UNIT NO:-04

* Data Acquisition Methods:-

Data acquisition systems are being used in ever increasing, large and wide fields in a variety of industrial and scientific areas, including the aerospace, biomedical and telemetry industries. The type of data acquisition system to be used depends upon the application and the intended use of recorded input data

A data acquisition system is a hardware extension of a computer system and must be installed like other hardware components like printers and hard drives.

Data acquisition systems are used to measure and record analog signals in basically two different ways:

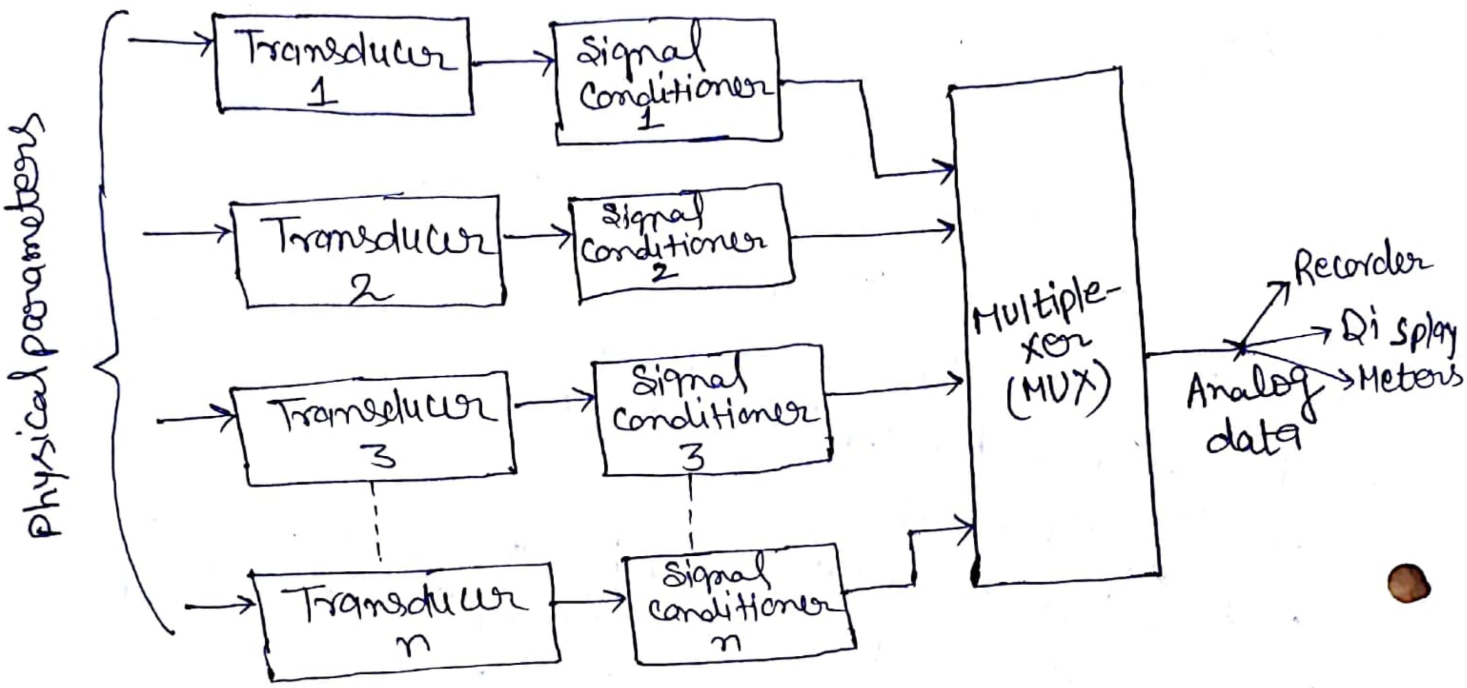
(i) signals which orginates from direct measurement of electrical quantities. These signals may be d.c or a.c voltages, frequency, or resistance etc.

(ii) signals which orginate from use of transducers.

Analog Data Acquistion System:-

An analog data acquisition system typically consists of some or all of the following elements.

Transducers:- Transducer is a device which is used to convert the physical parameters (Temp., pressure, force) into an electrical signals or it is used to measure directly the electrical quantities such as resistance, Voltage, freq etc.



Signal Conditioning:- The output signals of the transducer will be very low level (weak) signals which can not be used for further processing. So signal conditioners may include devices for amplifying, refining or selecting certain positions of these signals.

