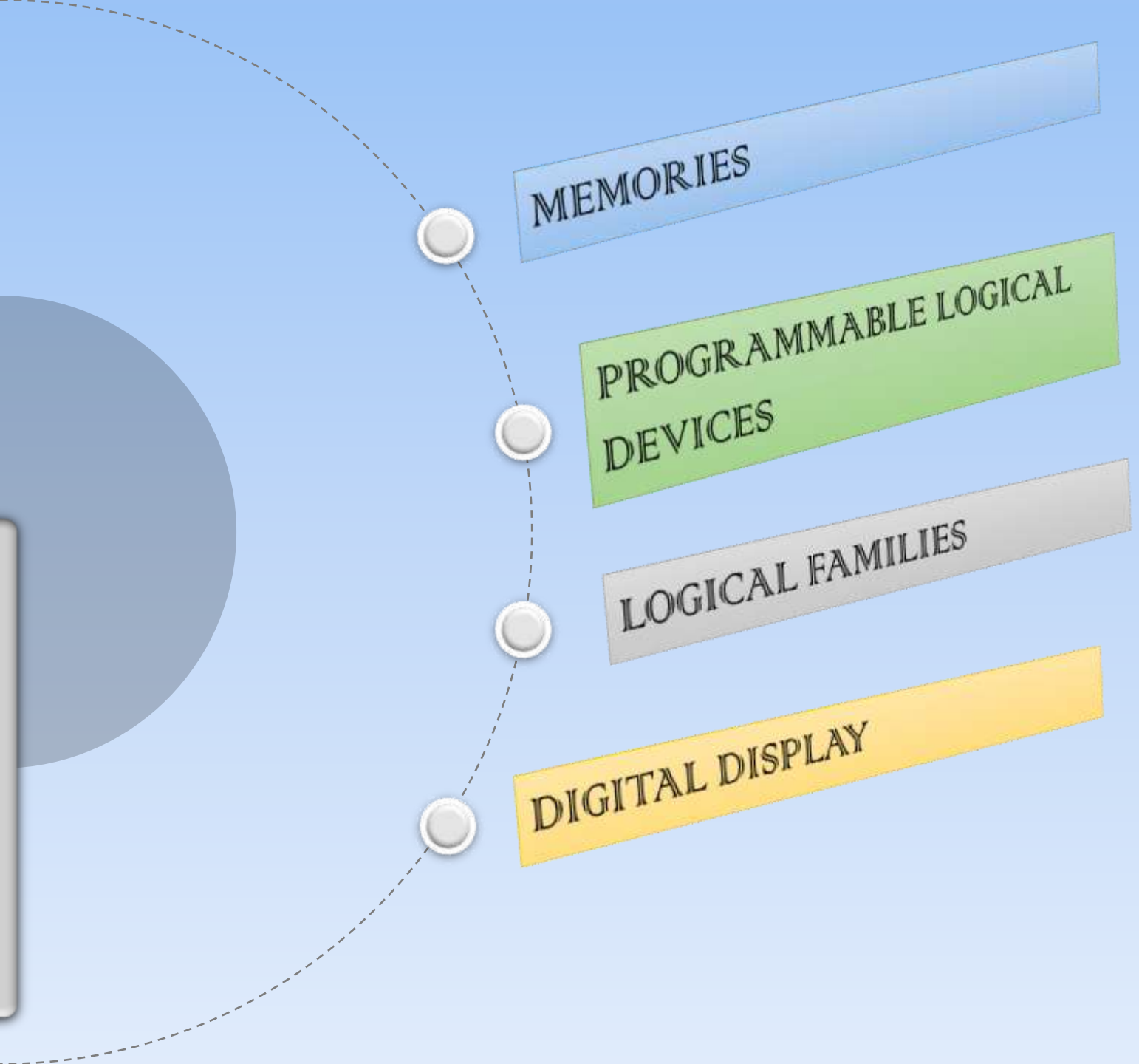

MEMORIES
PROGRAMMABLE LOGICAL DEVICES
LOGICAL FAMILIES
DIGITAL DISPLAY

MEMORIES

MEMORIES

- ✓ Devices that store digital information
- ✓ Represented in terms of bit, byte, nibble, KB,MB etc
- ✓ Consists of arrays of storage elements (latches, flip-flops or capacitors)
- ✓ Memories are made up of arrays of cells (cell can store either 1 or 0)
- ✓ Location specified by a row and a column is called Address of unit of data.
- ✓ Total number of bits that can be stored is called capacity
- ✓ Eg: 2x2 memory; 4 cells storing 4 bits

1	0
1	0

CAPACITY OF MEMORY

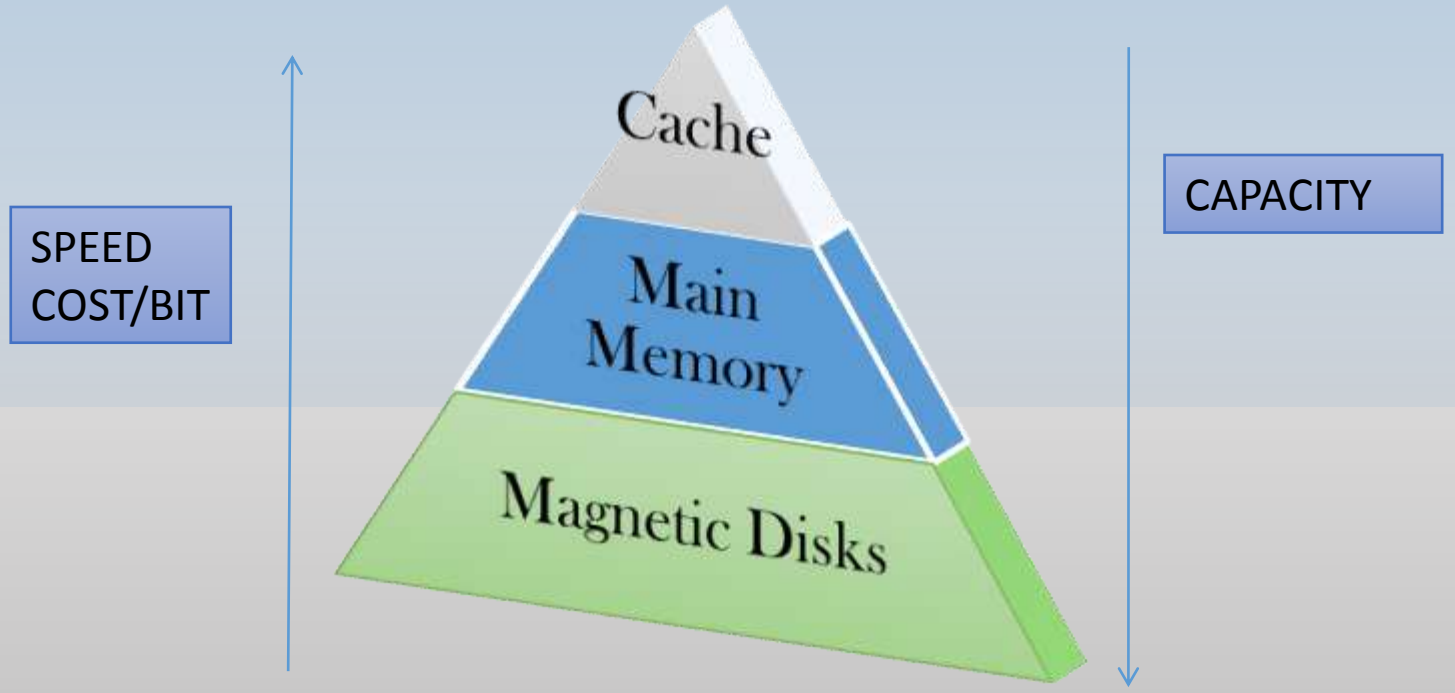
- ✓ Memories are identified by
  =no. of words * word size
- ✓ no. of words = power of 2

2^M =no. of words or address locations

N =word size

CLASSIFICATION OF MEMORIES

- ✓ Depends upon speed, capacity, units of transfer, volatile/non-volatile, erasable/non-erasable
- ✓ The memory unit is an essential component in any digital computer since it is needed for storing programs and data
- ✓ Not all accumulated information is needed by the CPU at the same time
- ✓ Therefore, it is more economical to use low-cost storage devices to serve as a backup for storing the information that is not currently used by CPU



