Digital Techniques (22320)

Unit V : Data Converts and PLDs
(Weightage - 14 marks)

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Questions

* State two features of ADC IC0809. (2m)
* Specification of IC-DAC 0808. (2m)
* Draw block diagram of Dual slope ADC and explain its working. (6m)
* List types of DAC. (2m)
* Describe working principle of successive approximation ADC (4m)
* Define Resolution & conversion time associated with ADC (2m) (option)

Compare

* Compare between R-2R ladder DAC and weighted resistor DAC. (4m)
* Compare following. i) RAM & ROM memory ii) EPROM & EEPROM (6m)
* Compare following i) Volatile-Non volatile memory. ii) SRAM & DRAM. (4m)
* Compare PLA & PAL. (4m)

Numericals

Q/ Calculate that analog output of 4 bit DAC if the digital input is 1101. Assume $V_{FS} = 5V$. (4m)

Q/ ~~Calc~~ Calculate analog o/p of 4bit DAC for digital input is 1100. Assume $V_{FS} = 5V$.

Q/ Calculate the analog output for 4bit weighted register type DAC for input -
i) 1011 ii) 1001 $V_{FS} = 5V$ ... (6m)

Fixed Question

* Draw block Diagram of Programmable Logic Array or Programmable Array Logic (4m)

Data Converter

A combinational Digital Circuit which converts the one form of data into other or vice versa is called Data converter..

Data converter.

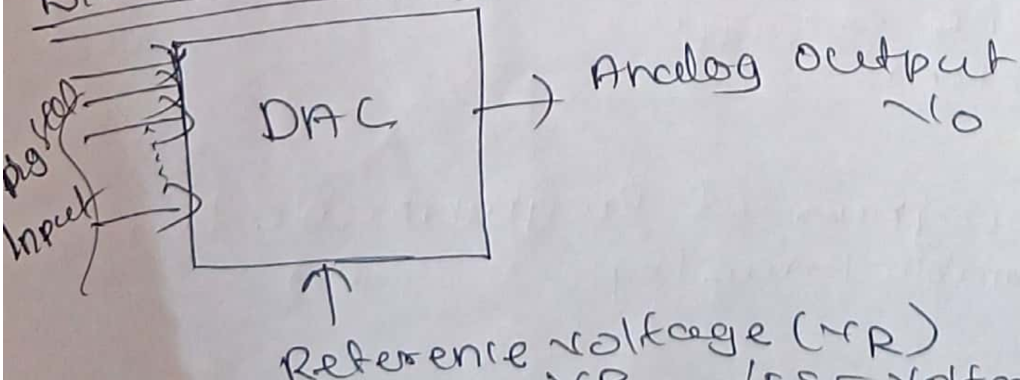
- Digital to Analog Converter (DAC)
  - Binary weighted register. DAC
  - R-2R ladder DAC.
- Analog to Digital converter (ADC)
  - Single slope
  - Dual slope
  - Successive approximation ADC
  - Counter type ADC
  - Flash type ADC.
  - Staircase ramp ADC

Digital to Analog Converter (DAC)

Q// List two types of DAC. (2m)

- Binary weighted Register DAC
- R-2R ladder DAC.