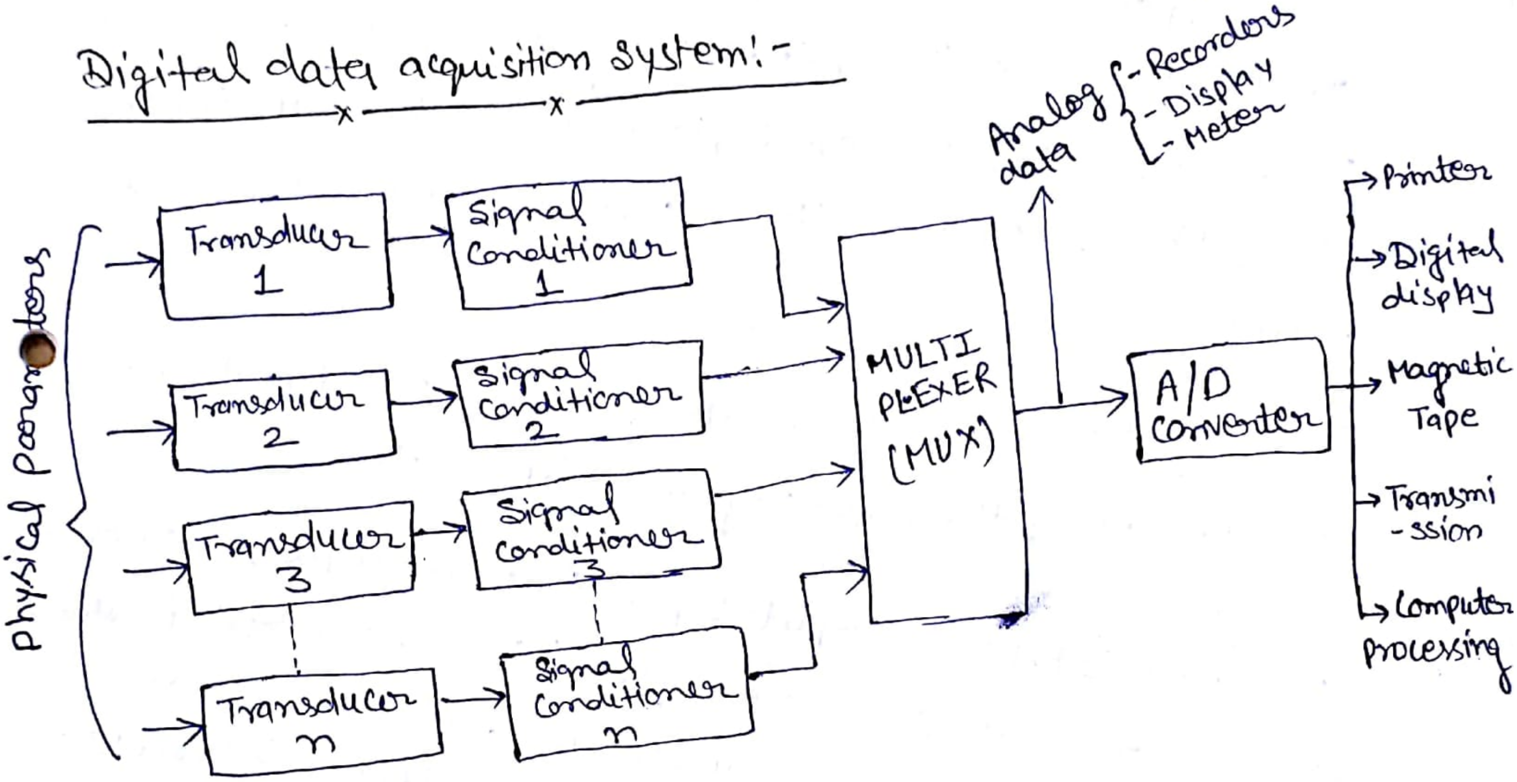
Multiplexer:- Multiplexing is the process of sharing a single channel with more than one output. Thus a multiplexer accepts multiple analog inputs and connects them sequentially to one measuring input.

The function of the multiplexer is to accept multiple analog inputs and provide a single output sequentially according to the requirements.

Recorders & display devices:- In display devices the data is displayed in a suitable form in order to monitor the input signals.

Data recorders are used to record the analog data.

Digital data acquisition system:-



A/D Converter:- The analog to digital (A/D) converter is generally used to convert the analog data into digital form. The digital data is used for the purpose of easy processing, transmission, digital display and storage. Processing involves various operations on data such as comparison, mathematical manipulations, data is collected, converted into useful form and utilized for various purposes like for control operation and display.

Counters/Timer:- A counter is a digital timing device. Counters are used for event counting, frequency measurement, period measurement, position measurement and pulse generation. Pulse generation counter/timer circuitry is useful for many applications, including counting the occurrences of a digital event, digital pulse timing and generating square waves and pulses. You can implement all these applications using three counter/timer signals - gate, source and output

Count register - It stores the current count of the counter. You can query the count register with software.

Source → It is an input signal that can change the current count stored in the count register. The counter looks for rising or falling edges on the source signal. Whether a rising or falling edge changes, the count is software selectable. The type of edge selected is referred to as the active edge of the signal. When an active edge is received on the source signal, the count changes. Whether an active edge increments or decrements the current count is also software selectable.

Gate:- It is an input signal that determines if an active edge on the source changes the count. Counting can occur when the gate is high, low or between various combinations of rising and falling edges. Gate settings are made in software.

Input:- I

Digital counters-

→ Output of counter will be sequence of repeated number.

- - - - - - - 2, 3, 5 7, 2, 3, 5, 7, - - - - - -

- - - 3, 5, 7, 2, 3, 5 7, 2, - - - - -

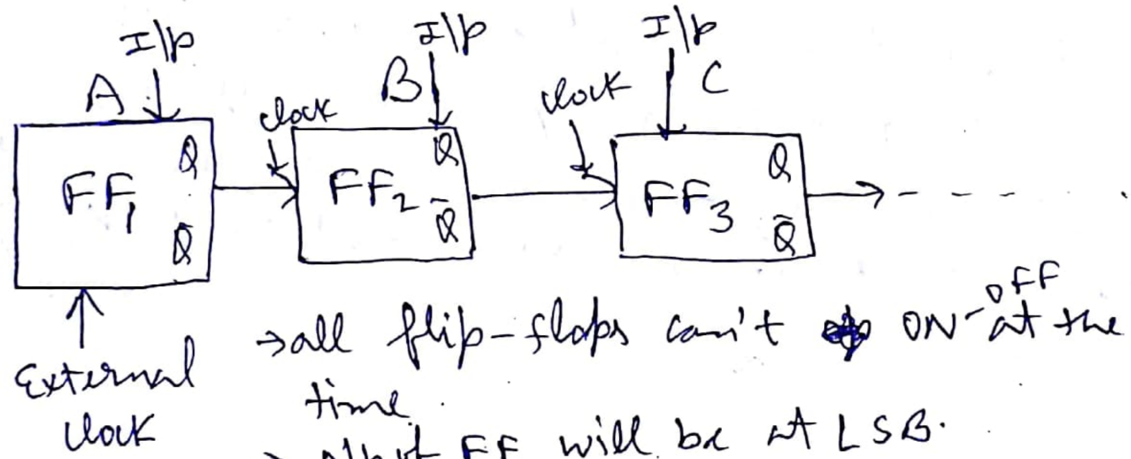
- - - - 5, 7, 2, 3, 5 7, 2, 3 - - - - -

- - - - - - 7, 2, 3, 5, 7, 2, 3, 5, - - - - - .