CLASSIFICATION OF MEMORIES

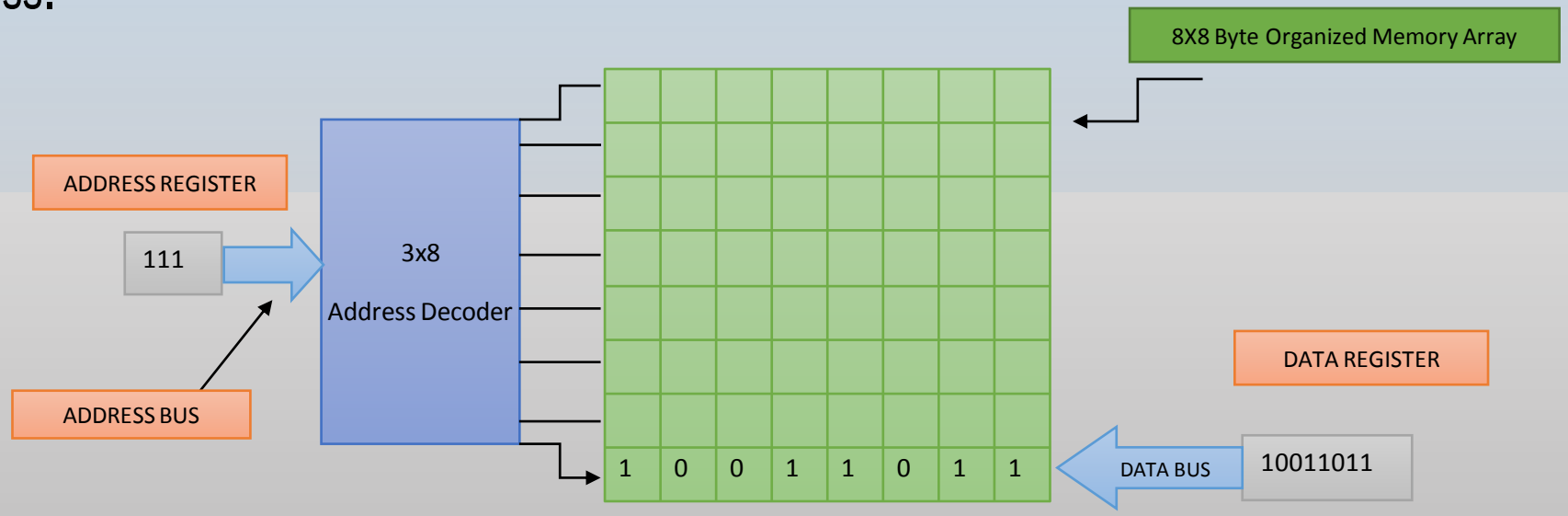
- ✓ The memory unit that directly communicate with CPU is called the main memory
- ✓ Devices that provide backup storage are called auxiliary memory
- ✓ The memory hierarchy system consists of all storage devices employed in a computer system from the slow by high-capacity auxiliary memory to a relatively faster main memory, to an even smaller and faster cache memory
- ✓ The main memory occupies a central position by being able to communicate directly with the CPU and with auxiliary memory devices through an I/O processor
- ✓ A special very-high-speed memory called cache is used to increase the speed of processing by making current programs and data available to the CPU at a rapid rate

GENERAL STORAGE METHOD

- **READ-WRITE OPERATION**
  - Data entered into memory during write operation and data comes out of memory during read operation from data bus.
  - The desired place to write or read data is located by address bus.
  - Binary code used for representing desired address on address bus, are decoded internally and appropriate address is selected.

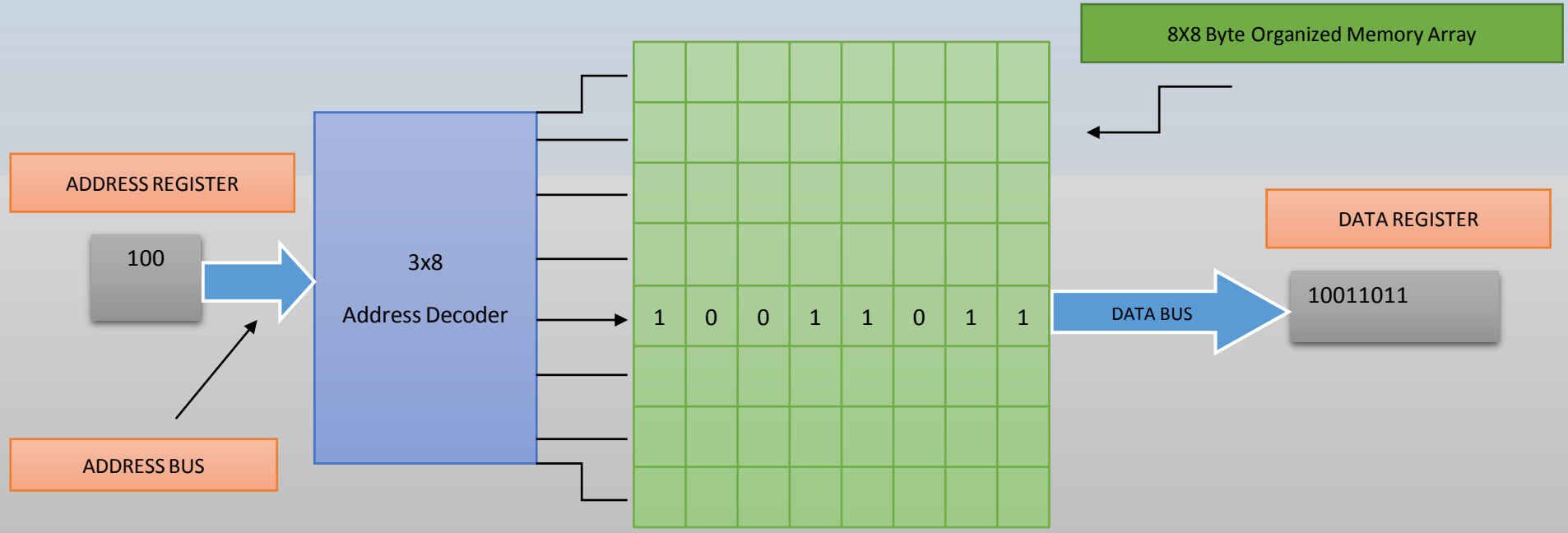
WRITE OPERATION

- ✓ **To write a byte of data in memory**
  - ✓ Address code is placed on address bus.
  - ✓ Address decoder decodes the address and select specified location in memory.
  - ✓ Data byte is placed on data bus.
  - ✓ When write command executes, data from data bus is placed in selected memory address.



READ OPERATION

- ✓ **To read a byte of data in memory**
  - ✓ Address code is placed on address bus.
  - ✓ Address decoder decodes the address and select specified location in memory.
  - ✓ When read command executes, copy of data stored in selected address is placed on data bus and loaded to data register.



TYPES OF MEMORIES

- **RAM:**
  - It is a volatile (data storage temporary ie. until power is on)
  - Have both read and write capability and random access
  - A RAM chip is better suited for communication with the CPU if it has one or more control inputs that select the chip when needed
  - Two types: SRAM and DRAM

DIFFERENCE BETWEEN SRAM AND DRAM

SRAM	DRAM
Use MOS for storing information in flip-flops	Use both BJT and MOS to store information in the form of charge of capacitors
Less capacity	High Capacity
No refresh circuit needed	Refresh circuit needed
Complex	Simple to build
Short read/write cycle	Long so slower
Expensive (high cost/bit)	Less costly
Eg: cache	Eg: Main Memory

BJT- Bipolar Junction Transistor
MOS- Metal Oxide Semiconductor

ROM

- ✓ Non volatile (Data storage permanently even if the power is turned off)
- ✓ Data can only be read but can’ t write, so read only memory
- ✓ Used in Boot Programs, System Programs (BIOS), Library Subroutines
- ✓ Can be constructed using both BJT and MOS

TYPES OF ROM

- ✓ **Mask ROM** - Once programmed by the manufacturer, then no change and use BJT as well as MOS
- ✓ **PROM** -Once can be programmed & use BJT as well as MOS
- ✓ **EPROM** -Erasable Programmable ROM & use MOS only and can be reprogrammed if an existing program in the memory array is erased first
- ✓ **EEPROM** -Electrically Erasable PROM, data can be erased and reprogrammed with electrical pulses
- ✓ **UVEPROM** -Ultra Violet Erasable PROM, erasure of data is done by the exposure of the memory area chip to high intensity ultraviolet radiation through the quartz window on top of the package

FIFO

- ✓ Formed by the arrangement of shift registers.
- ✓ First data bit written into memory is first to be read out.
- ✓ Can be used in case where two systems of different data rates must communicate.

LIFO

- ✓ Last in first out
- ✓ Last data to be stored is first to be retrieved.
- ✓ Found in applications involving microprocessors (stack) and other computing systems.

FLASH MEMORIES

- ✓ High density read/write and random access memories.
- ✓ High storage capacity.
- ✓ Non volatility.
- ✓ Cost effective.
- ✓ Comparatively fast operation.
- ✓ Less power.
- ✓ Used in floppy, Hard disk in laptops.
- ✓ No refresh needed.

COMPARISON

Memory Type	Non Volatile	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 LOGICAL DEVICES

PROGRAMMABLE LOGICAL DEVICES

- ✓ Devices in which the logic function is programmed by the user and in some cases can be reprogrammed many times.
- ✓ Has replaced hardwired fixed function logic device.
- ✓ Consumes less area than fixed function logic device
- ✓ Can be designed and changed without rewiring or replacing components and are faster than fixed one.

