA: Program. AND/OR)

Random-Access Memory

- Memory unit:
Stores binary information in groups of bits called words.
 - Memory word:
group of 1's and 0's and may represent a number, character(s), instruction, or other binary-coded information.
- Most computer memories use words that are multiples of 8 bits (byte). 32-bit word à 4 bytes

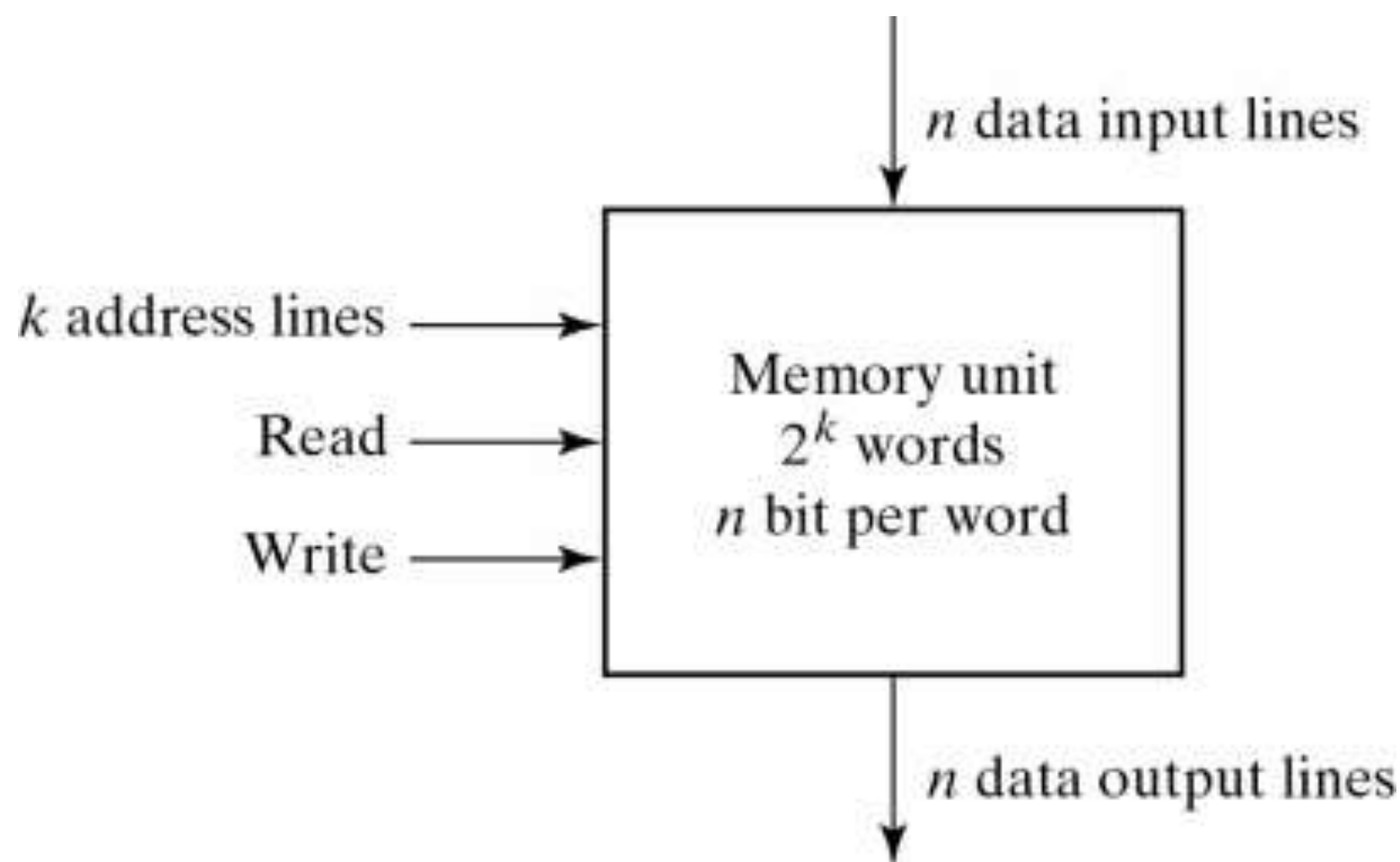


Fig. 7-2 Block Diagram of a Memory Unit

RAM: Write and Read Operations

- To transfer a new word to be stored into memory:
 1. Apply the binary address of the word to address lines.
 2. Apply the data bits that must be stored in memory to the data input lines.
 3. Activate the write input.

