Data acquisition system

(Information) (Collection)

analog / digital

A data acquisition system (DAS) is a set of hardware and software components used to collect and process data from various sources. The system typically includes sensors, analog-to-digital converters (ADCs), digital signal processors (DSPs), and computer systems that work together to measure and record data in real-time.

Types of Data Acquisition Systems

Data acquisition systems can be classified into the following two types:

- **Analog Data Acquisition Systems:** The data acquisition systems, which can be operated with analog signals are known as analog data acquisition systems.
- **Digital Data Acquisition Systems:** The data acquisition systems, which can be operated with digital signals are known as digital data acquisition systems.

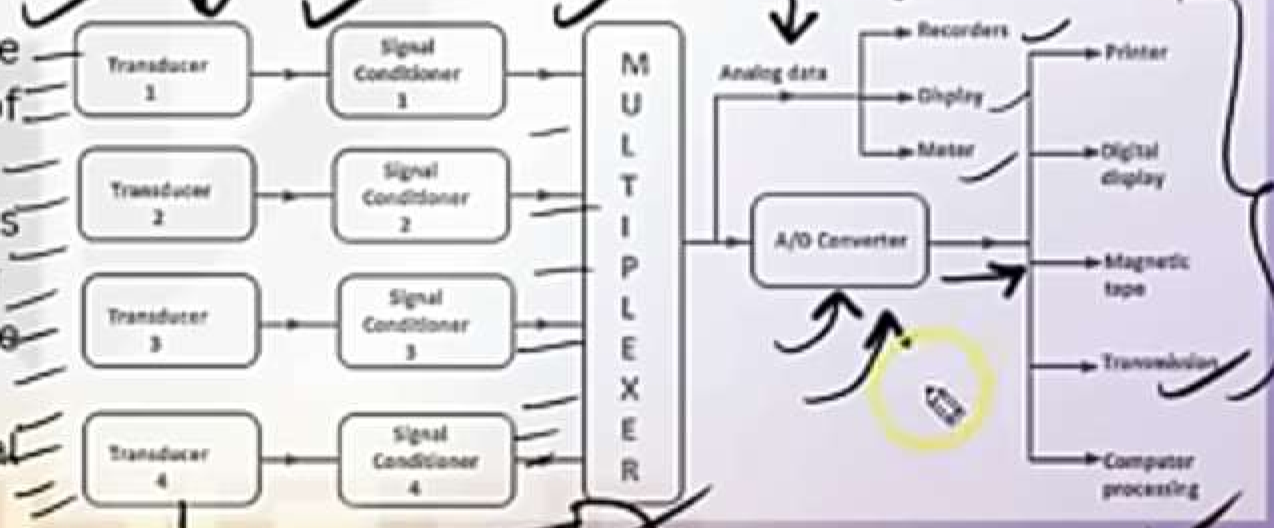
Data Acquisition Systems

Block Diagram of data acquisition system :

T, P -

amplify (weak, noise)

- **Transducer** - It converts physical quantities into electrical signals.
- **Signal conditioner** - It performs the functions like amplification and selection of desired portion of the signal.
- **Multiplexer** - connects one of the multiple inputs to output. So, it acts as parallel to serial converter
- **Analog to Digital Converter** - It converts the analog input into its equivalent digital output.
- **Display device** - It displays the data in digital format.
- **Digital Recorder** - It is used to record the data in digital format.
- **Magnetic tape instrumentation** - It is used for acquiring, storing & reproducing of input data.



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Types of Analog-to-digital converters (ADCs)

ADC, DAC — Imp.

1. Counter Type ADCs or Ramp type or staircase approximation ADC

The N-bit counter produces an n-bit digital o/p which is given as an i/p to the digital to analog circuit (DAC). The analog output equivalent to the digital i/p from DAC is contrasted with the i/p analog voltage with the help of an op-amp comparator.