Block Diagram

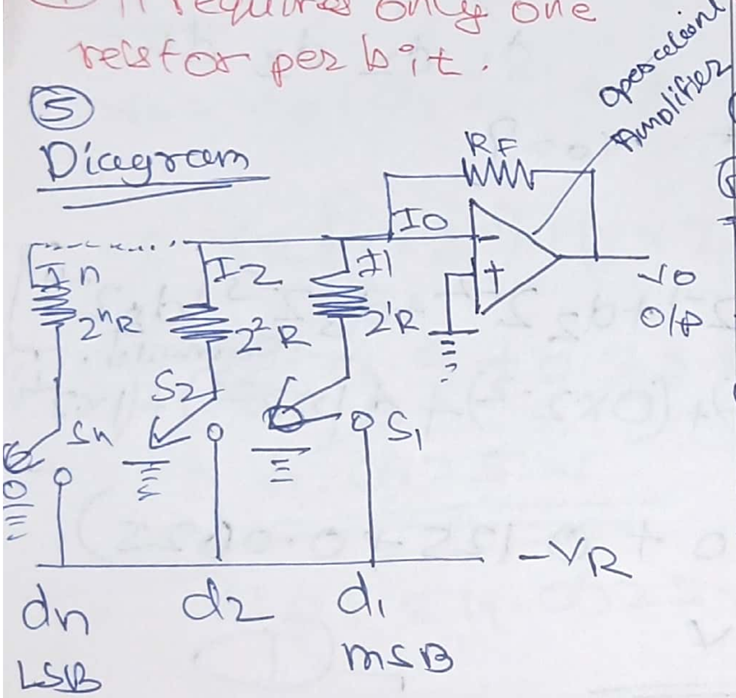


VR. VFS = Voltage Full Scale.

...ry weighted Register

1. ...is simple in construction.
2. It requires more than two resistor values.
3. It is not easy to extend for more number of bits.
4. It requires only one resistor per bit.

⑤ Diagram



Digital Inputs.

⑦ Easy to implement.

⑧ Cheaper

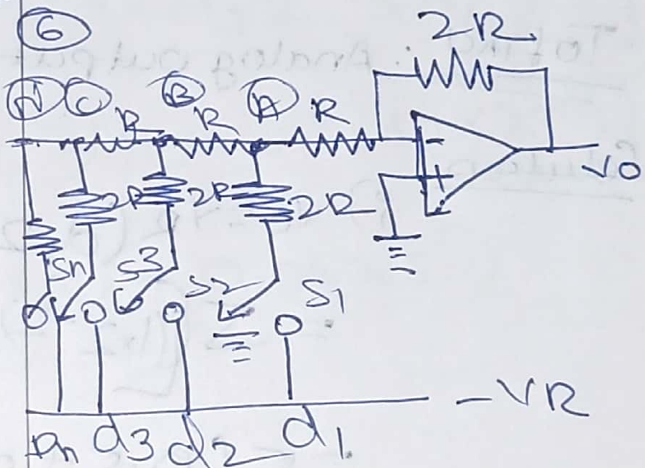
⑨ Vo =

$$V_R\left[d_1 2^{-1}+d_2 2^{-2}+\ldots d_n 2^{-n}\right]$$

Binary (R-2R) ladder Type

1. It is slightly complicated in construction.
2. It requires of only two values of resistors.
3. It can be easily expanded to handle more number of bits by adding the resistor.
4. It requires two resistor per bit.

⑥



To overcome accurate value 2-2R carried into exstoner Binary weighted Register.

⑦ Bit harded to implement.

⑧ Costly.

⑨ Vo =

$$-\left(\frac{RF}{R}\right)V_i=-\left(\frac{2R}{R}\right)\times\left(\frac{-V_R}{4}\right)$$

$$V_o=-V_R\frac{RF}{R}\left(\frac{B_1}{2^1}+\frac{B_2}{2^2}\cdots\frac{B_n}{2^n}\right)$$

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Numericals

Q1 Calculate the analog output for 4 bit weighted register type DAC for inputs. $V_{FS} = 5V$.
i) 1011
ii) 1001.

→ Given : 4 bit DAC.

$\boxed{V_{FS} = 5V = V_R}$

i) 1 0 1 1 — d_1 d_2 d_3 d_4

ii) 1 0 0 1 — d_1 d_2 d_3 d_4

To find : Analog output $V_0 = ?$

Solution

i) $V_0 = V_R(d_1 2^{-1} + d_2 2^{-2} + d_3 2^{-3} + d_4 2^{-4}]$ --- Formula.

$= 5\{(1\times2^{-1}) + (0\times2^{-2}) + (1\times2^{-3}) + (1\times2^{-4})$

$= 5(0.5 + 0 + 0.125 + 0.0625)$

$= 3.4375V$ — (1)

ii) $V_0 = V_R(d_1 2^{-1} + d_2 2^{-2} + d_3 2^{-3} + d_4 2^{-4}]$ --- Formula.