→ at least one flip-flop will present

counters

- Ripple counter (Asynchronous counter)
- Synchronous counter



→ all flip-flops can't ON-OFF at the same time.

→ o/p of FF1 will be at LSB.

MSB   LSB.

C B A

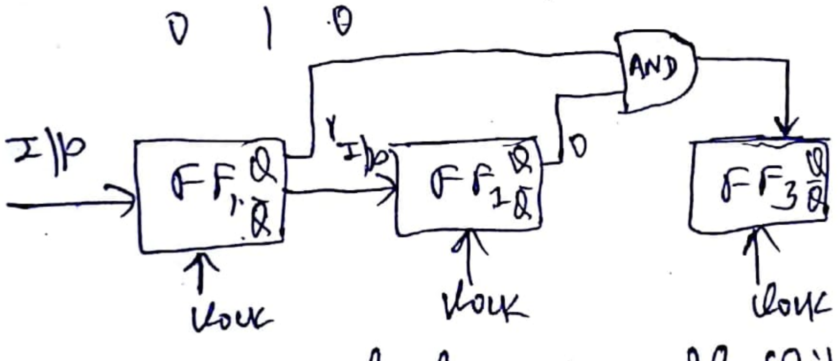
0 1 0

1 0 0

1 1 1

0 0 0

0 1 0



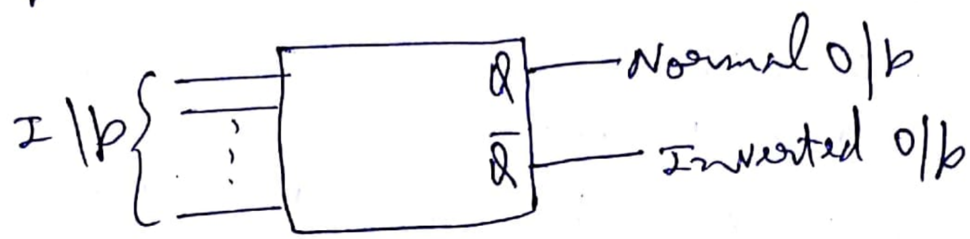
→ external clock for all flip-flop.

→ all flip-flops can ON-OFF at the same time

→ o/p of FF1 will be at LSB.

flip-flops

It is a memory element which is capable of storing one bit of information and it is used in clocked sequential circuits.



Counters -

- counters are sequential logic circuit which is used for a counting pulses.
- counters are used not only for counting but also for measuring frequency & time.
- are found in almost every digital systems.
- are designed by grouping of flip-flop
- counter is a digital device used to count no. of pulses & it can also be used as frequency divider.