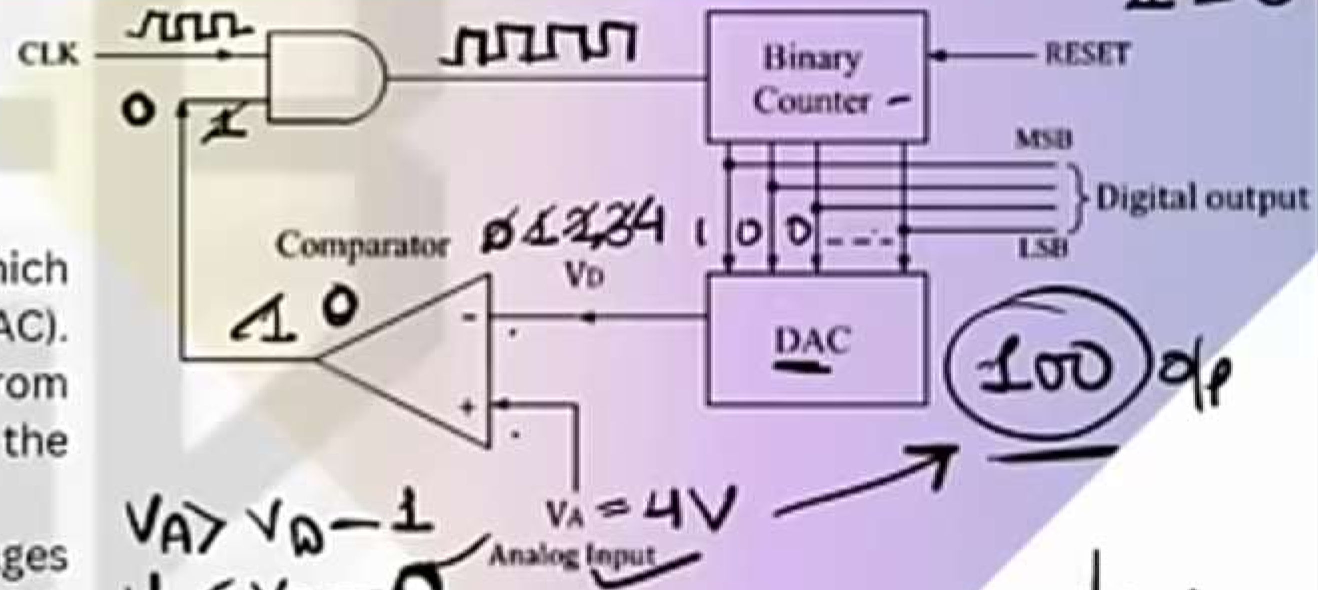
This Integrated Circuit evaluates the two voltages and if the produced DAC voltage is low, it gives a high pulse to the N-bit counter as a CLK pulse to raise the counter.

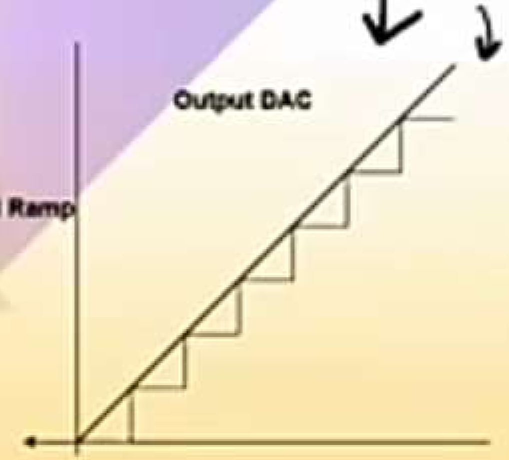
$V = 4V \rightarrow 100$ o/p

$V_A > V_D - 1$

$V_A < V_D - 0$

* $[(2^n - 1)$ clock pulses$]$





The moment Vin < VDAC, the comparator output is low, and AND gate is disabled, therefore blocking the clock pulses.

The last output of the counter is latched and this is the digital binary output of the given input voltage.

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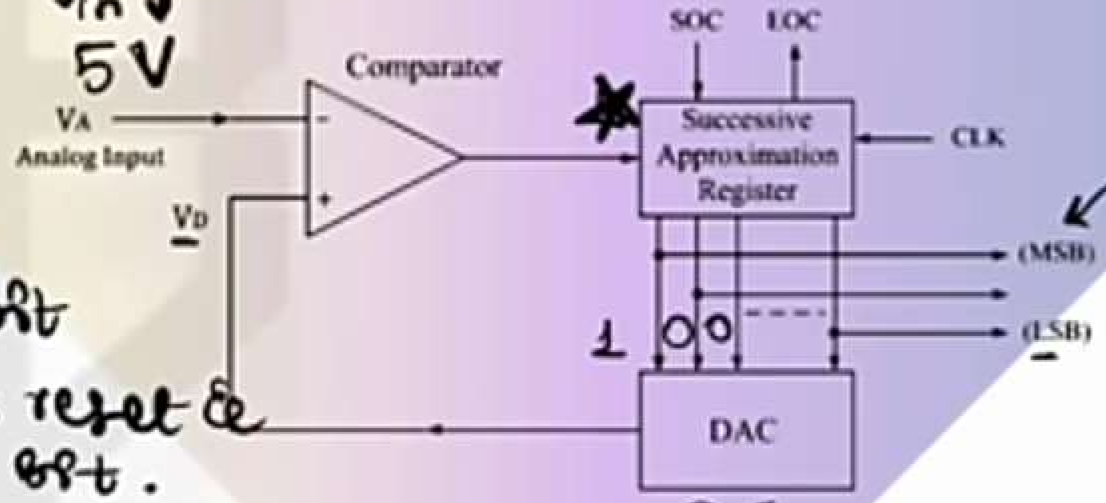
(fast) [cost, density (2^n-1)] MSB