$= 5(1\times2^{-1} + 0\times2^{-2} + 0\times2^{-3} + 1\times2^{-4})$

$= 5(0.5 + 0 + 0 + 0.0625)$

$= 2.8125V$ — (2)

From (1) & (2)

∴ 1011 = 3.4375V
∴ 1001 = 2.8125V

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Calculate Analog output of 4 bit DAC. if the digital input is 1101. Assume $V_{FS} = 5V$ (4m)

⇒ Given

4 bit DAC.

$\boxed{V_{FS} = V_R = 1101}$

Input: 1101.

$\begin{matrix} 1 & 1 & 0 & 1 \\ d_1 & d_2 & d_3 & d_4 \end{matrix}$

To find: V_o Analog output.

Soln

$V_o = V_R(d_1 2^{-1} + d_2 2^{-2} + d_3 2^{-3} + d_4 2^{-4}]$

$= V_R[(1 \times 2^{-1}) + (1 \times 2^{-2}) + (0 \times 2^{-3}) + (1 \times 2^{-4})]$

$= 5(0.5 + 0.25 + 0 + 0.0625)$

$= 4.0625V$

$\boxed{\therefore 1101 = 4.0625V}$

Q// Calculate analog output of 4 bit DAC for Digital input is 1100. Assume $V_{FS} = 5V$. (4m)

⇒ Given

4 bit DAC.

Input = 1100

$\begin{matrix} 1 & 1 & 0 & 1 \\ D_1 & D_2 & D_3 & D_4 \end{matrix}$

$\boxed{V_{FS} = 5V = V_R}$

To find

Analog output = ?

$V_o = ?$

Solution

$$V_o = V_R(d_1 \times 2^{-1} + d_2 \times 2^{-2} \times d_3 \times 2^{-3} \times d_4 \times$$

$$= 5((1 \times 2^{-1}) + (1 \times 2^{-2}) \times (0 \times 2^{-3}) \times (0 \times 2$$

$$= 5(0.5 + 0.25)$$

$$= 5(0.75)$$

$$V_o = 3.75\,V$$

$$\boxed{\therefore 1100 = 3.75\,V}$$

State two features of ADC IC 0809. (2M)
0808

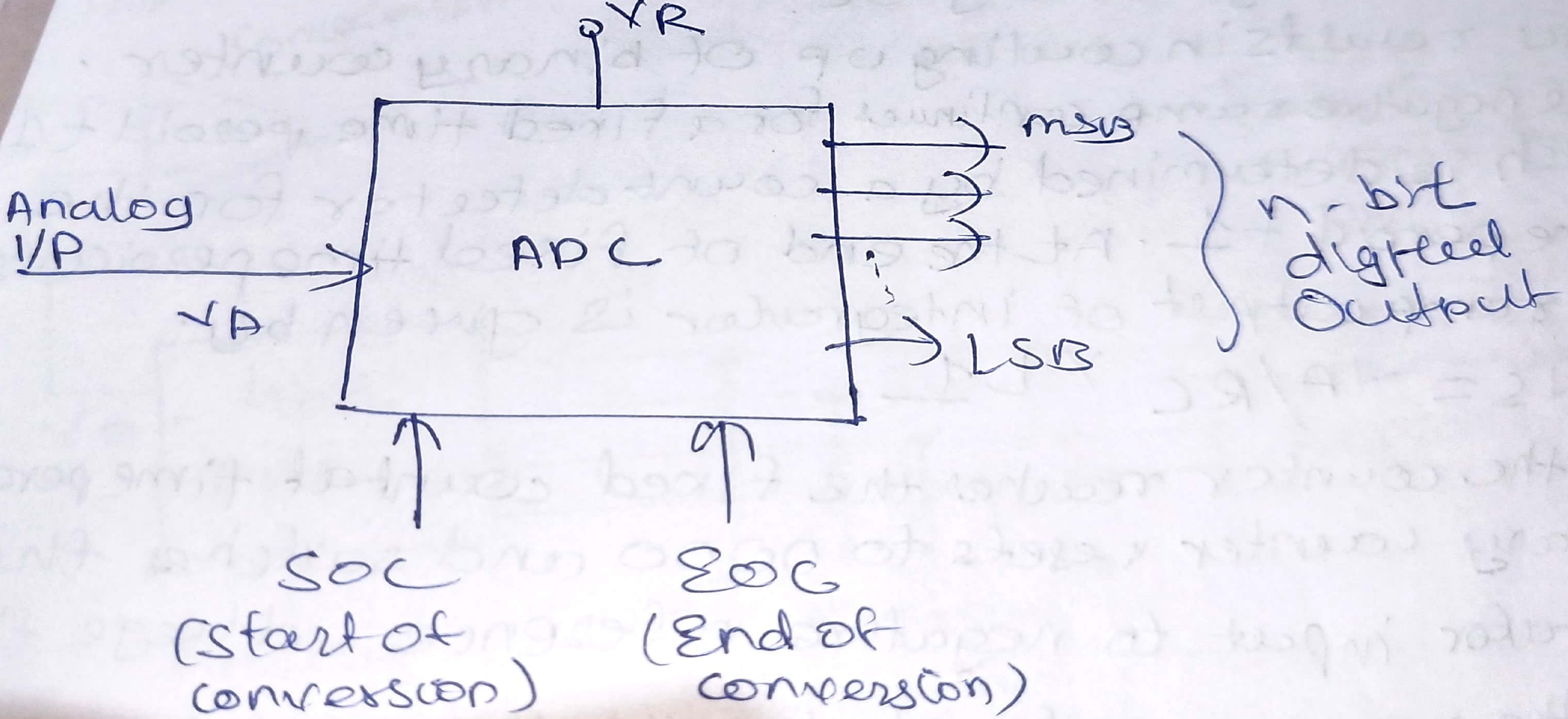
⇒ * Easy interface to all microprocessors.
* No zero or full-scale adjust required.
* 8-channel multiplexer with address logic.
* 0V to 5V input range with single 5V power suppl
* Output meet TTL voltage level specification.
* 0V to Vcc Input Range
* 28-pin molded chip carrier package.