To transfer a stored word out of memory:

1. Apply the binary address of the word to address lines.
2. Activate the read input.

Memory Types

Integrated circuit RAM units are available in two possible operating modes:

static and dynamic.

- Static RAM (**SRAM**) consists of internal latches that store **the binary** information. The stored information remains valid as long as power is applied to the unit.
- Dynamic RAM (**DRAM**) stores the **binary information in the form of** electric charges on capacitors provided by the MOS transistors. The charge on the capacitors tends to decay with time and the capacitors must be periodically recharged by refreshing of the dynamic memory every few milliseconds.

- DRAM offers reduced power consumption, large integration of units on chip.
- SRAM is faster; has shorter read and write cycles, SRAM is used in cache.
- Disadvantages: high power consumption, low density, expensive.

Volatile vs. Non-Volatile Memory

RAM (static and dynamic) is said to be volatile, since information is lost when power is turned off.

Non-volatile memory retains its information even when power is turned off.

1. Magnetic disks: stored data is represented by the direction of magnetization.
2. CD: compact disc is a piece of polycarbonate (a type of plastic) on which a spiral track has been impressed. This spiral track is a series of indentations ("pits") separated by flat areas ("land").
3. ROM: The internal storage elements are set to their values once and after that are only read.

EPROMS and PROMS

Erasable Programmable Read-Only Memory (**EPROM**) is a special type of memory that retains its contents until it is exposed to ultraviolet light.

To write to EPROM, you need a special device called a PROM Programmer or PROM burner (programmer). An EPROM differs from a PROM in that a PROM can be written to only once and cannot be erased.

EPROMs are widely used in personal computers since they enable the manufacturer to change the contents of the PROM before the computer is actually shipped. This means that bugs can be removed and new versions installed shortly before delivery.

EEPROMS and FLASH

- Electrically Erasable Programmable Read-Only Memory (**EEPROM**), is like **EPROM** except **that the previously** programmed connections can be erased with an electrical signal.
- **Flash memory is a type of EEPROM**
Information stored in flash memory is usually written in blocks rather than a byte or word at a time.

Virtual Memory?

- With virtual memory, the computer can look for areas of RAM that have not been used recently and copy them onto the hard disk. This frees up space in RAM to load the new application. Because it does this automatically, you don't even know it is happening, and it makes your computer feel like it has unlimited RAM space even though it has only 1 GB installed.

Quick Quiz

- EPROM is
 - A. infrared light erasable and magnetically programmable
 - B. magnetically erasable and electrically programmable
 - C. infrared light erasable and electrically programmable
 - D. ultraviolet light erasable and electrically programmable

Quick Quiz

- Which of the following is a temporary memory?
 - A. ROM only
 - B. RAM only
 - C. Both ROM and RAM
 - D. Neither ROM nor RAM

Quick Quiz

- Volatile memory is
 - A. ROM only
 - B. RAM only
 - C. Both ROM and RAM
 - D. Neither ROM nor RAM

Read-Only Memory (ROM)

- Read-only memory is a memory device in which permanent binary information is stored.