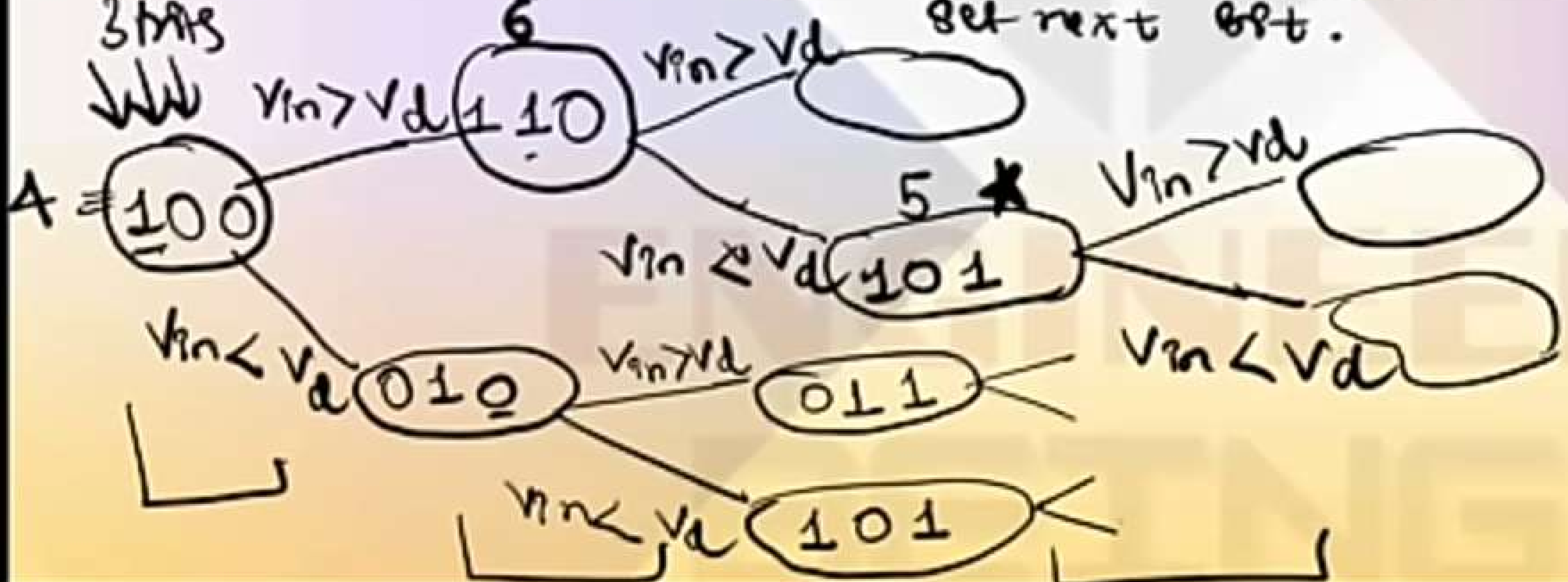
Sucessive Approximation Type ADC

1. If Vin is greater than the output of the DAC, the next bit will be set for a new comparison.
2. Otherwise, if the input voltage is less than the DAC value, set bit is reset , and the next bit will be set for a new comparison.

$V_{in} > V_d$ — set next Bit

$V_{in} < V_d$ — set bit is reset & set next bit.





$$\boxed{T_C = N\, T_{clk}}$$

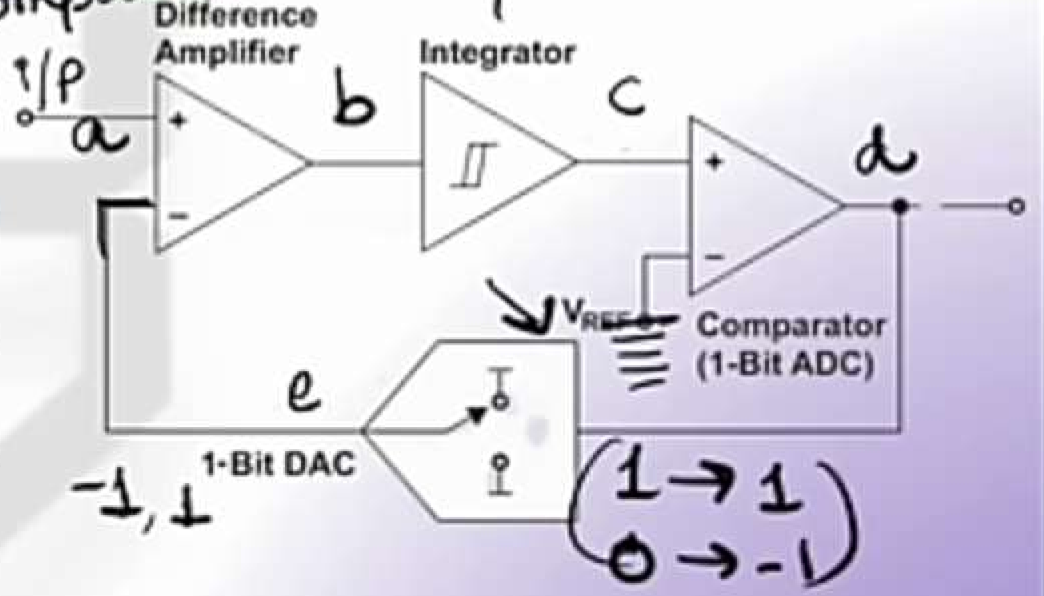
N → Bits

Sigma Delta ADC

3 integrator Σ δ, Δ comparator.

x — prev + present

- The input voltage VIN is first summed with the output of a feedback DAC.
- An integrator then adds the output of this summing node to a value it has stored from the previous integration step.
- A comparator outputs a logic 1 if the integrator output is greater than or equal to zero volts and a logic 0 otherwise.
- A 1-bit DAC feeds the output of the comparator back to the summing node.