Specification of IC-DAC 0808 (2M).

⇒ * The setting time is very fast 150 ns.
* Higher power dissipation will be 1000 mW.
* Resolution, Accuracy.
* Linearity - Linearity is conventionally equal to deviation of performance of converter from a best straight line.
* Format of Digital output - An A/D converter can be made for any standard digital code.
* Analog input voltage: This is maximum allowable input voltage range.

log to Digital

ck Diagram



Types of ADC

1) Successive Approximation type ADC
2) Dual slope ADC.

1) Dual slope ADC

- In this, the integrator generates two different ramps, one with the known analog input voltage VA and another with a known reference voltage -Vref. Hence it is called as dual slope ADC.

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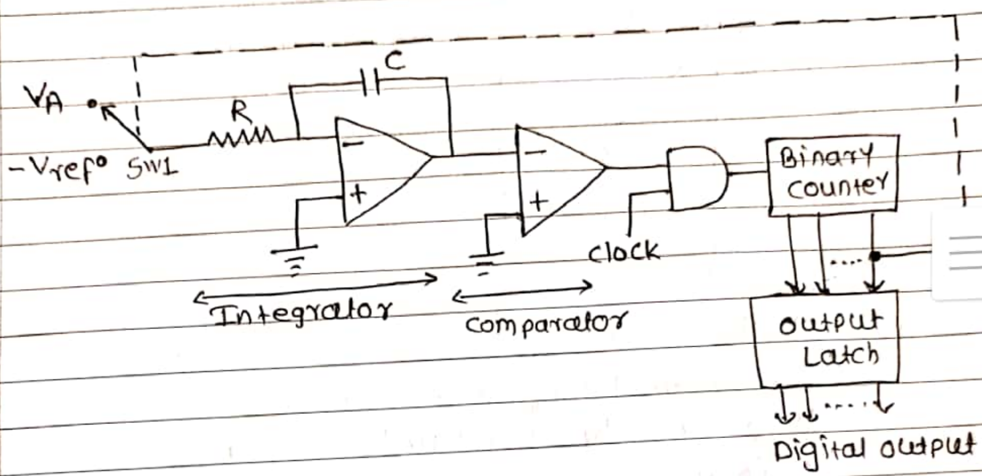