TYPES OF PLDs

- ✓ **SPLDs (Simple Programmable Logic Devices)**
  - ✓ Least complex than other forms of PLDs.
  - ✓ Can replace fixed function SSI or MSI devices and their interconnections

1. **PROM (Programmable Read Only Memory)**
   - ✓ Uses set of fixed non programmable AND gates as "Decoder" and **programmable OR gate array**
   - ✓ Comes with links that can be fused
   - ✓ Fused links refer to 0 and Unfused links refer to 1

TYPES OF PLDs

1. PROM (Programmable Read Only Memory)

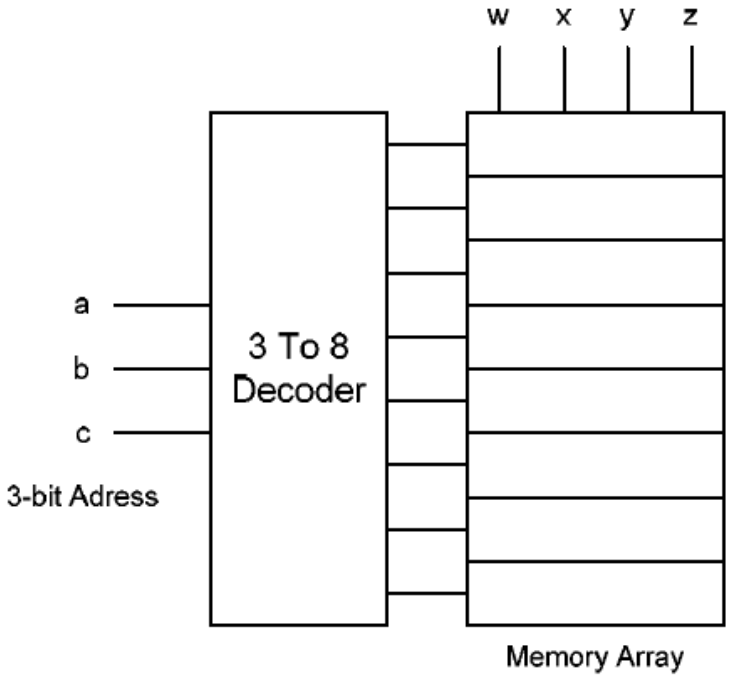
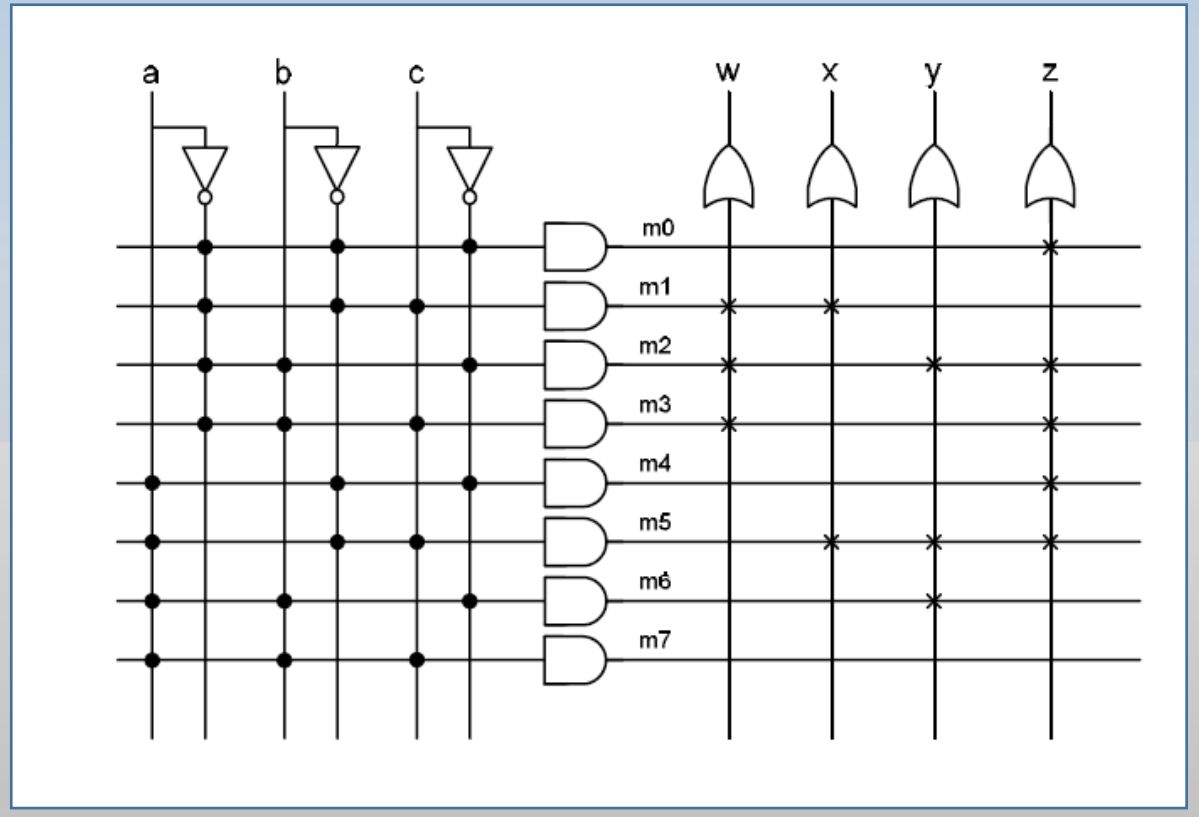


Figure 4.9 Memory View of ROM



TYPES OF PLDs - - - - Continued

2. **PLA (Programmable Logic Array) also called FPLA (Field PLA)**
   - ✓ Powerful tool to generate complex switching functions
   - ✓ Formed by the interconnection of two ROMs. (Product ROM and Sum ROM)
   - ✓ Consists of programmable array of 'AND' and then programmable 'OR' **array**
   - ✓ Programmable array is a grid of conductors that form rows and columns with a fusible link at each cross point. Arrays can be fixed or programmable.
   - ✓ Programmed by the user in the field not the manufacturer
   - ✓ **Logical functions determined by the absence or presence of connections at fixed pre-defined positions**
   - ✓ Similar to PROM but differ in their internal structure ie. **no decoders are required**
   - ✓ Realize combinational logic functions in terms of SOP
   - ✓ **Advantages of PLA**: minimum likelihood of errors, regularity of design, availability in LSI and MSI packages