a

$\downarrow$

$\boxed{a - e = b}$

$\downarrow$

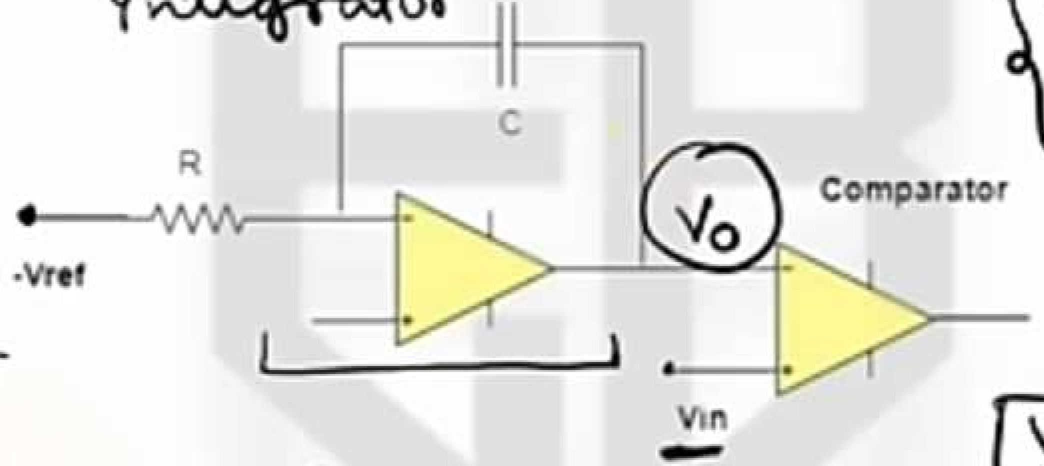
$\boxed{b + x = c}$

$c > 0 \longrightarrow d = 1 \longrightarrow 1$

$c < 0 \longrightarrow d = 0 \longrightarrow -1$

Single Slope ADC

Integrator



$$V_0 = -\frac{1}{RC}\int V\,dt$$

$$V_0 = \frac{-1}{RC}\int -V_{ref}\,dt$$

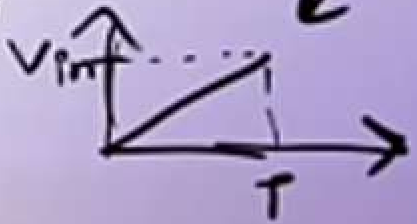
$$V_0 = \frac{V_{ref}T}{RC} = V_{in}$$

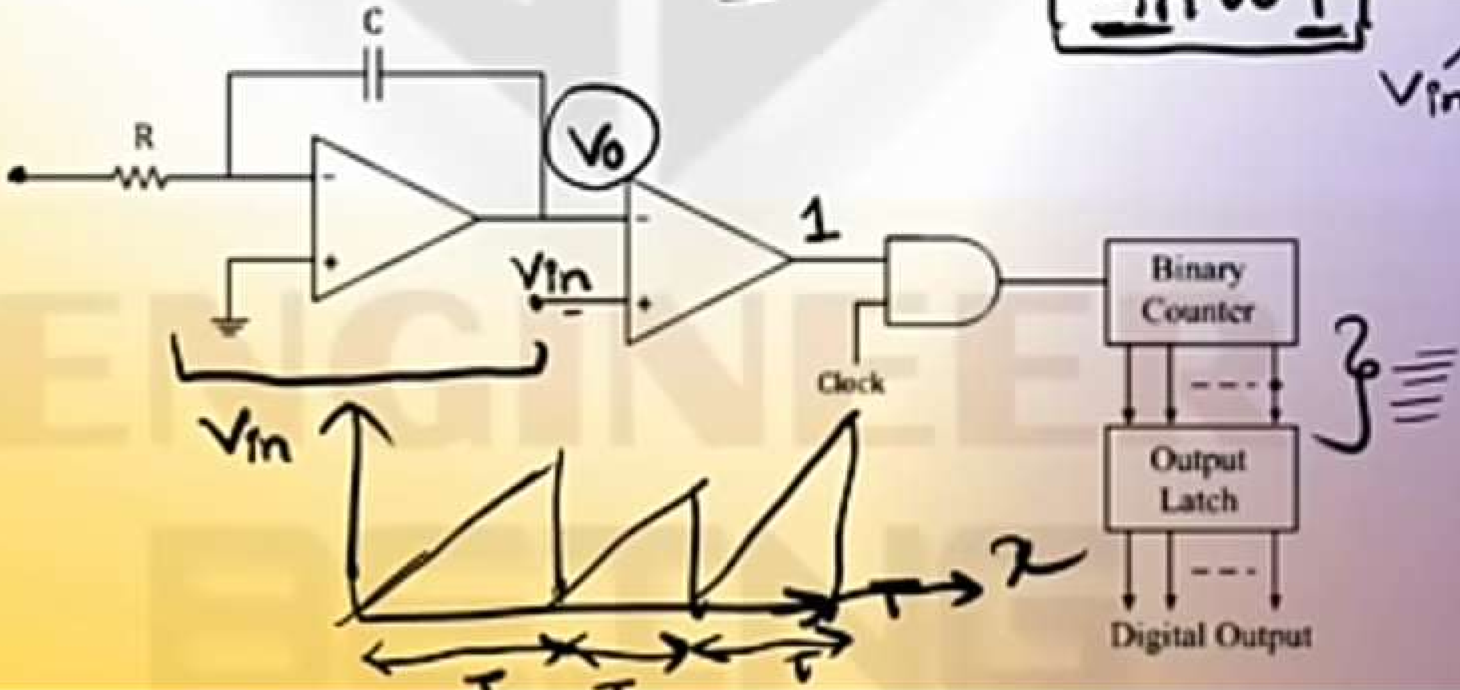
V_{ref} — Integrate → T

$V_0 = V_{in}$

$$\boxed{V_{in} = \frac{V_{ref}T}{RC}} \quad y = mx$$

$$\boxed{V_{in} \propto T}$$





$V_{ref} < V_{in}$

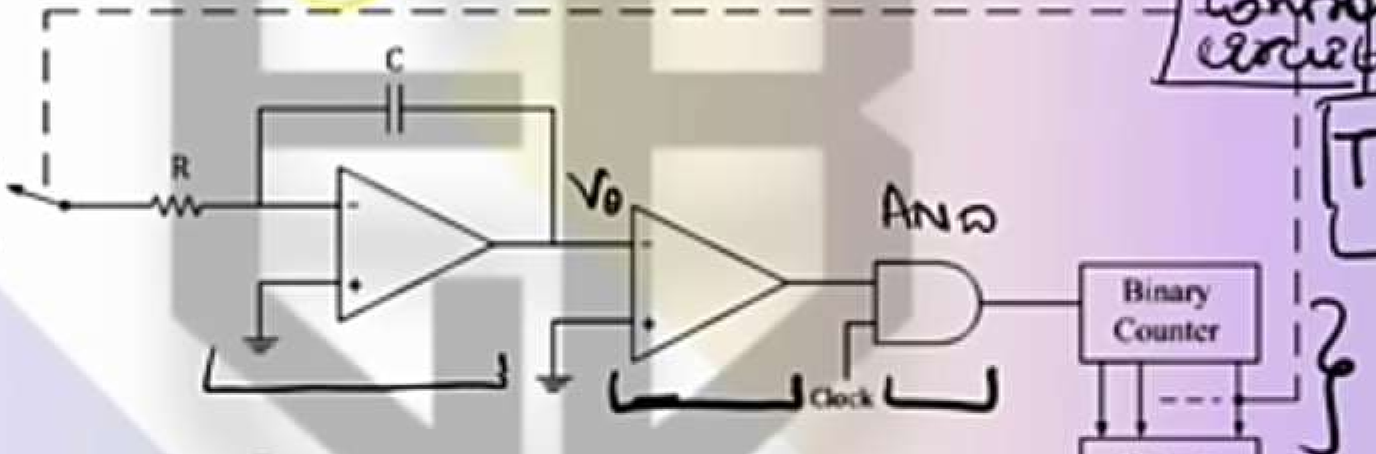
(accurate, slow, time consuming)

Dual slope or Integrating type ADC

$$V_0 = -\frac{1}{RC}\int V\,dt$$