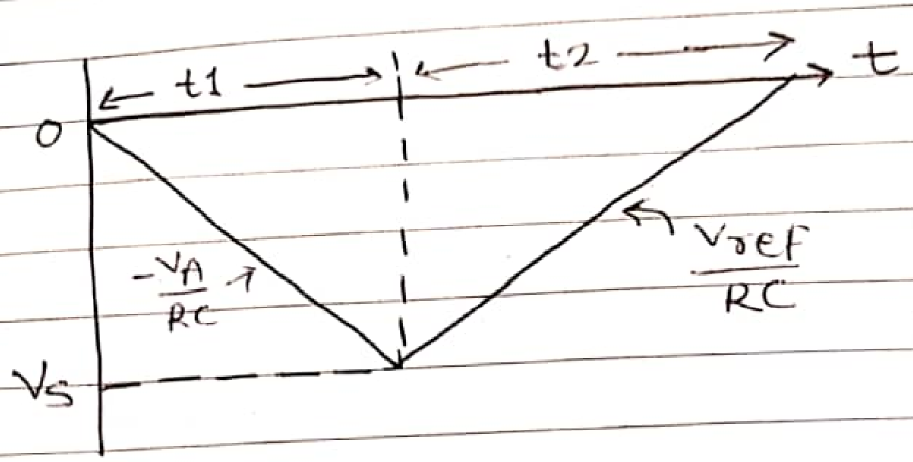
Operation

- First the analog input voltage VA is connected to an integrator.
- The analog input voltage VA is integrated by inverting integrator and generates a negative ramp output.
- The negative ramp continues for a fixed time period t1.

$$V_S = -\frac{V_A}{RC} \times t_1$$

- When the counter reaches the fixed count at time period t1, the binary counter resets to 0000 and switches the integrator input to a negative reference voltage -Vref

$$V_S = \frac{V_{ref}}{RC} \times t_2$$



Since ramp generator voltage starts at 0V, decreasing down to -Vs and then increasing up to 0V, the amplitude of negative and positive ramp voltages can be equated as

$$\frac{V_{ref}}{RC} \times t_2 = \frac{-V_A}{RC} \times t_1$$

$$t_2 = -t_1 \frac{V_A}{V_{ref}}$$

$$\boxed{V_A = -V_{ref} \times \frac{t_2}{t_1}}$$

Thus the unknown analog input voltage VA is proportional to the time period t2.

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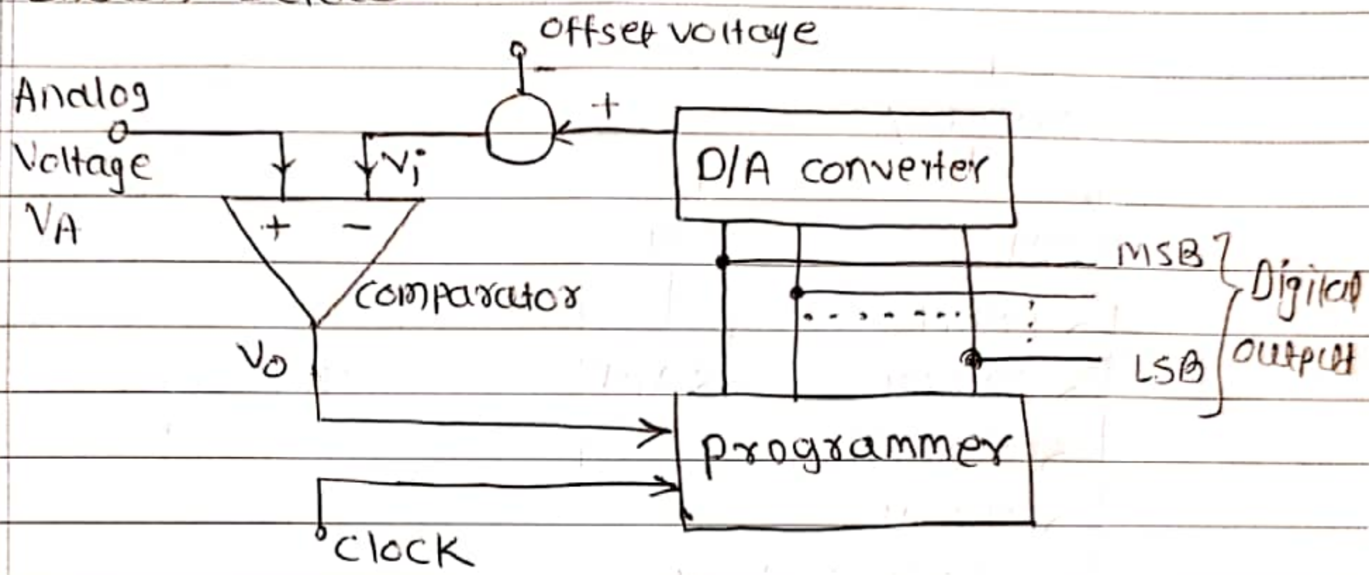
* Draw the circuit of successive approximation type ADC and explain its working.