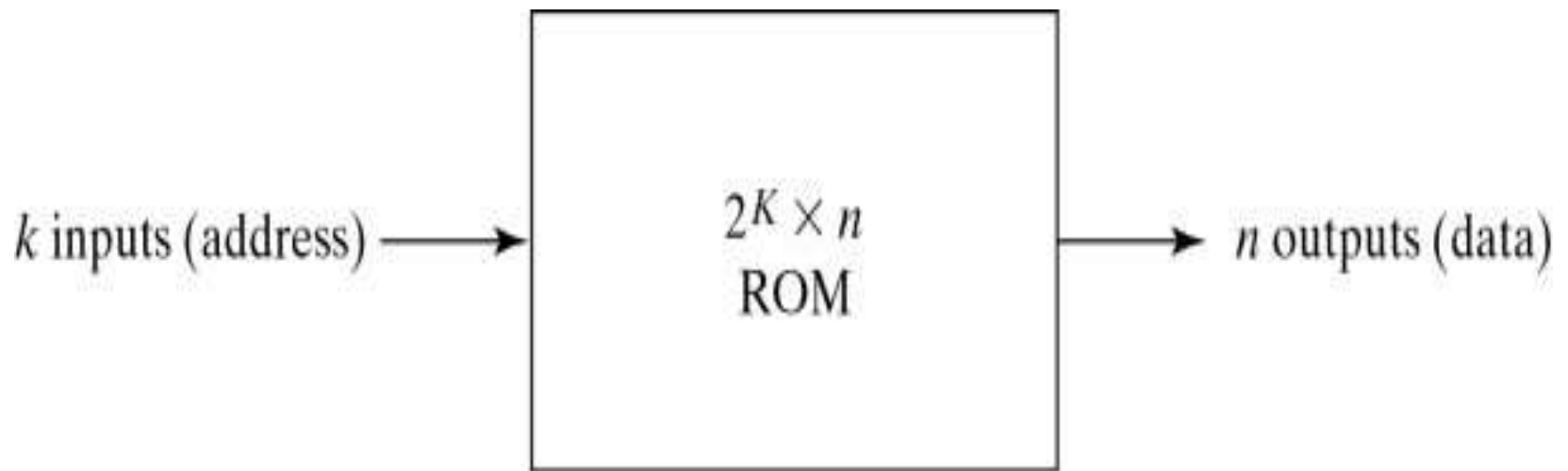