$$V_1 = -\frac{1}{RC}\int V_A\,dt$$

$$\boxed{V_1 = -\frac{V_A}{RC}\cdot T_1}$$



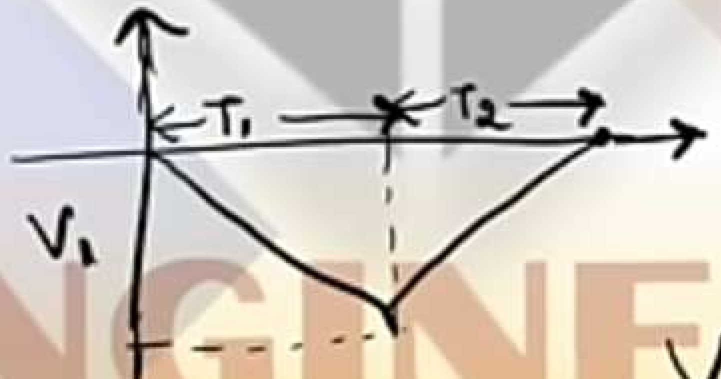
$$\boxed{T = 2^{n+1}\,T_{clk}}$$

$$T_2 = \frac{V_A T_1}{V_{ref}}$$

$$\boxed{V_A \propto T_2}$$

$$V_2 = -\frac{1}{RC}\int -V_{ref}\,dt$$

$$\boxed{V_2 = \frac{1}{RC} V_{ref}\, T_2}$$



$$V_0 = V_1 + V_2$$

$y = mx$

$$\frac{V_A T_1}{\cancel{RC}} = \frac{V_{ref} T_2}{\cancel{RC}}$$

$$V_0 = -\frac{V_A T_1}{RC} + \frac{V_{ref} T_2}{RC} = 0$$

Types of digital-to-Analog-converters (DACs)

Weighted Resistor DAC

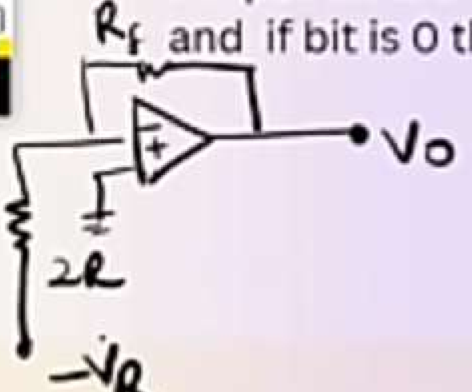
- This circuit has a network of binary weighted resitors.
- if input bit is 1 then switch will connect to reference voltage and if bit is 0 then resistor will connect to ground.