TYPES OF PLDs - - - - Continued

2. **PLA (Programmable Logic Array) also called FPLA (Field PLA)**

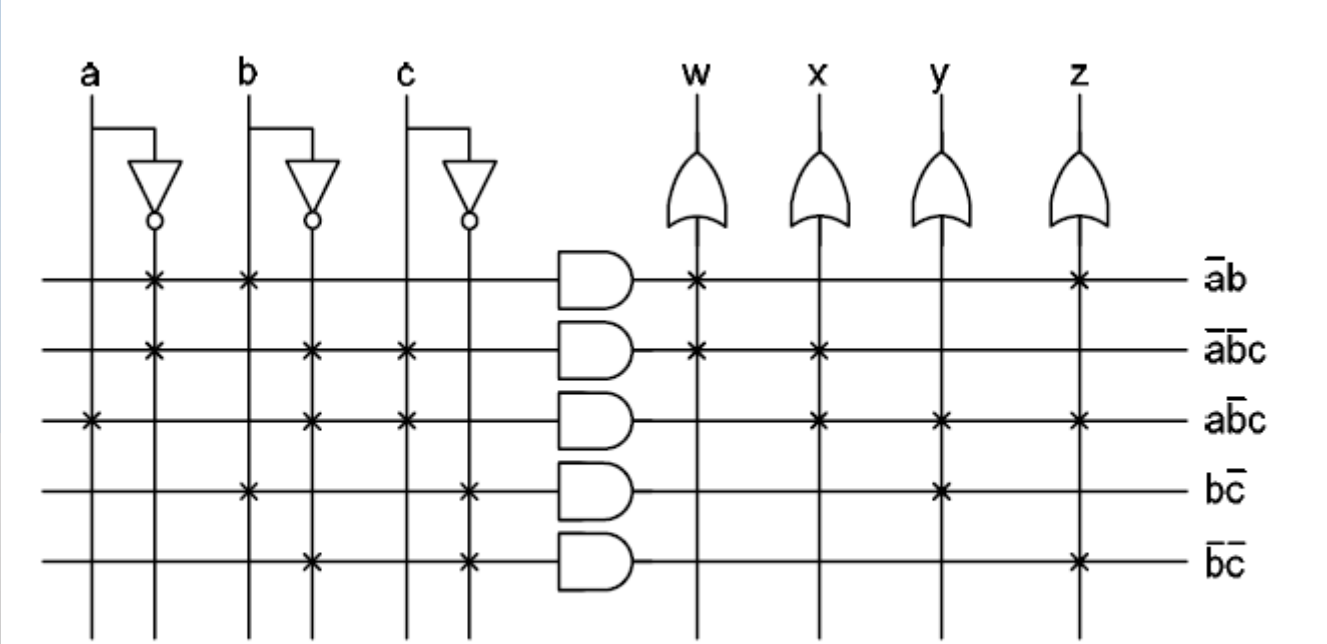


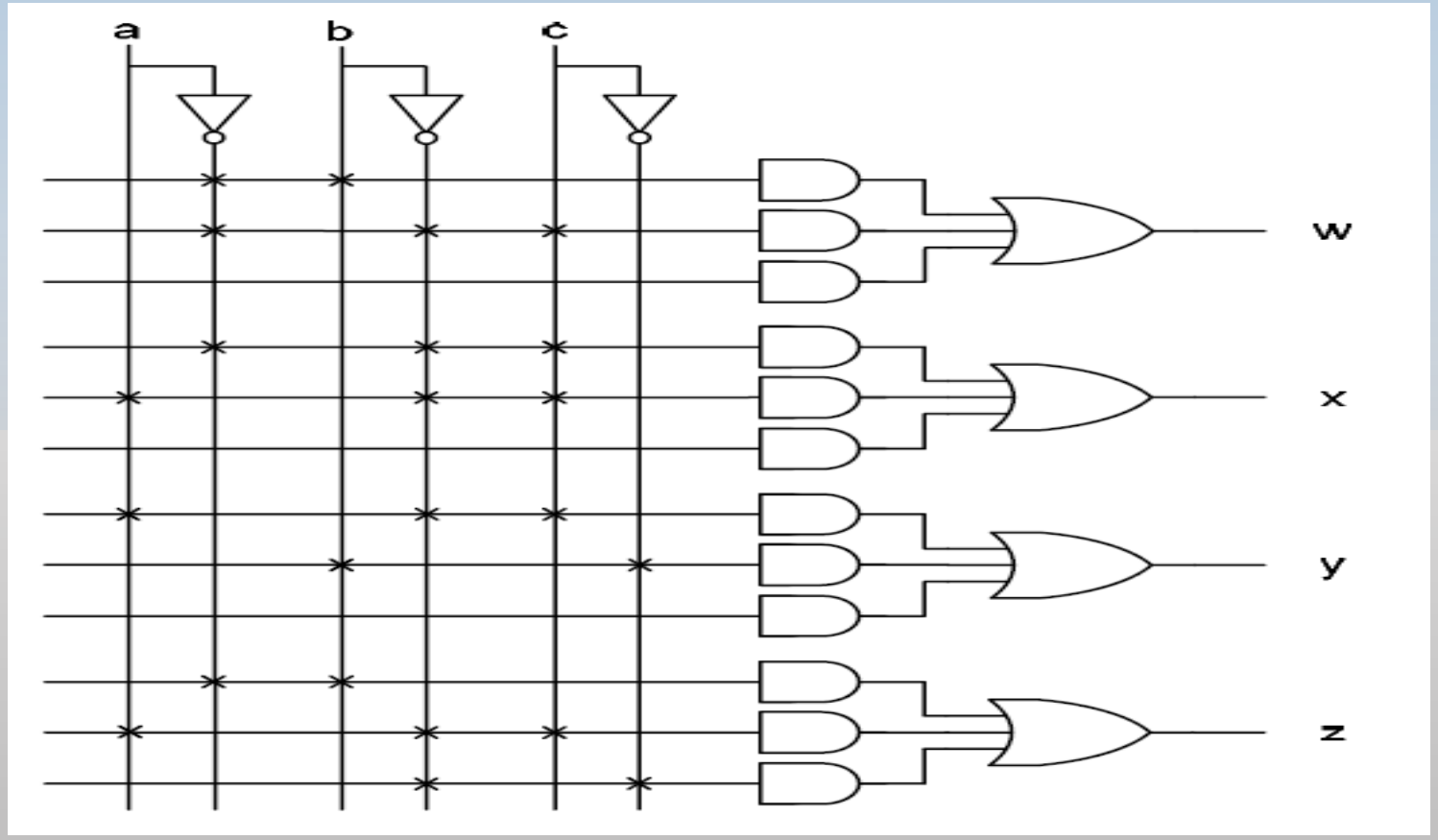
Figure 4.14 PLA Implementation

TYPES OF PLDs - - - - Continued

3. **PAL (Programmable Array Logic)**
   - ✓ Architecture simpler than PLA as it omitted the programmable OR array
   - ✓ Hence, **faster smaller and cheaper**
   - ✓ Longer delays in PLA due to fusible links in both 'AND' and 'OR' programmable arrays and circuit also complex, so to overcome those disadvantages of PLA, PAL consisting of Programmable 'AND' array but fixed 'OR' **array with Output Logic**
   - ✓ Implemented with **bipolar technology** (TTL or ECL)

TYPES OF PLDs - - - - Continued

3. PAL (Programmable Array Logic)

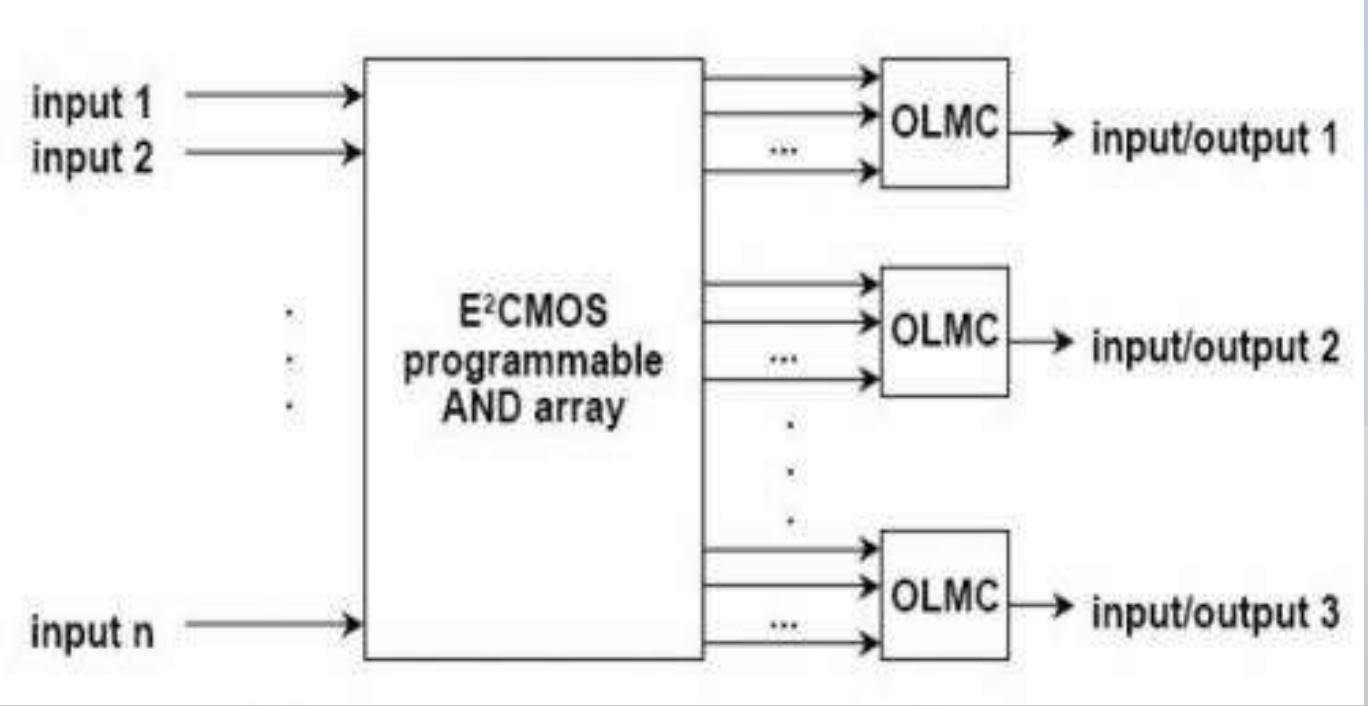


TYPES OF PLDs - - - - Continued

4. **GAL (Generic Array Logic)**
   - ✓ **Innovation of PAL** and has same logical properties as PAL but can be **erased and reprogrammed**
   - ✓ Very useful in prototyping stage of design where any bugs can be corrected by reprogramming.
   - ✓ Consists of **reprogrammable AND array and a fixed OR array with programmable output configurations** (these are two difference between PAL and GAL)
   - ✓ Uses **E^2CMOS (Electrically Erasable CMOS) technology** instead of Bipolar technology and fusible links

TYPES OF PLDs - - - - Continued

4. GAL (Generic Array Logic)



Output logic macrocells (OLMCs)

TYPES OF PLDs - - - - Continued

- ✓ **CPLDs (Complex Programmable Logic Devices)**
  - ✓ PALs and GALs are available only in small sizes, equivalent to few hundred logic gates, so for **bigger logic circuits**-CPLDs
  - ✓ Typical CPLD is equivalent to **2 to 64 SPLDs**
  - ✓ Contains equivalent of several PALs linked by programmable interconnections, all in one integrated circuits
  - ✓ Have much **higher capacity** than SPLDs and **more complex logic circuit** to be programmed into them
  - ✓ Complexity in between that of PALs and FPGA and architecture features of both
  - ✓ **Features common with PAL**: non volatile configuration memory and can function immediately on system startup
  - ✓ **Features common with FPGA**: large number of gates available.
  - ✓ **Difference between FPGA**: FPGA has absence of on chip non volatile memory and CPLD is used to load configuration data for an FPGA from non volatile memory, CPLD is based on sea of gates (SOP) whereas FPGA based on Look up tables