Analog to digital converter –

The following methods are most commonly used –

(i) simple potentiometeric and servo method

(ii) Successive approximation method

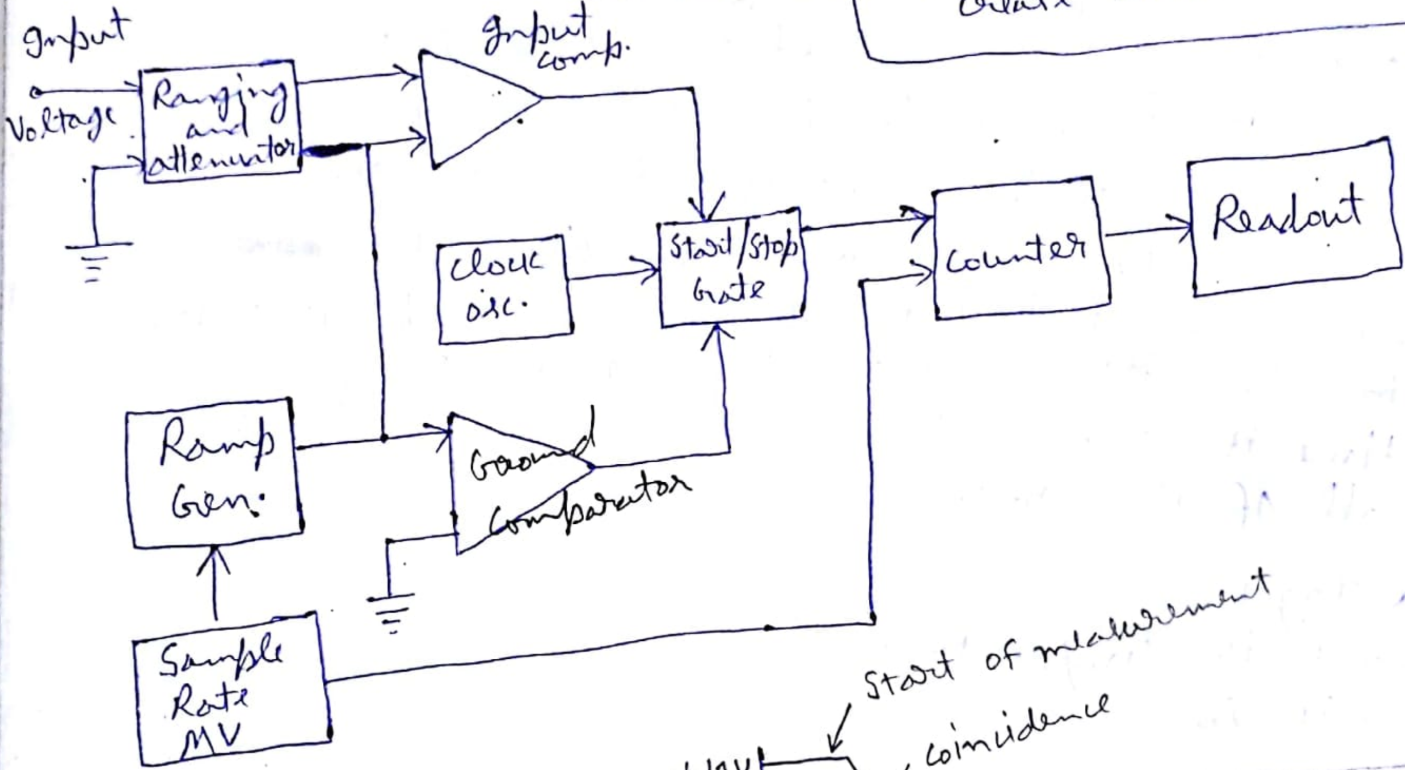
(iii) ramp type

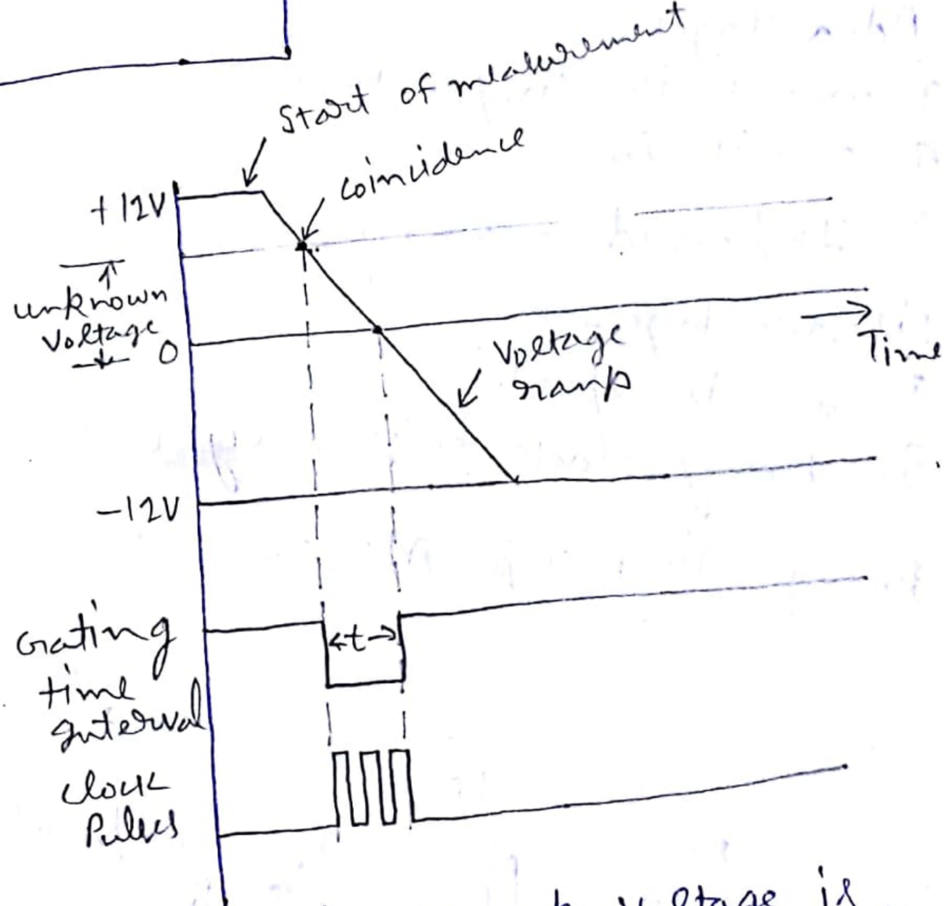
(iv) Integrating type

(v) Dual – slope integrating type

② ... of operation is based upon ...
Disadvantages- ① Low accuracy
② mechanical movement can create errors.

Ramp type-





At the start of measurement a ramp voltage is generated. A negative going ramp is shown in fig. but a positive going ramp may also be used. The ramp voltage is continuously compared with the voltage being measured. At the instant the value of ramp voltage is equal to that of unknown voltage, then an input comparator, generates a pulse which opens a gate

The ramp voltage continues to decrease till it reaches ground level (Zero Voltage). At this instant another comparator called ground comparator generates a pulse and closes the gate.

The time elapsed between opening and closing of the gate is t as indicated in fig. During this time interval pulses from a clock pulse generator pass through the gate and are counted and displayed.

The decimal no. as indicated by the readout is a measure of the value of input voltage.

The sample rate multivibrator provides an initiating pulse for the ramp generator to start its next ramp voltage. At the same time it sends a pulse to the counters which sets all of them to 0.