$2^3\,2^2\,2^1\,2^0$

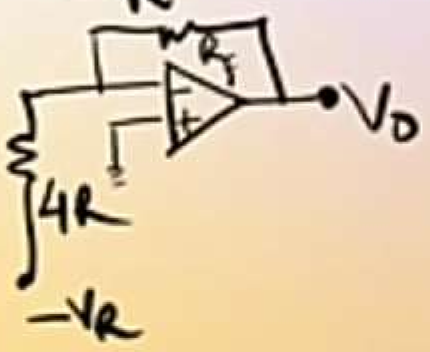
$1000 = 8$ → $\frac{V_R}{2}$

$0100 = 4$ → $\frac{V_R}{4}$

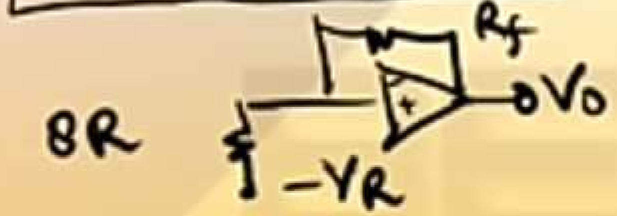
$0010 = 2$ → $\frac{V_R}{8}$



$$\boxed{V_0 = \frac{-R_f}{R_f} \times V_i = \frac{R}{2R} \times V_R = \frac{V_R}{2}}$$