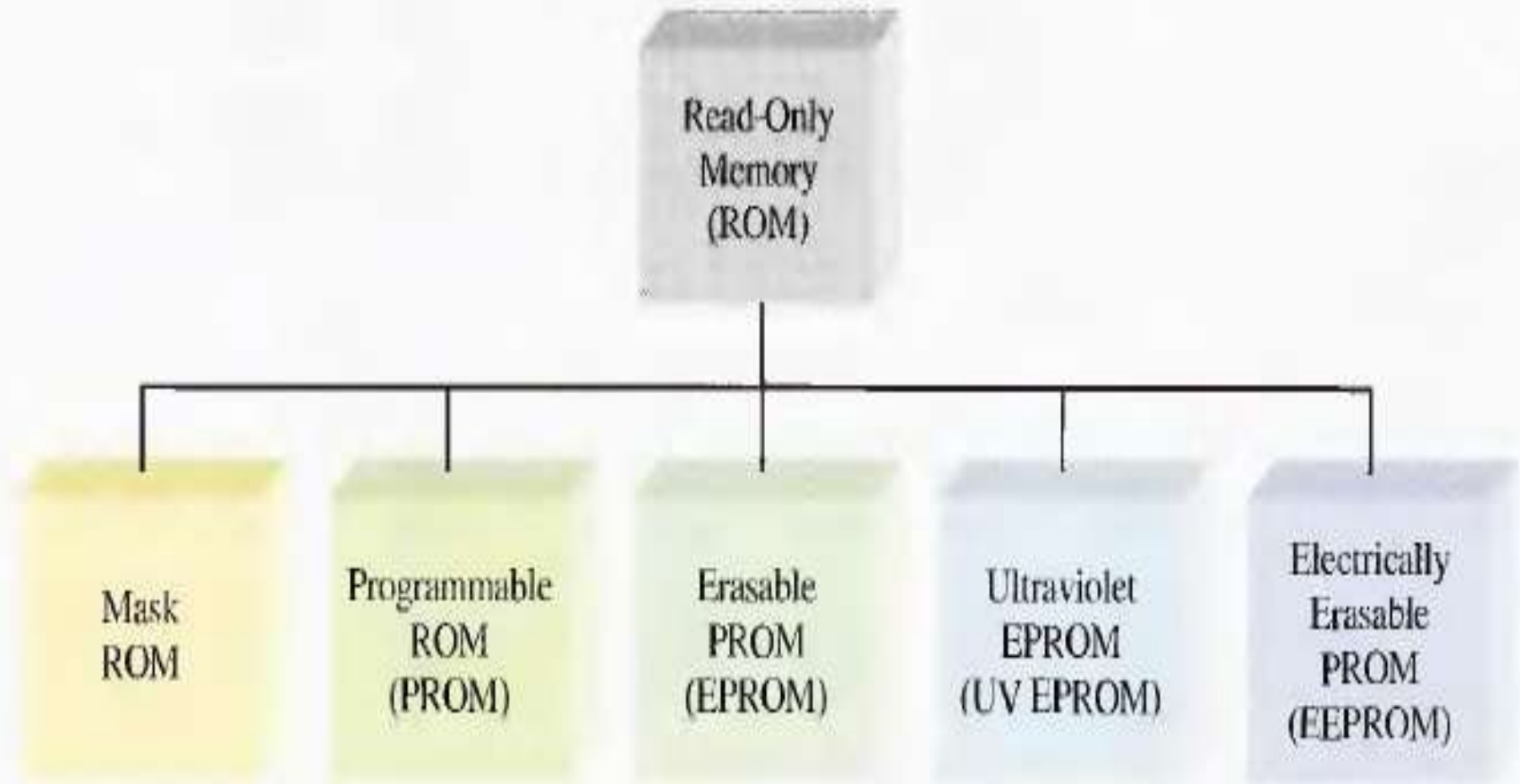