→ - The successive approximation A/D converter is shown below:



- An analog voltage (V_A) is constantly compared with voltage V_i, using a comparator.
- The output produced by comparator (V_o) is applied to an electronic programmer.
- If $V_a = V_i$ then $V_o = 0$ & then no conversion is required. The programmer displays the value of V_i in the form of digital O/P.
- But if $V_a > V_i$, then value of V_i is increased by 50% of earlier value.
- If $V_a < V_i$, then V_i is decreased by 50% of earlier value.
- This new value is converted into analog form by D/A converter so as to compare it with V_A again. This procedure is repeated till we get $V_a = V_i$.

* List various specifications of DAC.

→

1) Resolution:

The smallest possible change in the analog output that is affected by a unit change (i.e. one bit) in digital input is known as the resolution of DAC.

$$\% \text{ Resolution} = \frac{V_{FS}}{2^n - 1} \times 100$$, where

V_{FS} → Full scale voltage

2) Linearity:

The linearity of DAC is a measure of the precision with which the linear input output relationship is satisfied.

3) Accuracy:

The accuracy of DAC is defined as the closeness of the output analog voltage to the expected

4) Settling time:

It is defined as the amount of time necessary to settle to an analog output value of desired accuracy i.e within $\frac{1}{2}$ LSB of the final value after the digital input has changed.

5) Temperature stability:

The analog output of DAC should not change due to change in temperature.

6) Speed: It is defined as the time needed to perform a conversion from digital to analog.

Memories

* The subsystem of digital processing system which provides the storage facility is reffered to as memory.
* Till recently, the memories used were mostly of magnetic type.
* But nowdays semiconductor have become popular due to their small size, low cost, high speed, high reliability and ease of expansion of memory size.

Classification

- Memories
  - Sequential memories
    - Shift Registers
    - Charge coupled Devices
  - Read and write memories (RAM)
    - SRAM
    - DRAM
  - Read only memory
    - ROM
    - PROM
    - EPROM
    - EEPROM / E2PROM
  - Content Addressable memory (CAM)

Compare RAM/ROM

RAM	ROM
① RAM stands for Random Access memory.	① ROM stands for Read Only memory
② Both Read and write operations can be performed.	② Only Read operation can be performed
③ These are volatile memory	③ these are non-volatile memory.
④ Types: SRAM (Static RAM), DRAM (Dynamic RAM)	④ Types: PROM, EPROM, E2/EEPROM
⑤ Applications: Computer, calculator	⑤ Application: Computer, microprocessor
⑥ Temporary Storage	⑥ Permanent storage
⑦ writing data faster and stores in MB's	⑦ writing data slower and stores in GB's

~~compare SRAM/DRAM~~

Compare SRAM/DRAM

SRAM	DRAM
SRAM stands for Static Random Access memory.	DRAM stands for Dynamic Random Access Memory
Each static RAM cell is flipflop.	Each dynamic RAM cell consist of MOSFET and a capacitor
More number of componants per cell.	Only two componentsper cell.
Less number of memory cell /unit area	More number of memory cell per area
Does not require refreshing	Require refreshing.
Faster memories	Slower memories.
Power consumption is less	Power consumption is more
Faster in speed.	Slower in speed.
Less storage capacity	More storage capacity.
Bits stored in form of voltage	Bits stored in form of charges
Cheaper	Expensive.