TYPES OF PLDs - - - - Continued

- ✓ **CPLDs (Complex Programmable Logic Devices)**

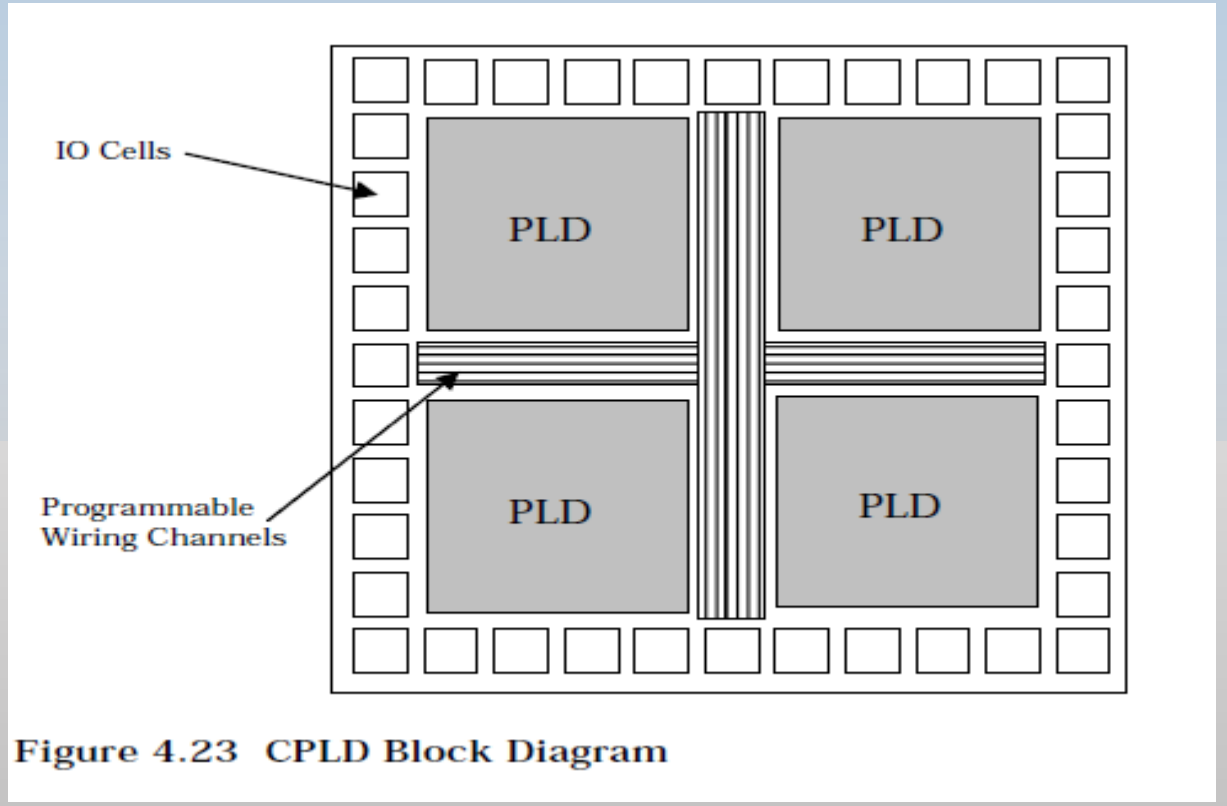


Figure 4.23 CPLD Block Diagram

TYPES OF PLDs - - - - Continued

- ✓ **FPGAs (Field Programmable Gate Arrays)**
  - ✓ Based on **gate array technology**
  - ✓ Uses a grid of logic gates, similar to that of an ordinary gate array called **logical blocks** but programming is done by customer not by the manufacturer, in the field outside the factory.
  - ✓ The configuration is **volatile** and must be reloaded whenever power applied or different function (storing configuration in PROM or EEPROM) is required
  - ✓ Consumes **more power** than CPLDs
  - ✓ FPGA **have many registers or memory storage** as compared to CPLD
  - ✓ **CPLD**- good choice for **wide combinational logic applications**
  - ✓ **FPGA**- good choice for **large state machines (microprocessors)**

TYPES OF PLDs - - - - Continued

- ✓ **FPGAs (Field Programmable Gate Arrays)**

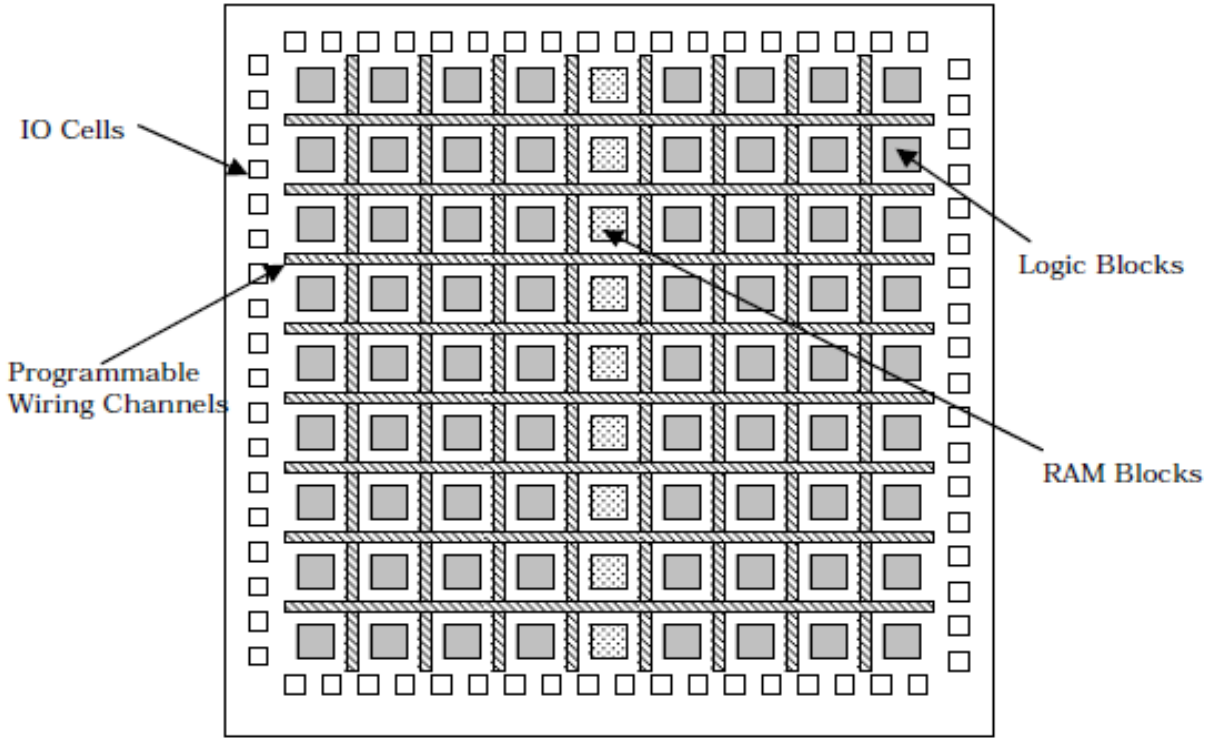


Figure 4.30 FPGA General Structure

LOGICAL FAMILIES

WHY IC? (INTEGRATED CIRCUIT)

- ✓ High performance
- ✓ High temperature bearing
- ✓ Low cost
- ✓ Compatible to larger circuits.

WHY SILICON IN IC?

- ✓ Easily available
- ✓ Cheap
- ✓ High temperature bearer
- ✓ Easy to fabricate.

LEVELS OF INTEGRATION

- ✓ Fixed function digital ICs are classified and listed below according to their complexity from the least complex to the most complex.

1. **Small Scale Integration (SSI)**
   - ✓ Fixed function ICs that contains only few equivalent gate circuits (transistors numbering in the tens) on a single chip
   - ✓ Include basic gates, flip-flops, transistors

2. **Medium Scale Integration (MSI)**
   - ✓ Fixed function ICs that contains 10 to 100 equivalent gate circuits (hundreds of transistors) on each chip
   - ✓ Include encoders, decoders, counters, registers, multiplexers, arithmetic circuits etc

LEVELS OF INTEGRATION

3. **Large Scale Integration (LSI)**
   - ✓ Fixed function ICs that contains 100 to 10000 equivalent gate circuits (tens of thousands of transistors) on each chip
   - ✓ Include large memories, 1 KB RAM, calculator chips, first microprocessors etc

4. **Very Large Scale Integration (VLSI)**
   - ✓ Fixed function ICs that contains 10000 to 100000 equivalent gate circuits (hundreds of thousands of transistors) on each chip
   - ✓ Include 1 MB RAM, second generation and later microprocessors chips etc

5. **Ultra Large Scale Integration (ULSI)**
   - ✓ Fixed function ICs that contains more than a million equivalent gate circuits (more than a million of transistors) on each chip
   - ✓ Include very large memories, large microprocessors, large single-chip computers etc

SOME TERMINOLOGIES

- ✓ **Fan Out:** Maximum number of output gates that can be reliably can be driven under worst condition
- ✓ **Fan In:** Maximum number of inputs that can be applied to a gate without improving its logical function
- ✓ **Noise immunity:** The ability to withstand noise, **Higher, the better**
- ✓ **Propagation delay product:** propagation delay * power dissipation
  - **Larger Propagation delay means the circuit is slow**
  - **Power Dissipation lesser, the better**
- ✓ **High Packing Density** means **less fabrication area** required
- ✓ **ESD-Electrostatic discharge: not sensitive is better**

BJT vs. MOSFET

The transistors BJT and MOSFET are both useful for amplification and switching applications. Yet, they have significantly different characteristics.