Fig. 7-9 ROM Block Diagram

Types of ROM



Comparison of Different Memories

MEMORY TYPE	NONVOLATILE	HIGH-DENSITY	ONE-TRANSISTOR CELL	IN-SYSTEM WRITABILITY
Flash	Yes	Yes	Yes	Yes
SRAM	No	No	No	Yes
DRAM	No	Yes	Yes	Yes
ROM	Yes	Yes	Yes	No
EPROM	Yes	Yes	Yes	No
EEPROM	Yes	No	No	Yes

Programmable Logic Device (PLD)

- Programmable logic devices (PLD) are designed with configurable logic and flip-flops linked together with programmable interconnect.
- PLDs provide specific functions, including
 - Device-to-device interfacing
 - Data communication
 - Signal processing
 - Data display
 - Timing and control operations, and almost every other function a system must perform

PLDs (continued)

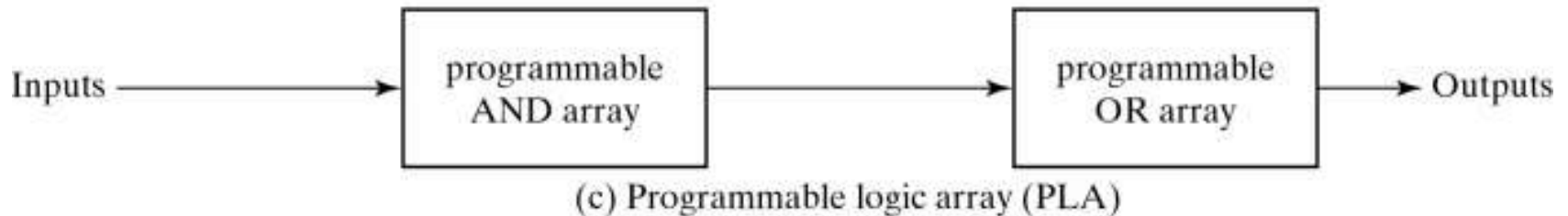
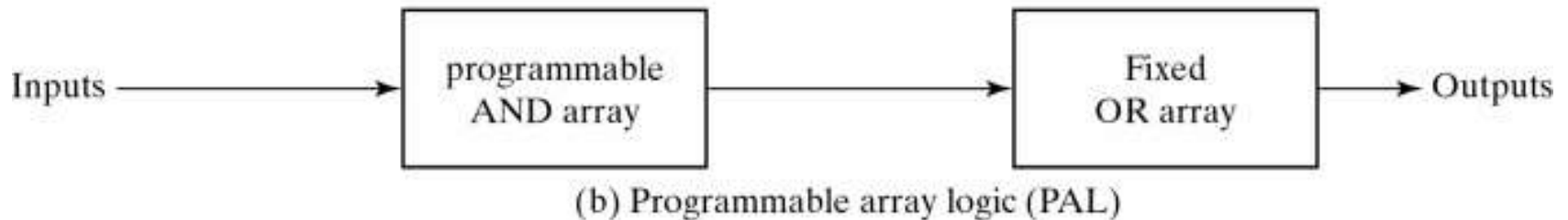
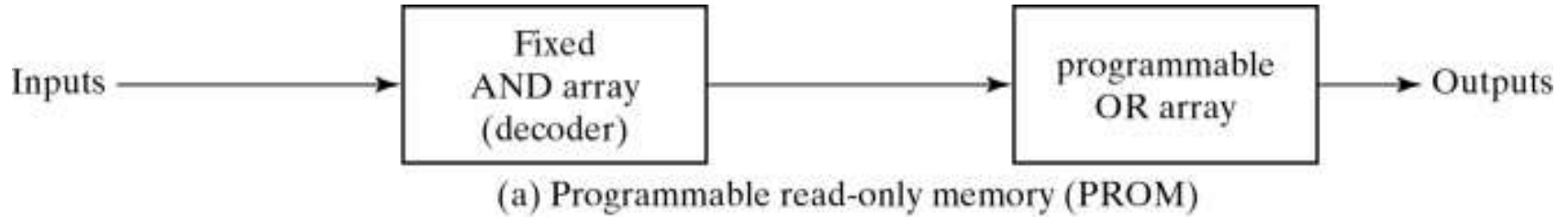


Fig. 7-13 Basic Configuration of Three PLDs

Programmable Logic ARRAY (PLA)