Compare Volatile & Non-volatile memory

Volatile Memory	Non-volatile Memory
The memory required electrical power supply to keep information stored is called volatile memory.	Memory that will storing info. without need of electrical power is called non-volatile memory
All RAMs are volatile memories	All ROMs, ~~are~~ EPROMs are nonvolatile memories.
Information stored is lost when power is switched off.	Information stored is retained even after power is OFF.
Used for temporary storage of information.	Used for permanent storage of information.
Stored information is retained as long as power is on.	No effect of power, on stored information.

...e EPROM and EEPROM / E^2PROM

EEPROM	EPROM
EEPROM stands for Electrically Erasable Programmable Read only memory.	EPROM stands for Erasable Programmable Read only memory
Can be erased by using electrical signal.	Ultraviolet light is used to erase the content of EPROM
Can be erased in small time 10ms.	Requires 20-30min for erasing.
Low density	High density.
Expensive than EPROM.	Cheaper than EEPROM.
Not required to remove the chip from the circuit for erasing and reprogramming.	Chip has to be removed from the circuit for erasing & reprogramming.
It morden version of EEPROM.	It is mordern version of PROM.

(Optional)
Compare EPROM & Flash

EPROM	Flash
Can be erased only byte by byte by giving electric pulses.	Can be erased block by block by giving electric pulses.
Byte programmable	Block programmable
Cost is more	Cost is less
Programming is faster	Programming is slower.

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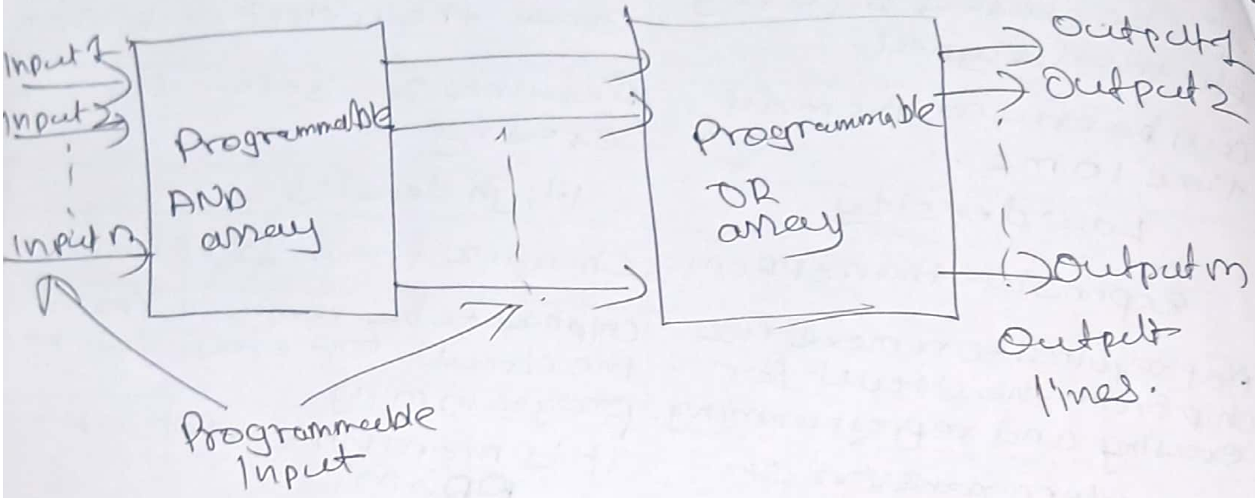
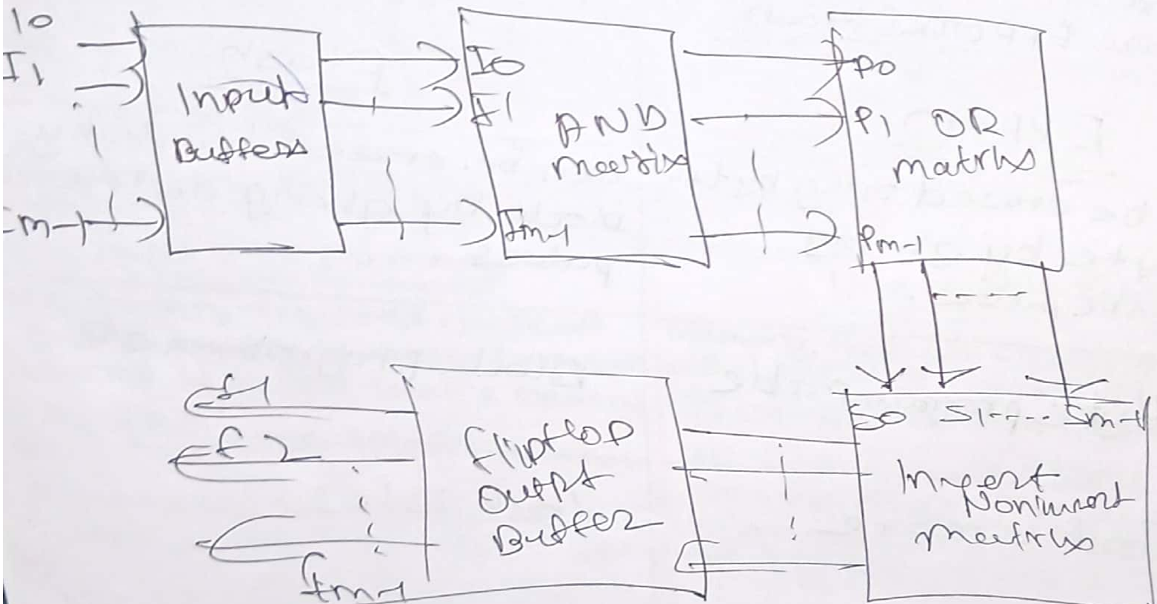
Programmable logic Devices (PLDs) — PAL, PLA, GAL