BJT	MOSFET
Bipolar Junction Transistor	Metal Oxide Semiconductor Field-Effect Transistor
BJT has an emitter, collector and base	MOSFET has a gate, source and drain
Preferred for low current applications like for switching purposes for instance, simply because they are cheaper	Preferred for high power functions
	In digital and analog circuits, MOSFETs are considered to be more commonly used than BJTs these days as they handle power more efficiently
The operation of BJT is dependent on the current at the base. (current-controlled device)	The operation of MOSFET depends on the voltage at the oxide-insulated gate electrode (voltage-controlled device)
Two type of BJTs, the NPN transistor and the PNP transistor	NMOS, PMOS, CMOS

TRANSISTOR TRANSISTOR LOGIC (TTL)

- ✓ Based on BJT technology
- ✓ **Appropriate in SSI and MSI circuits**
- ✓ Good noise performance
- ✓ Power dissipation high
- ✓ Large Propagation delay
- ✓ less packing density, so large fabrication area required
- ✓ Not sensitive to ESD(Electrostatic Discharge)
- ✓ Fan out/in 10/6
- ✓ used in many **applications such as computers, industrial controls, test equipment and instrumentation, consumer electronics, synthesizers**

EMITTER COUPLED LOGIC (ECL)

- ✓ Based on BJT technology
- ✓ **Used in high speed application circuits as propagation delay is very less, so faster**
- ✓ Packing density higher than TTL but less than MOS circuits
- ✓ Less noise immunity (cant be used in high noise environment)
- ✓ Not sensitive to ESD(Electrostatic Discharge)
- ✓ High Fan out operation possible Fan out/in 50/5
- ✓ High power consumption
- ✓ Limited Voltage Swing

INTEGRATED INJECTION LOGIC(I^2L)

- ✓ Merged Transistor Logic
- ✓ Based on BJT technology
- ✓ **Used in LSI circuits**
- ✓ High packing density
- ✓ Less power dissipation as no use of resistors
- ✓ Propagation delay large
- ✓ Low logical swing
- ✓ Lower noise immunity
- ✓ Not sensitive to ESD

METAL OXIDE SEMICONDUCTOR (MOS)

- ✓ Based on MOS technology
- ✓ **Used in LSI, VLSI and ULSI circuits**
- ✓ Less power dissipation
- ✓ Less area required so high packing density
- ✓ Sensitive to ESD
- ✓ Difference between CMOS and NMOS/PMOS is **NMOS/PMOS cant give exactly the same output as input** but CMOS can. so CMOS has the advantage over NMOS/PMOS

COMPLEMENTARY METAL OXIDE SEMICONDUCTOR (CMOS)

- ✓ Based on MOS technology (Combination of NMOS and PMOS)
- ✓ **Used in LSI, VLSI and ULSI circuits**
- ✓ Highest packing density so compact circuit fabrication ie. less area required
- ✓ Low power consumption (5V or 3.3V power supply required) and can vary over a wide range than TTL (2-6V for CMOS to 4.5-5.5V for TTL)
- ✓ Least power dissipation
- ✓ High speed operation
- ✓ High noise immunity
- ✓ Sensitive to ESD(Electrostatic Discharge)

SUMMARY

Logical Specifications	I^2L	ECL	TTL	CMOS
Power supply required	**1V**	**5 to 32V**	**4.5 to 5.5V**	**3 V**
So, Better is **I^2L, CMOS,** then **TTL** and then **ECL as per operating voltage**				
Propagation Delay	**TTL > I^2L > CMOS >= ECL** so, fastest is **ECL, CMOS** then **I^2L** and lastly **TTL**			
Noise Immunity	**Low**	**Poor**	**Good**	**Highest**
Packing Density	**High**	**Higher than TTL but lower than I^2L, CMOS**	**Less**	**Highest**
Power Dissipation	**Less**	**High**	**High**	**least**
Sensitive to ESD	**No**	**No**	**No**	**Yes**
Technology	**BJT**	**BJT**	**BJT**	**MOS**

DIGITAL DISPLAYS

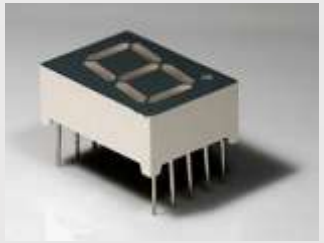
DIGITAL DISPLAY

- ✓ A display that gives the information in the form of characters (numbers or letters)
- ✓ A display device is an output device for presentation of information in visual or tactile form (the latter used for example in tactile electronic displays for blind people)
- ✓ When the input information is supplied as an electrical signal, the display is called an electronic display.
- ✓ Common applications for electronic visual displays are televisions or computer monitors.

SEGMENT DISPLAY

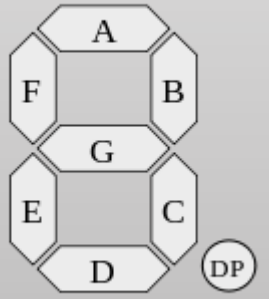
- ✓ Some displays can show only digits or alphanumeric characters.
- ✓ They are called segment displays, because they are composed of several segments that switch on and off to give appearance of desired glyph.
- ✓ The segments are usually single LEDs or liquid crystals.
- ✓ They are mostly used in digital watches and pocket calculators.
- ✓ There are several types:
  - ✓ Seven-segment display (most common, digits only)
  - ✓ Fourteen-segment display
  - ✓ Sixteen-segment display

SEVEN SEGMENT DISPLAY

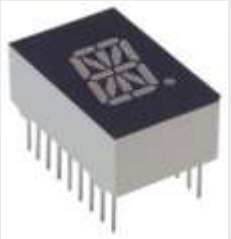


Hexadecimal encodings for displaying the digits 0 to F							
Digit	a	b	c	d	e	f	g
0	**on**	**on**	**on**	**on**	**on**	**on**	off
1	off	**on**	**on**	off	off	off	off
2	**on**	**on**	off	**on**	**on**	off	**on**
3	**on**	**on**	**on**	**on**	off	off	**on**
4	off	**on**	**on**	off	off	**on**	**on**
5	**on**	off	**on**	**on**	off	**on**	**on**
6	**on**	off	**on**	**on**	**on**	**on**	**on**
7	**on**	**on**	**on**	off	off	off	off
8	**on**	**on**	**on**	**on**	**on**	**on**	**on**
9	**on**	**on**	**on**	**on**	off	**on**	**on**
A	**on**	**on**	**on**	off	**on**	**on**	**on**
b	off	off	**on**	**on**	**on**	**on**	**on**
C	**on**	off	off	**on**	**on**	**on**	off
d	off	**on**	**on**	**on**	**on**	off	**on**
E	**on**	off	off	**on**	**on**	**on**	**on**
F	**on**	off	off	off	**on**	**on**	**on**

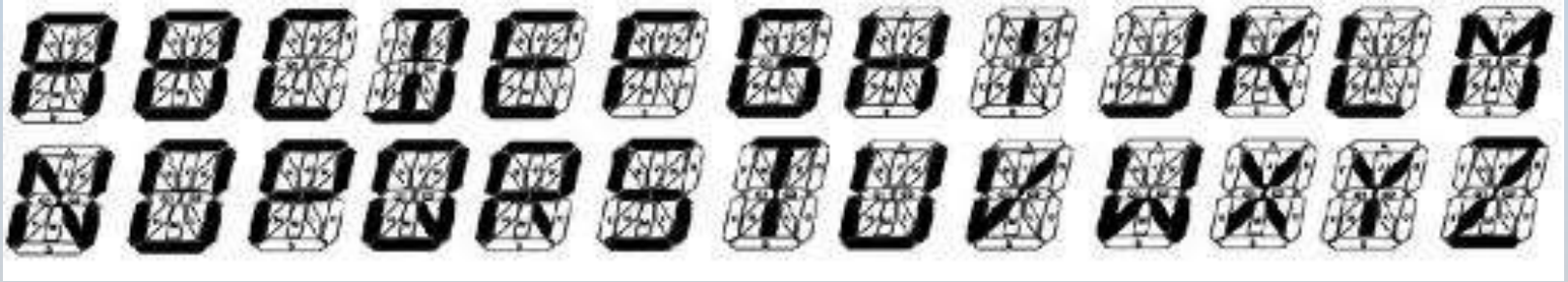
- ✓ Digital display generally used to display numbers but can display certain alphabets too.
- ✓ Common cathode and common anode type of seven segment display.
- ✓ Common cathode is active high display and Common anode is active low
- ✓ Widely used in digital clocks, electronic meters, and other electronic devices for displaying numerical information

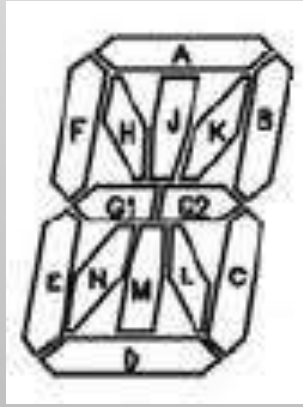


FOURTEEN SEGMENT DISPLAY



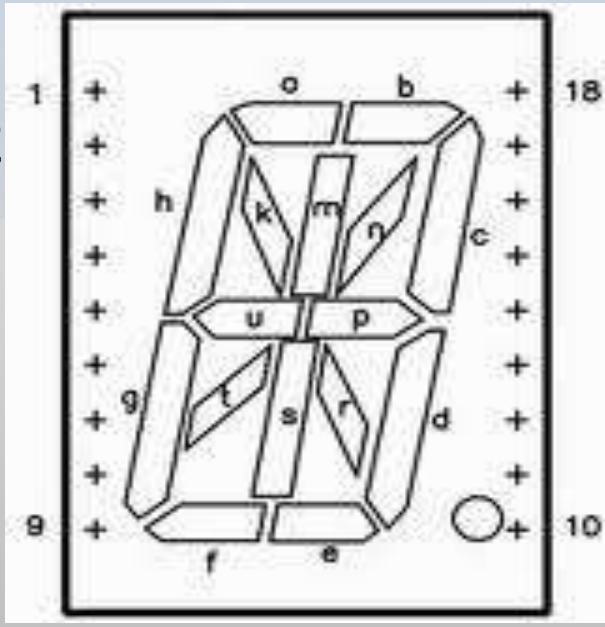
- ✓ Referred to as a starburst display or a "Union Jack" display
- ✓ Display based on 14 segments that can be turned on or off to produce letters and numerals
- ✓ Having an additional four diagonal and two vertical segments with the middle horizontal segment broken in half.