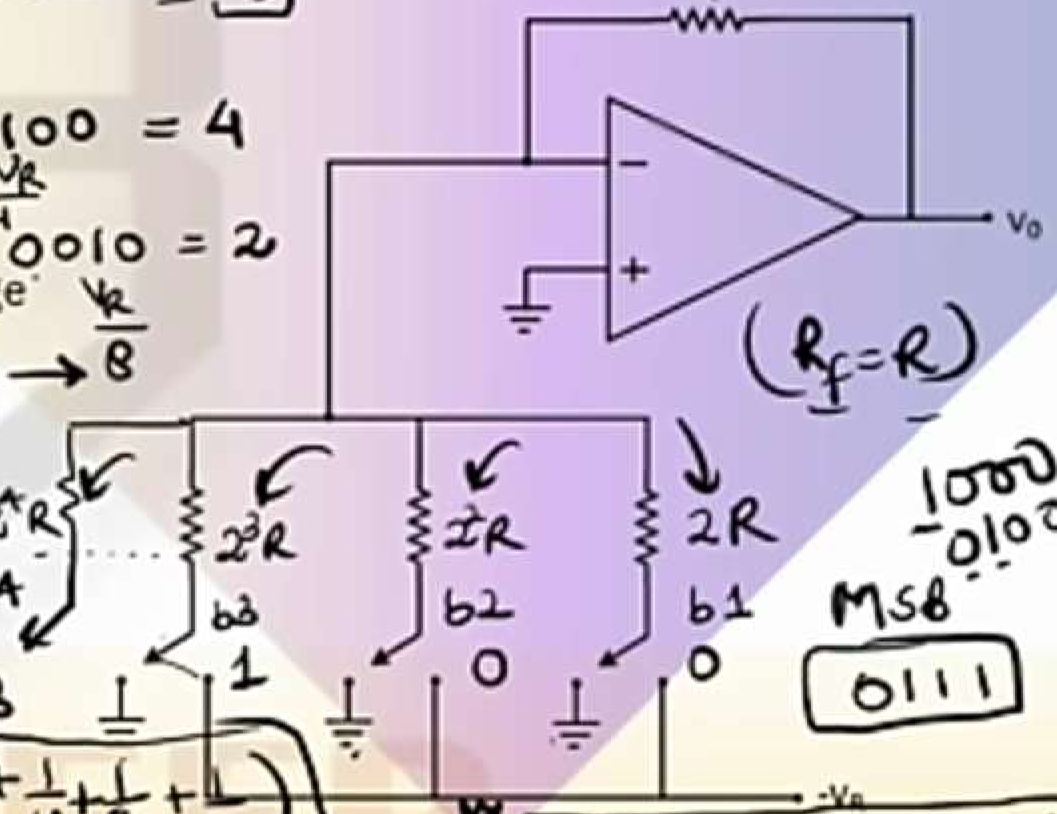


$$\boxed{V_0 = \frac{+R}{4R} \times V_R = \frac{V_R}{4}}$$



$$\boxed{V_0 = \frac{+R}{8R} \times V_R = \frac{V_R}{8}}$$

Summing Amplifier



$(R_f = R)$

1000
0100
MSB
0111

$$\boxed{V_0 = V_R\left(0 + \frac{1}{4} + \frac{1}{8} + \frac{1}{16}\right)}$$

$$V_0 = V_R\left(\frac{b1}{2} + \frac{b2}{2^2} + \frac{b3}{2^3} \cdots\right)$$

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$2R \| 2R = R$

$\boxed{100 = 4}$

R-2R Ladder DAC

$$V_{th} = \frac{(-V_R)\,2R}{4R}$$

$\boxed{V_{th} = -V_R/2}$ $\boxed{R_{th} = R}$

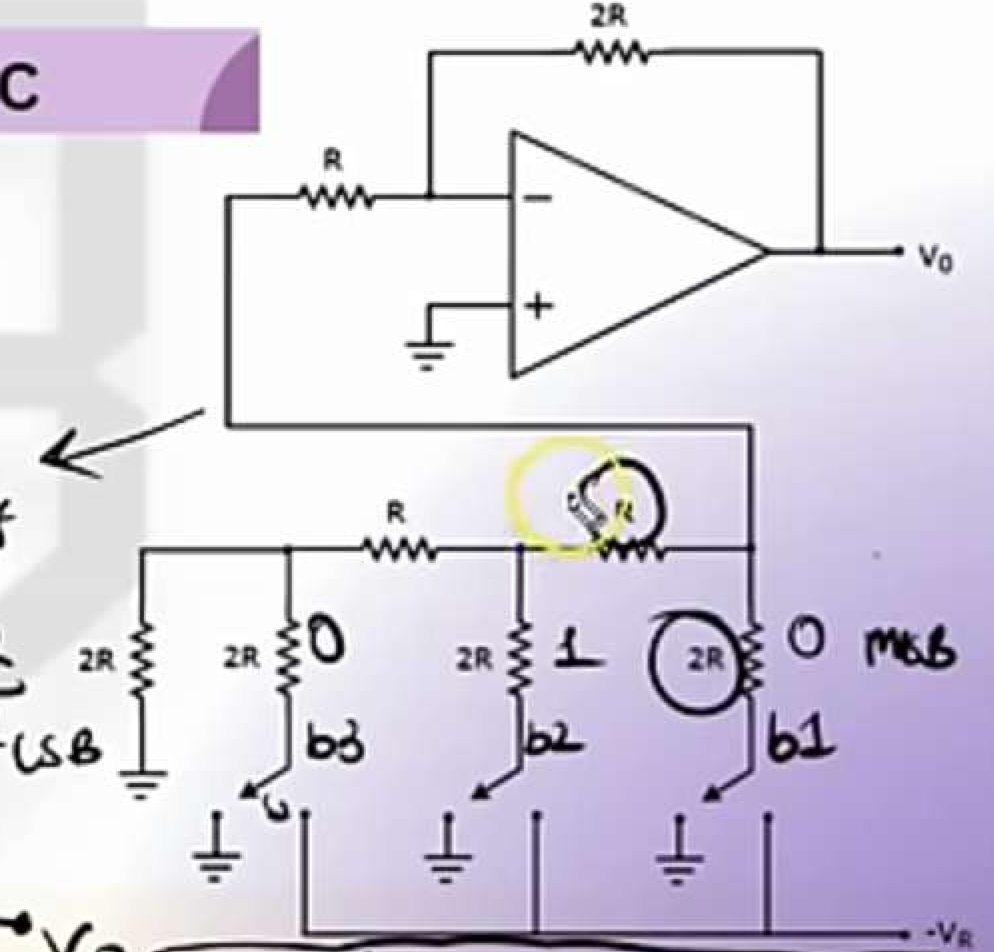
$-V_R/2$

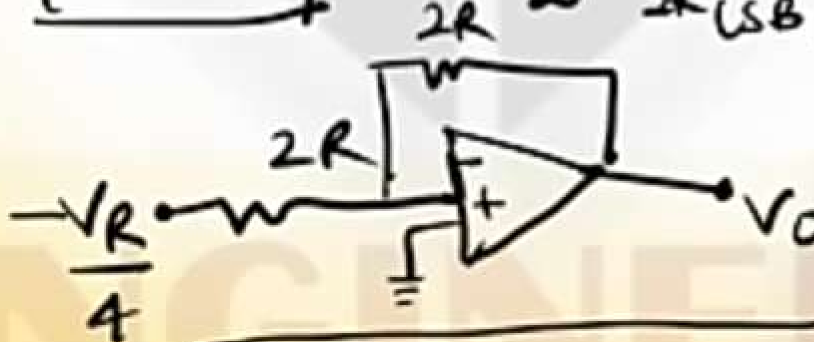
$\boxed{V_o = V_R/2}$

$$V_o = -\frac{V_i}{R_i} \times R_f$$

$$V_o = \frac{V_R}{2} \times \frac{2R}{2R}$$

$010 = 2$





$-\frac{V_R}{4}$

$$V_{th} = \frac{-V_R \cdot 2R}{4R} = \frac{V_R}{2}$$

$$V_{th} = -\frac{V_R}{2} \times \frac{2R}{4R} = -\frac{V_R}{4}$$

$$\boxed{V_o = \frac{V_R}{4} \times \frac{2R}{2R} = \frac{V_R}{4}}$$

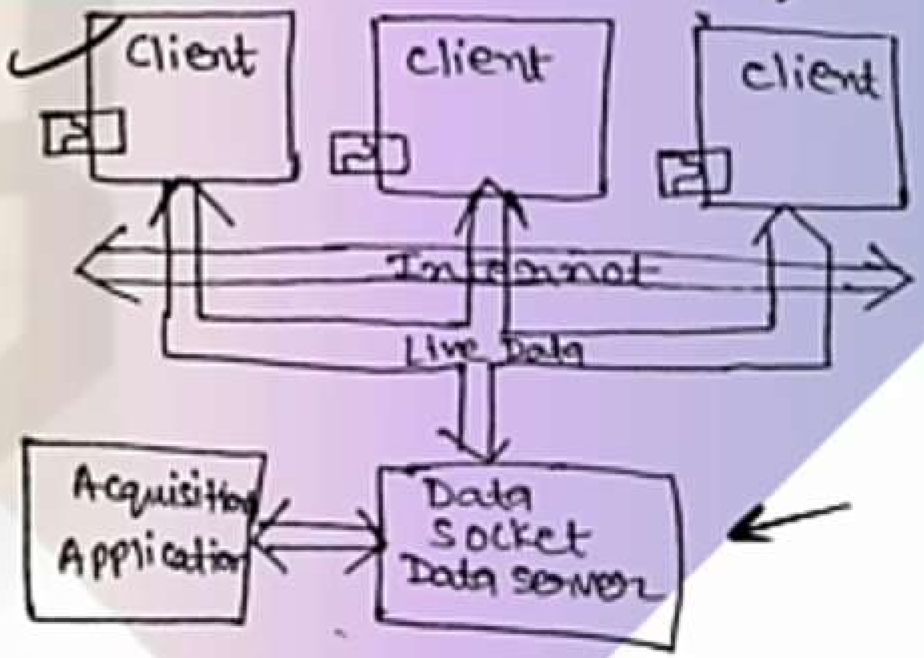
$$\boxed{V_o \; V_R\left(\frac{b_1}{2} + \frac{b_2}{2^2} + \frac{b_3}{2^3} + \cdots\right)}$$

$001 \rightarrow \frac{V_R}{8}$ $010 \quad \frac{V_R}{4}$

Use of Data Sockets in Network Communication

{ADC DAC} * Request

- Data sockets play a critical role in network communication by allowing programs running on different computers to communicate with each other over a network.
- A data Socket application specifies the data location by using a familiar networking standard.
- Data Socket Transfer protocol connects a Data socket application to live data by specifying a connection to Data Socket server.