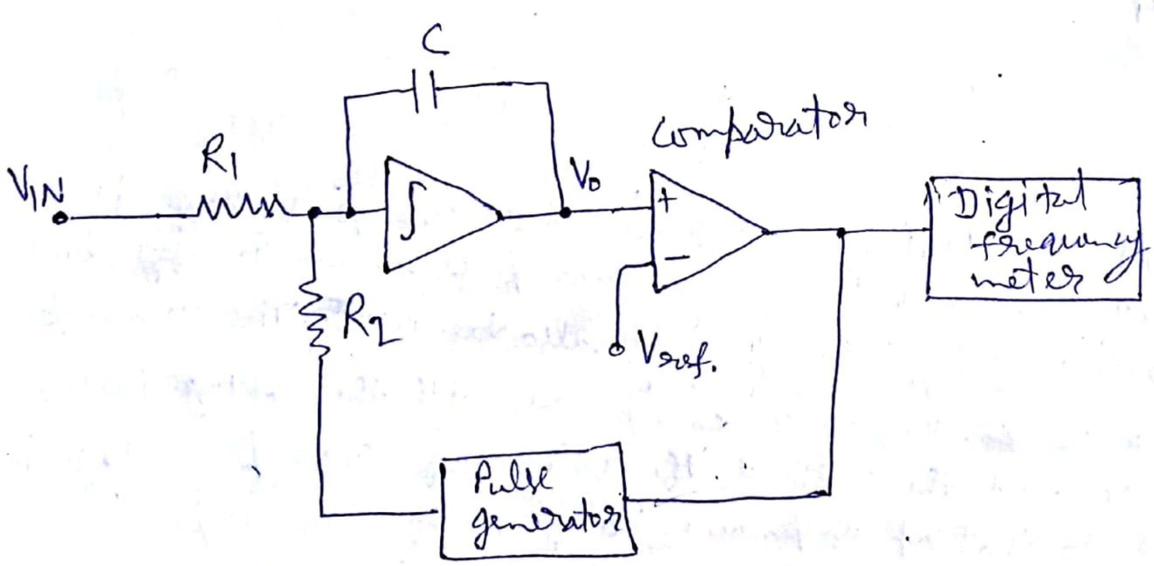
Advantages –

1. circuit is simple to manufacture.
2. Cost is low
3. Improved accuracy

Disadvantages –

1. Slow is speed.
2. Many clock pulse may waste in comparison.

Integrating Type A/D Converter –



This is also known as Voltage to frequency conversion. An integrator is used to convert input voltage VIN in to ramp form. This Voltage charges the capacitor 'C' and generated integrator output V_o.

when $V_o > V_{ref}$. then comparator changes its state from low to high, so as to trigger the precision pulse generator. The pulse generator produces a negative going pulse that discharges the capacitor C.

The rate of charging and discharging produces a signal frequency i.e. directly proportional to applied input Voltage V_{in}. This frequency is then read by digital frequency meter.

$t_2 V_{ref.} = V_{IN} t_1$

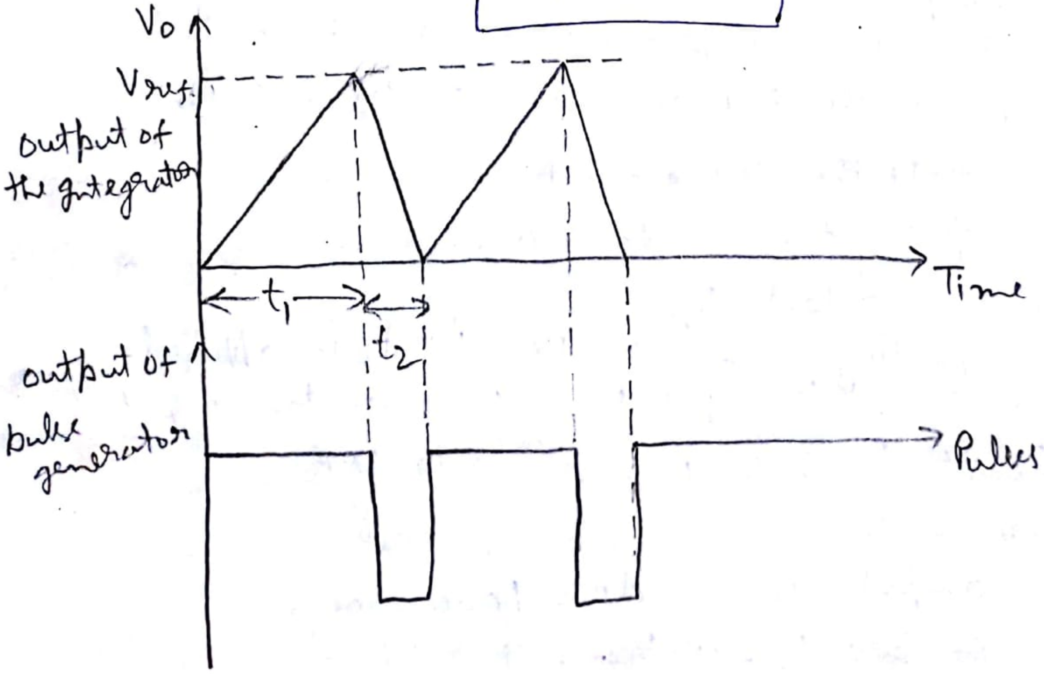
Now, $$t_2 = \frac{V_{IN} t_1}{V_{ref.}}$$