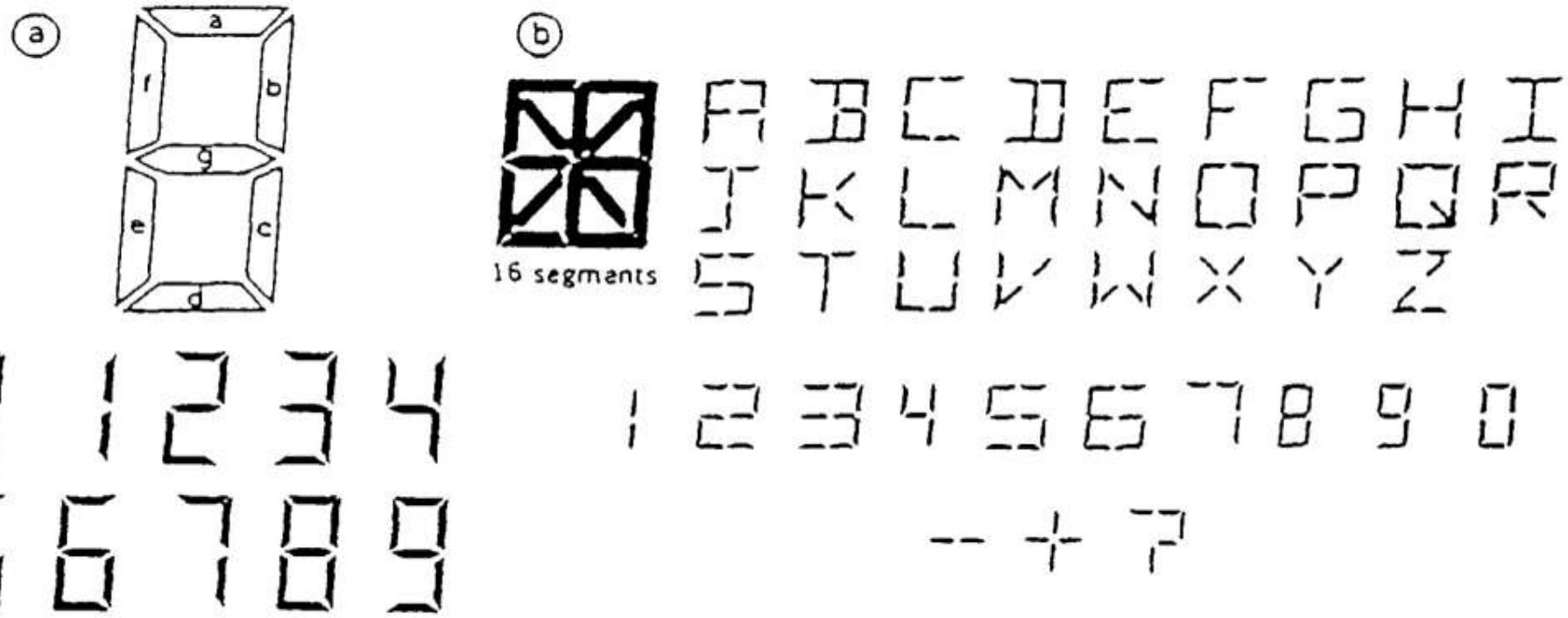


SIXTEEN SEGMENT DISPLAY

- ✓ Referred to as "Union Jack" display or a "British Flag" display
- ✓ Display based on 16 segments that can be turned on or off according to the graphic pattern to be produced
- ✓ Designed to display alphanumeric characters
- ✓ Adding four diagonals and two vertical segments and splitting the three horizontal segments in half
- ✓ A fourteen-segment display splits only the middle horizontal segment



SIXTEEN SEGMENT DISPLAY



DIGITAL VOLTMETER

- ✓ An electronic voltmeter that gives readings in digits
- ✓ are a special case of Analog to digital converter
- ✓ They measure voltage - and are general purpose instruments commonly used to measure voltages in labs and in the field.
- ✓ DVMs display the measured voltage using LCDs or LEDs to display the result in a floating point format.
- ✓ They are an instrument of choice for voltage measurements in all kinds of situations.
- ✓ Obviously, if voltage measurements are taken and the results are displayed digitally with LED or LCD displays, the instrument has to contain an A/D converter.

LCD DISPLAY

- ✓ A digital display that uses liquid crystal cells that change reflectivity in an applied electric field
- ✓ Flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals.
- ✓ Liquid crystals do not emit light directly.
- ✓ Have replaced cathode ray tube (CRT) displays in most applications
- ✓ More energy efficient and can be disposed of more safely than a CRT. Its low electrical power consumption enables it to be used in battery powered electronic equipment.
- ✓ It is an electronically modulated optical device made up of any number of segments filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in color or monochrome.
- ✓ Used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, signage, consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephones,

LED DISPLAY

- ✓ Diode such that light emitted at a p-n junction is proportional to the bias current; color depends on the material used
- ✓ Flat panel display, which uses light-emitting diodes as a video display.
- ✓ A LED panel is a small display, or a component of a larger display.
- ✓ They are typically used outdoors in store signs and billboards and sometimes used as form of lighting, for the purpose of general illumination, task lighting, or even stage lighting rather than display.

PLASMA DISPLAY

- ✓ A type of flat panel display common to large TV displays 30 inches (76 cm) or larger.
- ✓ Are called "plasma" displays because the technology utilizes small cells containing electrically charged ionized gases, or what are in essence chambers more commonly known as fluorescent lamps.

Advantages

✓Picture quality

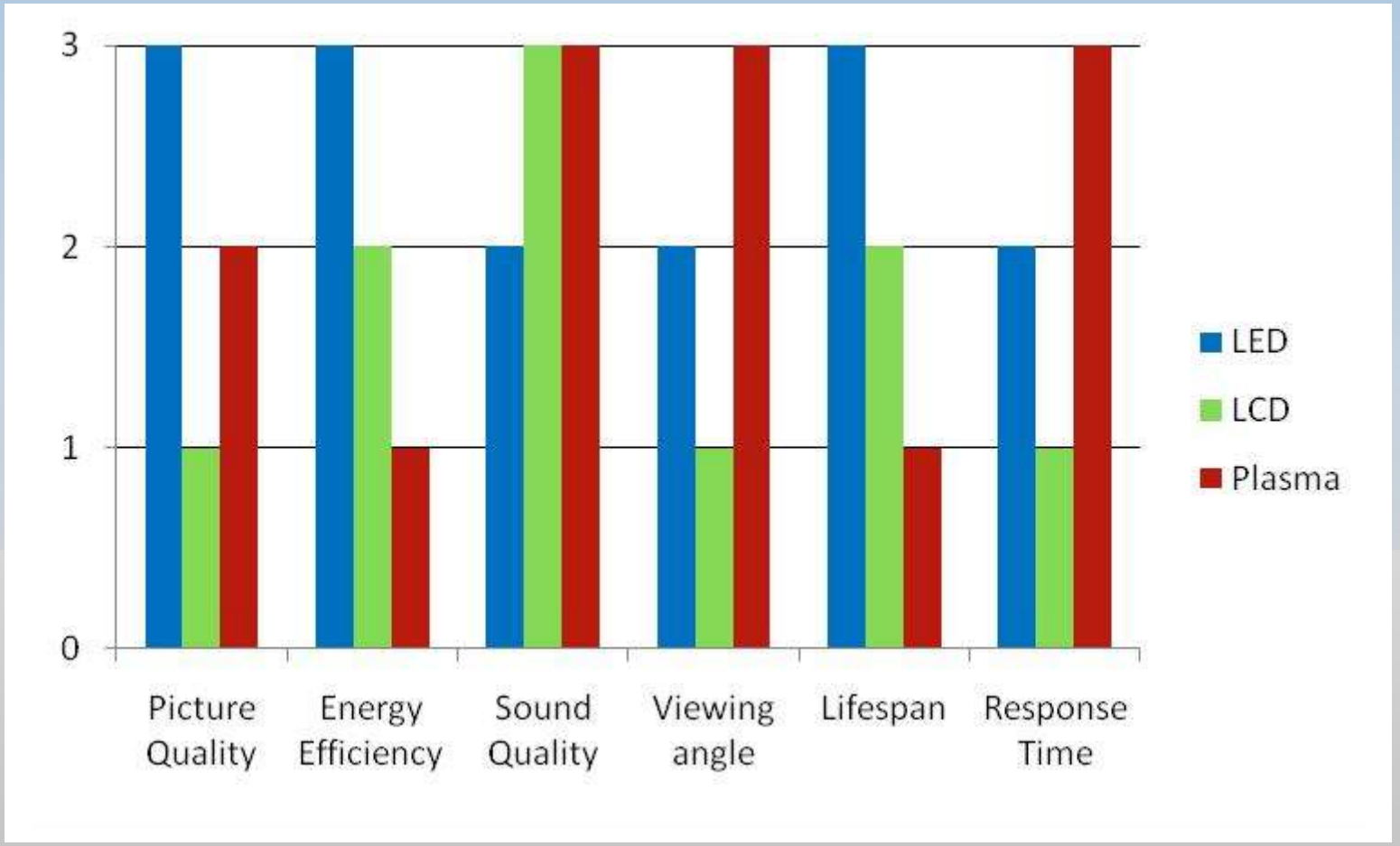
- ✓ Capable of producing deeper blacks allowing for superior contrast ratio
- ✓ Wider viewing angles than those of LCD; images do not suffer from degradation at high angles like LCDs
- ✓ Less visible motion blur, thanks in large part to very high refresh rates and a faster response time, contributing to superior performance when displaying content with significant amounts of rapid motion