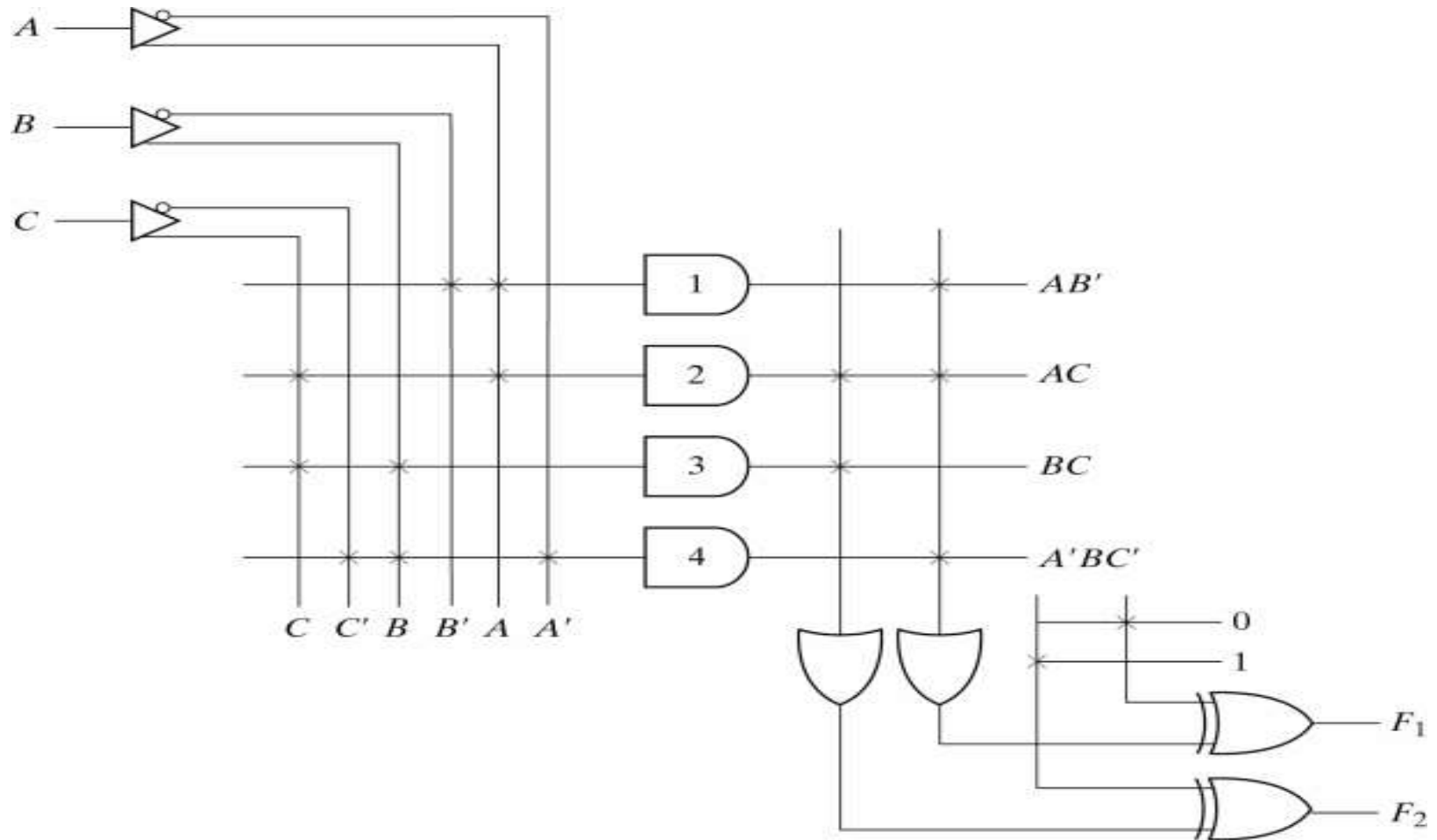


Fig. 7-14 PLA with 3 Inputs, 4 Product Terms, and 2 Outputs

PLA Programming example

- Implement the following function with a PLA:
- $F1 = (0,5,6,7)$
- $F2 = (0,1,2,4)$

		<i>BC</i>		<i>B</i>	
		00	01	11	10
<i>A</i>	0	1	1	0	1
<i>A</i>	1	1	0	0	0

C

$$F_1 = A'B' + A'C' + B'C'$$

$$F_1 = (AB + AC + BC)'$$

		<i>BC</i>		<i>B</i>	
		00	01	11	10
<i>A</i>	0	1	0	0	0
<i>A</i>	1	0	1	1	1

C

$$F_2 = AB + AC + A'B'C'$$

$$F_2 = (A'C + A'B + AB'C')'$$

PLA programming table						
	Product term	Inputs			Outputs	
		<i>A</i>	<i>B</i>	<i>C</i>	(C)	(T)
					<i>F</i> ₁	<i>F</i> ₂
<i>AB</i>	1	1	1	—	1	1
<i>AC</i>	2	1	—	1	1	1
<i>BC</i>	3	—	1	1	1	—
<i>A'B'C'</i>	4	0	0	0	—	1

Fig. 7-15 Solution to Example 7-2

Programmable Array Logic (PAL)

- The programmable array logic (PAL) is a logic device with fixed OR array and a programmable AND array. It is easier to program but not as flexible as PLA.