$$V_{IN} = \frac{t_2 V_{ref.}}{t_1}$$

$$V_{IN} = \frac{K}{t_1}$$

$$V_{IN} = K f_o$$

$$\boxed{V_{IN} \propto f_o}$$

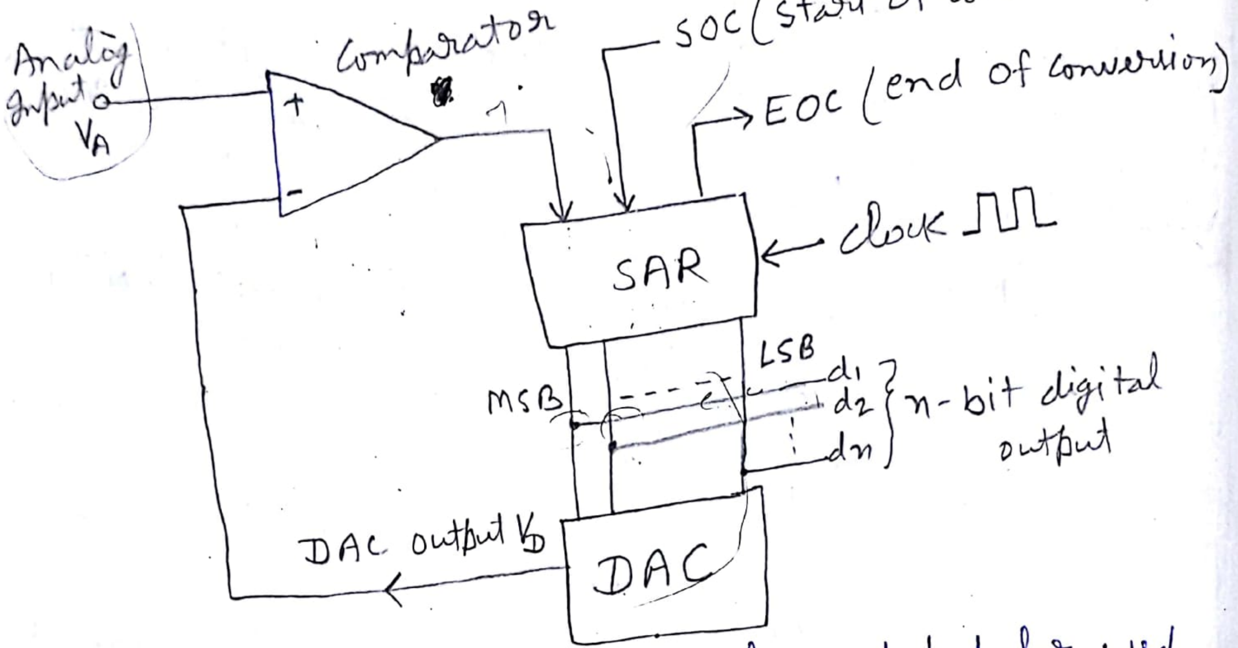


Advantages –

① It can be used as digital frequency meter

② There is no effect of variation in R and C values on frequency 'fo', because frequency depends only on input voltage V_{IN}.

Successive Approximation ADC –



It is one of the most widely and popular used ADC technique. This Technique uses an efficient method to complete n-bit conversion in just n- clock periods.

The successive approximation register SAR receives the comparator output, clock and start conversion signals and produces an n-bit digital output along with the end of conversion i.e. EOC signal.

⇒ Initially initiate the "SOC" input,

SAR output, $d_1 - - - d_8 = 00000000$

∴ DAC output, $V_D = 0$

The corresponding output of DAC i.e. V_D is applied to comparator. $(V_D < V_A)$ then comparator output goes high (positive) which is applied to SAR.

∴ Bit is made 1

⇒ New SAR output, $d_1 - - - d_8 = 1000\,0000$

Compare V_D with V_A.

If $V_D < V_A$, then comparator output goes high (positi...

which is applied to SAR. In response to high comparator output, the MSB d_1 is maintained at 1 and the next bit d_2 is made 1.

$\Rightarrow$ New SAR output, $d_1 - - - d_8 = 1100\ 0000$
compare V_D with V_A
$V_D < V_A$, comparator output is high (+ve)
Make bit $d_3 = 1$

$\Rightarrow$ New SAR output, $d_1 - - - d_8 = 1110\ 0000$
Compare V_D with V_A
$V_D > V_A$, comparator output is low (−ve)
So make bit $d_3 = 0$ and $d_4 = 1$

$\Rightarrow$ New SAR output, $d_1 - - - d_8 = 1101\ 0000$.
compare V_D with V_A.
$V_D < V_A$, comparator output is high
So make bit $d_5 = 1$

$\Rightarrow$ New SAR output, $d_1 - - - d_8 = 11011000$
compare V_D with V_A
$V_D > V_A$, comparator output is low
So make bit $d_5 = 0$ and $d_6 = 1$

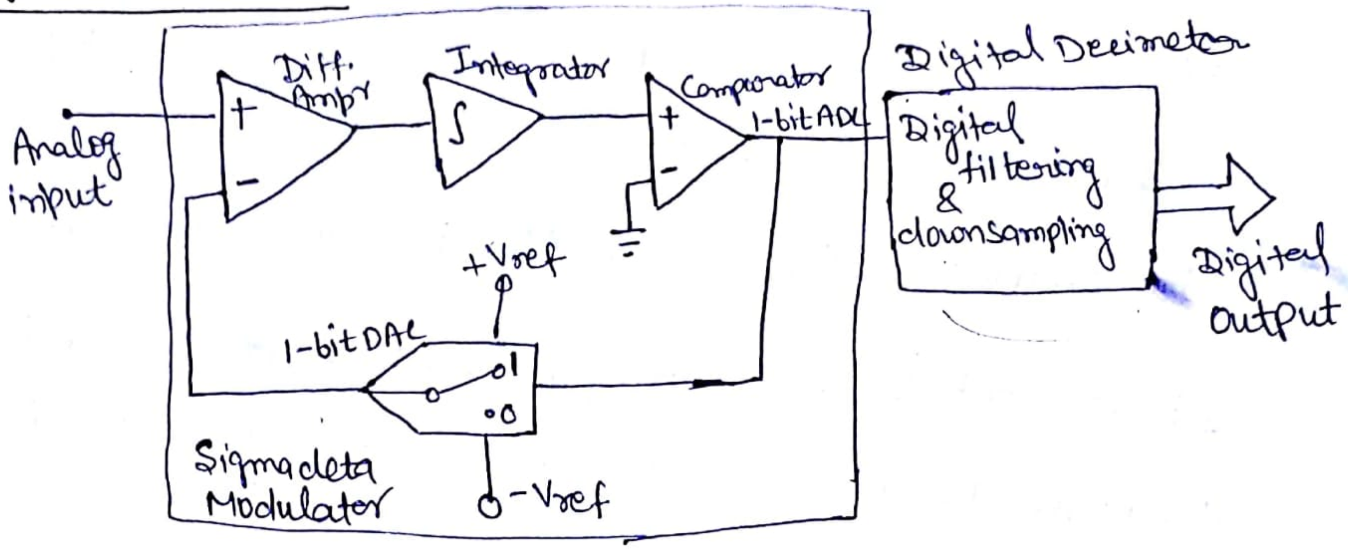
$\Rightarrow$ New SAR output, $d_1 - - - d_8 = 11010100$
Compare V_D with V_A
$V_D > V_A$
So make bit $d_6 = 0$ and $d_7 = 1$