An programmable logic devices is an electronic component used in to build reconfigurable of digital circuits.

Imp Block Diagram of Programmable logic Array. (PLA)

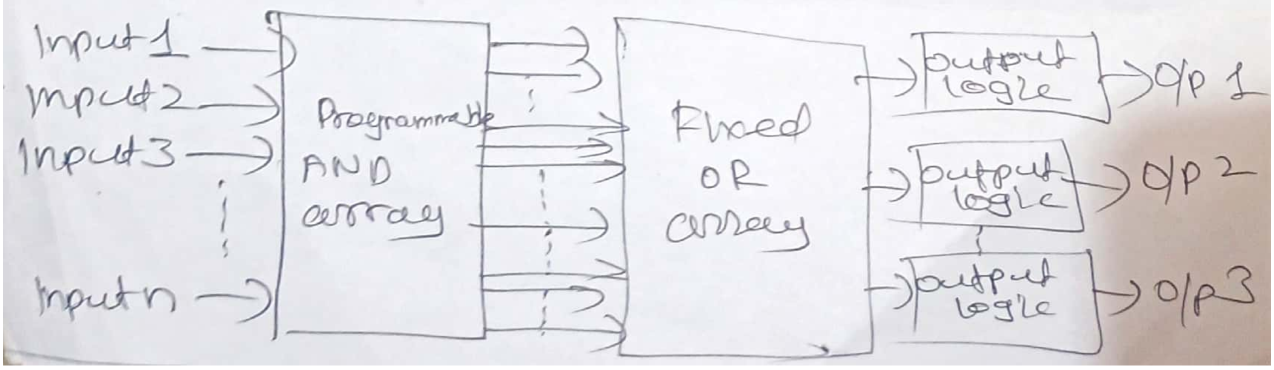


OR



Block Diagram of PAL

Programmable Array logic



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PLA	PAL
Programmable logic Array	Programmable Array logic
Both AND & OR array are programmable.	OR array is fixed and AND array is programmable
It is costly	It is cheaper
It is complex.	It is simple
Large no. of function can be implemented.	Provides the limited no. of functions.
Provides more programming flexibility.	Offers less flexibility, but more likely to used.
It can implement SOP with any no. of terms.	It can implement SOP with limited no. of terms.

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