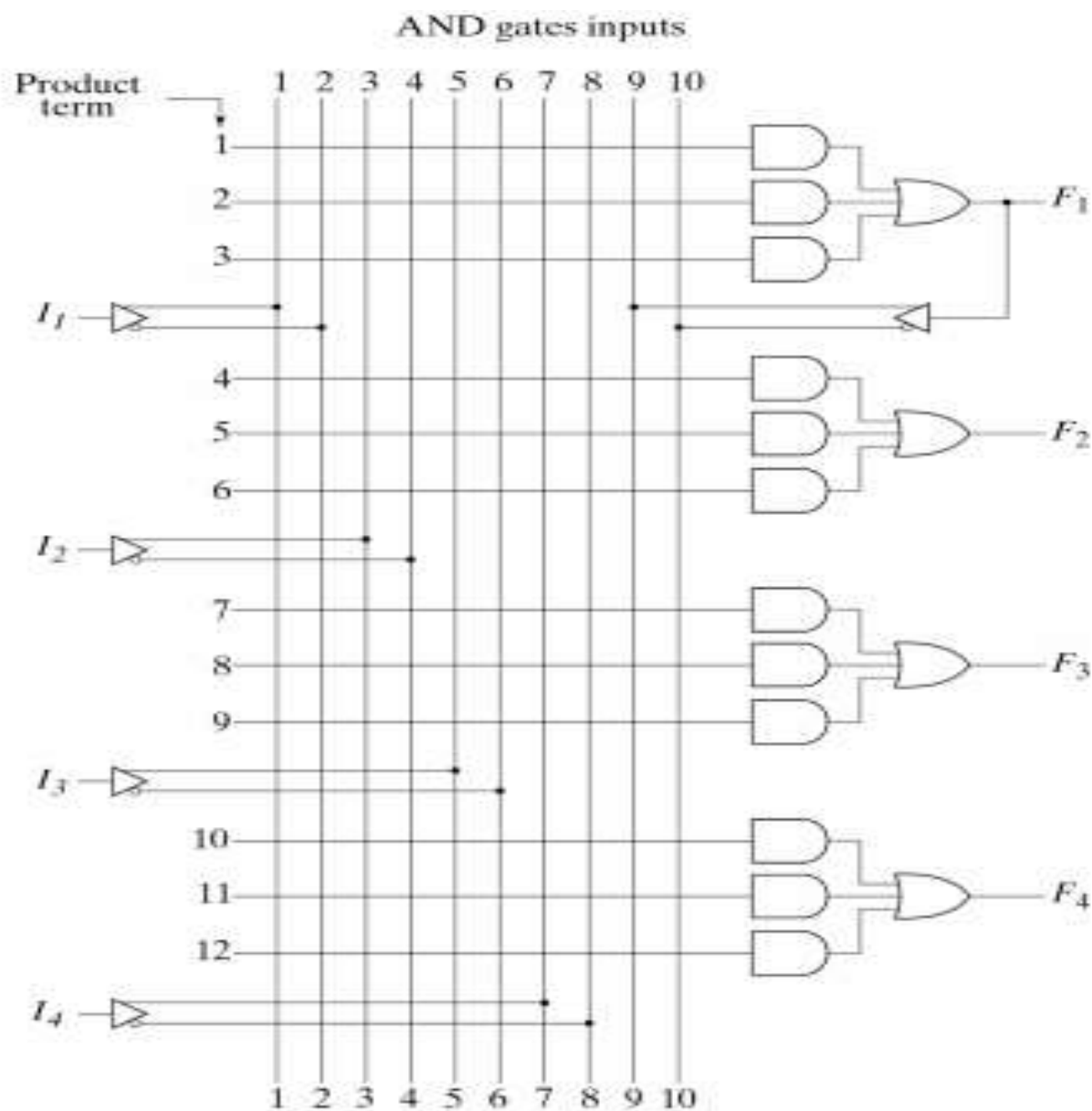


Fig. 7-16 PAL with Four Inputs, Four Outputs, and Three-Wide AND-OR Structure

PALs and PLAs

PLA is the most flexible

- One PLA can implement a huge range of logic functions
- BUT many pins; large package, higher cost