$\Rightarrow$ New SAR output, $d_1 - - - d_8 = 11010010$

Stop as $V_D = V_A$

Advantages — ① Its greatest advantage is its very high speed. The conversion time is equal to the 'n' clock cycle period for n-bit ADC. Thus conversion time is very short.
② Conversion time is constant and independent of the amplitude of analog signal V_A.

① Sigma Delta ADC:-



Working Principle:-

Analog signal which is to be digitized is applied to the non inverting terminal of difference amplifier. Inverting terminal of difference amplifier is connected with either +Vref or -Vref depends on output of 1-bit DAC. Output of difference ampr is integrated using integrator.

Output of integrator is applied to the non inverting terminal of comparator. In this case comparator works as 1-bit ADC and produces output as 1 or 0. Output of comparator is connected to the 1-bit DAC. DAC is used to connect either +Vref or -Vref to the inverting terminal of difference ampr. DACs output is then again subtracted from analog input. This process is continuous in closed loop. After each loop 1 bit ADC produces 1 or 0.

output of 1-bit ADC is also connected to the digital decimation
It is used for digital filtering and down sampling. It
produces n-bit digital output in binary format.

Advantages of sigma delta ADC:-

1. sigma delta ADC is inexpensive since all circuitry within the converter is digital.
2. The output of sigma delta ADC is inherently linear.
3. It do not require sample and hold circuit. It is because due to high sampling rate and low precision.

Disadvantages:-

1. It is limited to high resolution and very low freq. applications.
2. It is not possible to use sigma delta ADC for multiplexed ac input signals.

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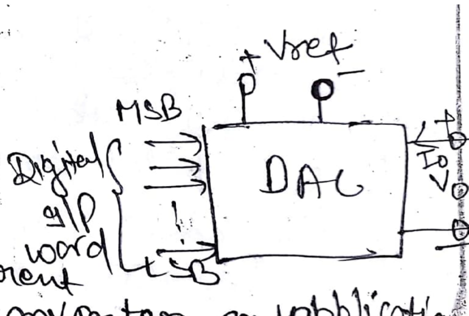
Digitel to Analog conversion:-

A digital input word D& Vref to combine the control the O/P of D/A converter.
The O/P of D/A com be O/P voltage or current depending up on the design of converter and application.



mathematically the D/A converter can be described as follows (7)

$$V_o = KV_{FS}\left(d_1 2^{-1} + d_2 2^{-2} + \cdots + d_n 2^{-n}\right] + V_{OS}$$

V_o = O/P voltage

K = gain usually adjusted to value 1

V_{FS} = Full Scale O/P voltage

V_{REF} = Reference voltage controls the full Scale O/P voltage

V_{OS} = Off set voltage; the O/P voltage of converter when the digital input are equal to zero. The offset voltage is normally adjusted to zero.

$d_1, d_2 \cdots d_n$ = n bit input word d_1 is MSB and d_n is LSB.

Basic DAC circuits →

1) weighted Resistor Type DAC → One of simplest ckt uses a summing ampr with weighted resistor network that are weighted in binary progression. The digital input word control the switches logical 1 indicates the closed switch and logical '0' indicates the open switch.

$$I_o = I_1 + I_2 + \cdots + I_n$$

$$I_o = d_1 \frac{V_R}{2R} + d_2 \frac{V_R}{2^2 R} + \cdots + d_n \frac{V_R}{2^n R}$$

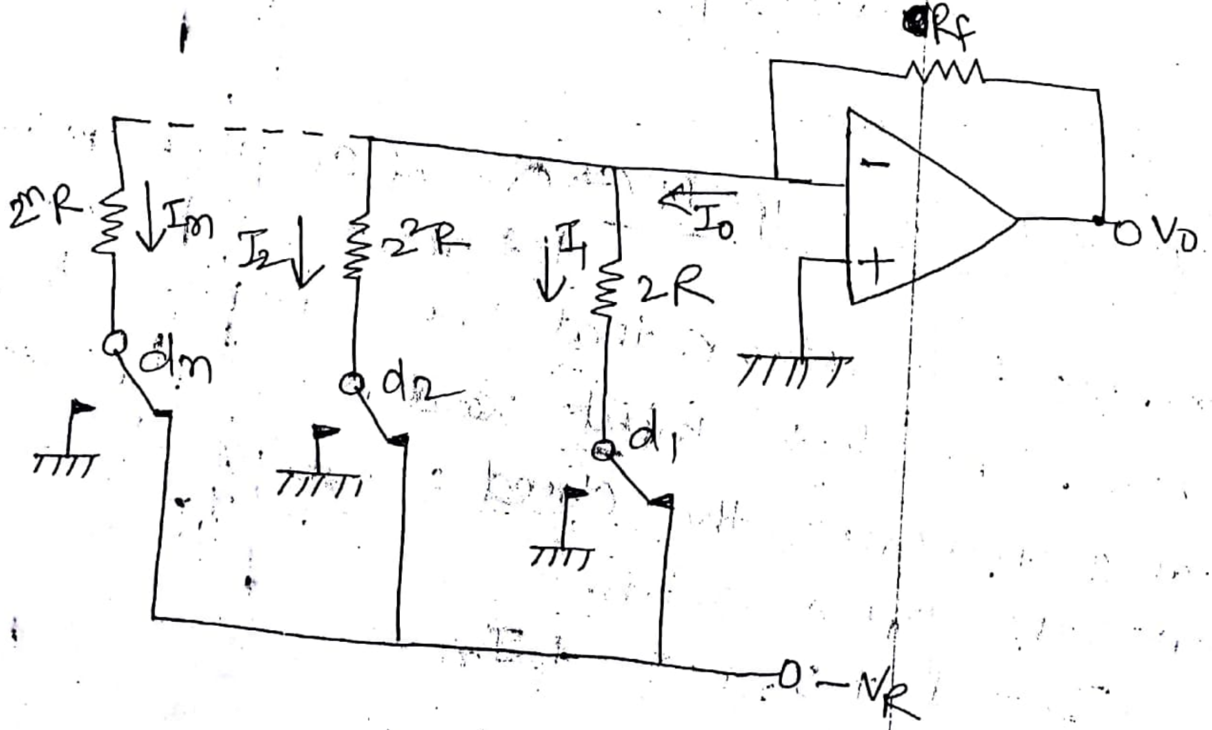
$$I_0 = \frac{V_R}{R}\left[d_1 2^{-1} + d_2 2^{-2} + \cdots + d_n 2^{-n}\right]$$