Protocols TCP/IP

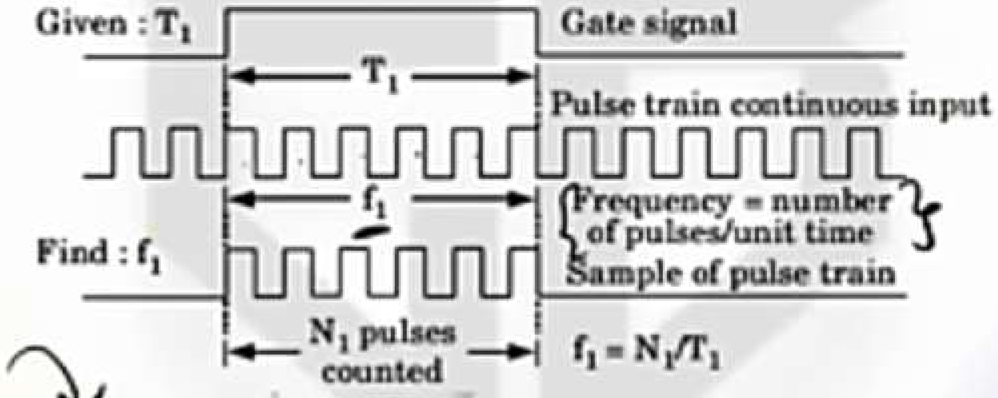
A data socket server is a type of network server that uses sockets to communicate with clients and provides various network-based services like file transfer, messaging, and web services.

Data Socket is an easy to use, high performance programming tool designed specifically, for sharing and publishing live data in measurement and automation applications b/w different applications and between machines across the intemet.

counter and timer

- The counter and timer functions let users measure either the frequency or the period of an input signal, and the total number of pulses or cycles captured in a specified time period.
- These functions are enabled when the digital I/O ports are set up as inputs.
- Counter and timer functions can be programmed to start and stop external hardware (or software) when certain logical conditions in the data acquisition system have been met, such as turning on a valve after a specific number of pulses are counted in a particular time period. (on/off)
- Built-in timers also provide "pulse stream output" signals when the digital I/O ports are programmed as outputs.
- These timers provide precise and stable output signals and should be used for all applications instead of any software generated timing signals.

The input to a counter is typically a pulse train. A counter measures the number of input pulses during a given time period and then determines the frequency of the signal.



A timer measures the time period required for a preprogrammed number of cycles of input signals to occur.