PALs are more restricted / you trade number of OR terms vs number of outputs

- Many device variations needed
- Each device is cheaper than a PLA

Field Programmable Gate Arrays (FPGAs)

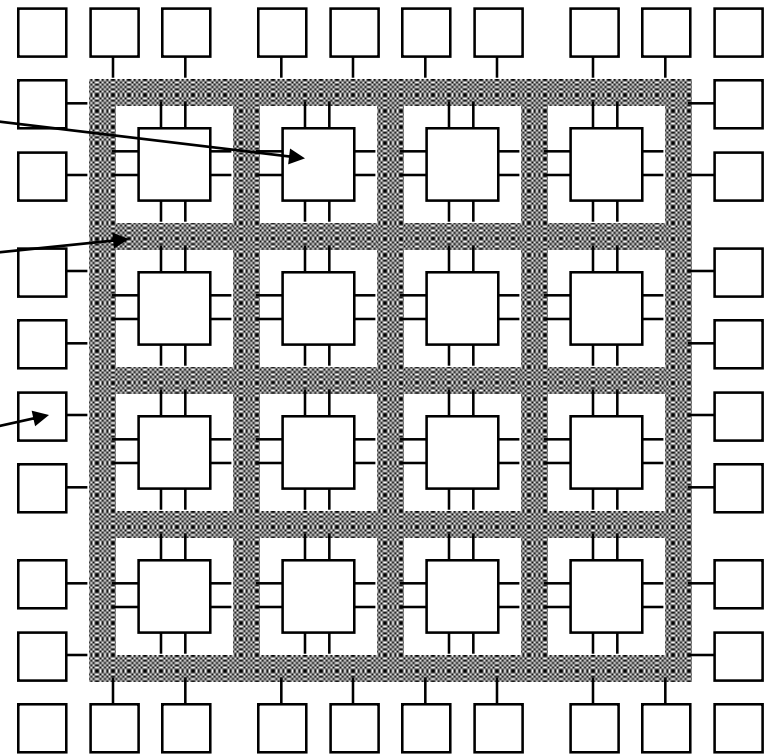
- FPGAs have much more logic than CPLDs
 - 2K to >10M equivalent gates
 - Requires different architecture
 - FPGAs can be RAM-based or Flash-based
 - RAM FPGAs must be programmed at power-on
 - External memory needed for programming data
 - May be dynamically reconfigured
 - Flash FPGAs store program data in non-volatile memory
 - Reprogramming is more difficult
 - Holds configuration when power is off

FPGA Structure

- Typical organization in 2-D array
 - Configurable logic blocks (CLBs) contain functional logic (could be similar to PAL22V10)
 - Combinational functions plus FFs
 - Complexity varies by device
 - CLB interconnect is either local or long line
 - CLBs have connections to local neighbors
 - Horizontal and vertical channels use for long distance
 - Channel intersections have switch matrix
 - IOBs (I/O logic Blocks) connect to pins
 - Usually have some additional C.L./FF in block

Field-Programmable Gate Arrays structure

- Logic blocks
 - To implement combinational and sequential logic
- Interconnect
 - Wires to connect inputs and outputs to logic blocks
- I/O blocks
 - Special logic blocks at periphery of device for external connections



Quick Quiz

- The PLD which is more flexible
 - A. PLA
 - B. ROM
 - C. PAL
 - D. Fixed logic

Quick Quiz

- The size of the PLA is specified by the
 - A. Number of product terms
 - B. Number of inputs
 - C. Number of the outputs
 - D. All of the above

Quick Quiz

- PAL consists of following matrix
 - A. Fixed AND matrix and a programmable OR matrix
 - B. Programmable AND matrix and a fixed OR matrix
 - C. Both AND and OR matrix are fixed
 - D. Both AND and OR matrix are programmable