PLASMA DISPLAY

Disadvantages

- ✓ Picture quality
  - ✓ Recent models have a pixel orbiter that moves the entire picture slower than is noticeable to the human eye, which reduces the effect of burn-in but does not prevent it
  - ✓ Due to the bistable nature of the colour and intensity generating method, some people will notice that plasma displays have a shimmering or flickering effect with a number of hues, intensities and dither patterns.
  - ✓ Screen burn in is a problem associated with Plasma displays. When an image is left on the screen for a long time, the display produces a "ghost" of the image
  - ✓ Use more electrical power, on average, than an LCD TV
  - ✓ Does not work as well at high altitudes above 2 km due to pressure differential between

DIFFERENCES



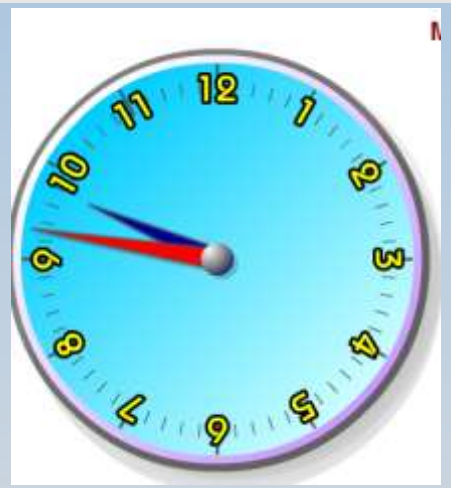
DIFFERENCES

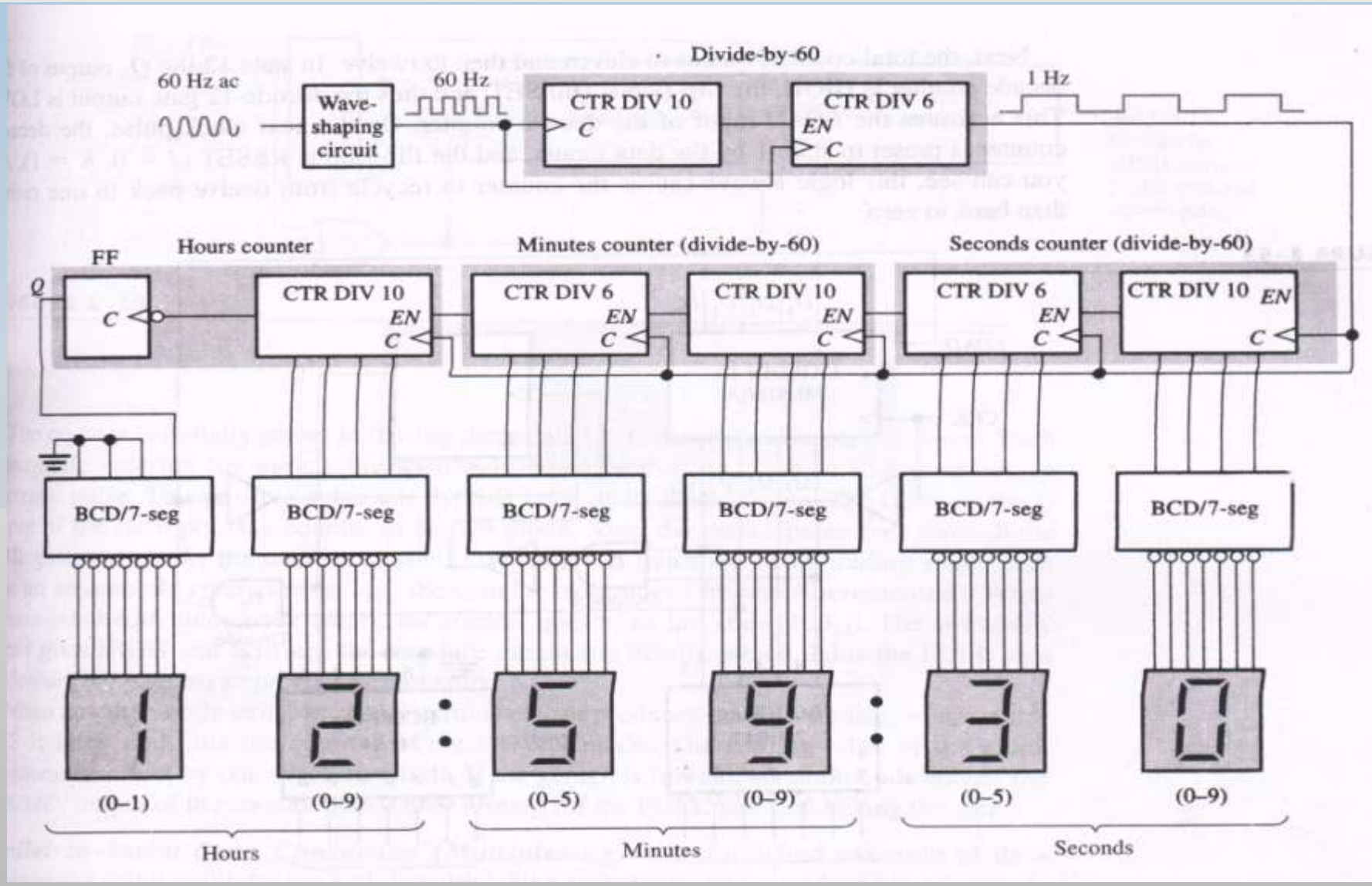
	LCD DISPLAY	LED DISPLAY	PLASMA DISPLAY
WORKING	✓LCDs require a separate light source because they do not illuminate themselves ✓Cold cathode fluorescent lamps(CCFL) are used in LCD monitors for backlighting ✓Work by filtering light when it gets an electric charge	✓Use light emitting diodes, for backlighting ✓LED screens emit their own light while displaying an image	✓Gases like xenon and neon are excited by electric pulses produced by the electrodes. ✓Plasma monitors display images using phosphors. Phosphors don't require backlighting – they light the image and display color at the same time.
SIZE AND COST	✓Least cost compared to other two	✓Edge-LED monitors are thinner than standard LCD; ✓Costly as compared to LCD	✓Higher size and hence costly
POWER CONSUMPTION	High	Save up to 30%-40% power than a LCD monitor of same size	30% more higher than LCD
PLAYING FAST MOVING VIDEOS (RESPONSE TIME)	Contrast levels are good but not as led and plasma, so poor	Between LCD and Plasma	Contrast levels are way higher than any other displays, so good

DIFFERENCES

	LCD DISPLAY	LED DISPLAY	PLASMA DISPLAY
SCREEN BURN IN/ GHOSTING	NO	LED monitors are softer on the eyes compared to LCD monitors which makes them the right choice for people who work for long hours on their computers	Yes but temporary
PICTURE QUALITY	✓Have to maintain a viewing angle of 30^{o} to see the picture properly but has good contrast and brightness making it suitable for any situation, so advantageous than plasma for long hours	✓Improved brightness and contrast levels than lcd, ✓Provides a better overall picture clarity, resolution and finer colors than lcd, ✓Get the same picture quality even when viewed from different angles; ✓LED monitors offer more intense lighting than cold cathode fluorescent lamps.	✓Viewing angle is greater than other two but not so apt for computer working for long hours
USAGE AT HIGHER HEIGHTS	Not affected by heights	Not affected by heights	Max is 6000 ft, so cannot be used at higher heights
LIFE SPAN	Lives for as long as the backlight lives, repairable	Lives longer than both	No chance of replacing any of the materials

DIGITAL CLOCK






Any Query?