$$\therefore V_0 = -I_0 R$$

$$V_0 = -V_R\left[d_1 2^{-1} + d_2 2^{-2} + \cdots + d_n 2^{-n}\right]$$

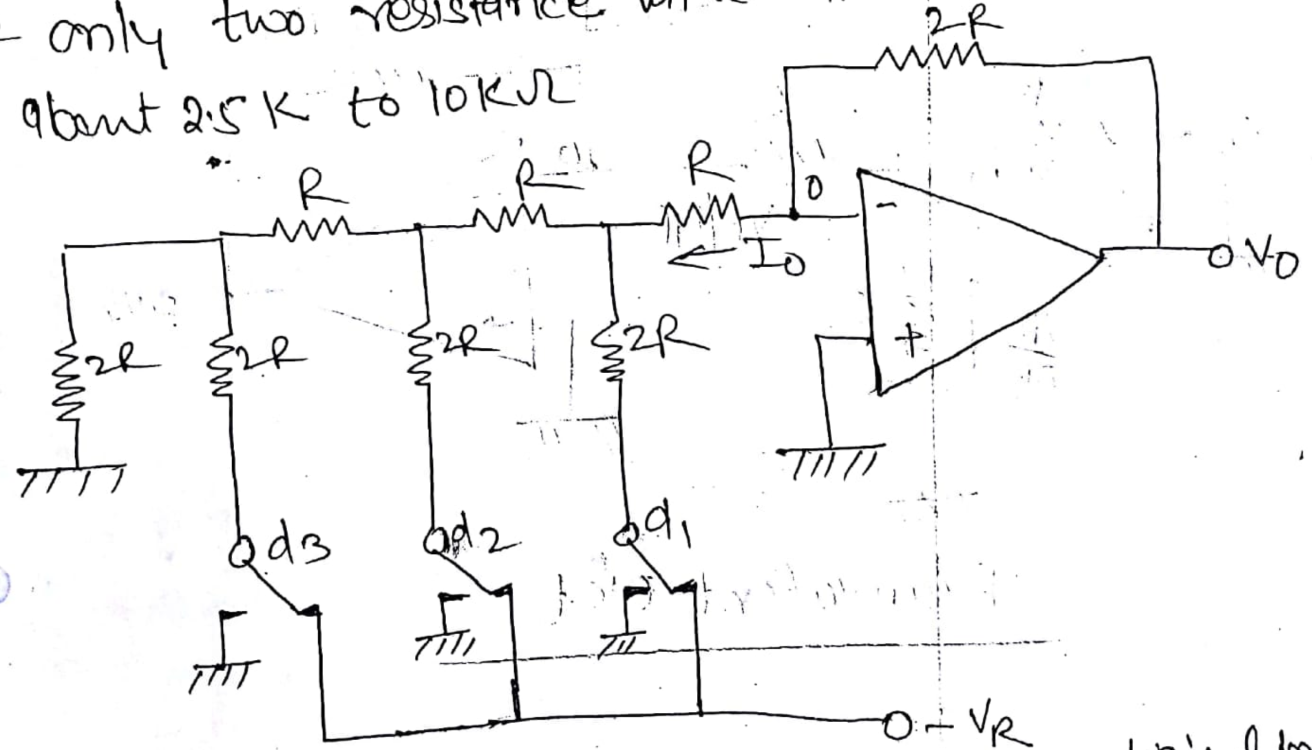
Several problem arises in actual DAC using weighted resistor ckt. A number of bit increases the range of resistance value gets awkward.

For 8 bit convertor the resistance needed R, 2R, 4R ---- 128R. the largest resistance is 128 times of smallest resistance. For 12 bit convertor, the largest resistance is 2048 times of smallest. Accurate resistance ratio to be maintained over a wide range of resistance value. Switches are in series with the resistance. The ON resistance is very low & zero offset voltage.



designer can meet the last two requirement by using good MOSFET because of accurate ratio and resistance range in weighted resistor DAC are impractical

(2) R-2R ladder ckt → One way to solve the problem of binary weighted resistor is use to ladder ckt. R-2R ladder ckt avoid the problem of wide range of resistance value. It well suited integrated ckt realization and it requires matching of only two resistance value. The value of R typically about 2.5K to 10KΩ



The switch position to correspondence the digital input the input impedance is word low (for a high gain ampr the input impedance is very low and voltage at point 0 is zero). The ckt is simplified in the equivalent ckt. The current in the resistor branchs can easily calculated and are indicates the ckts. The o/p current is

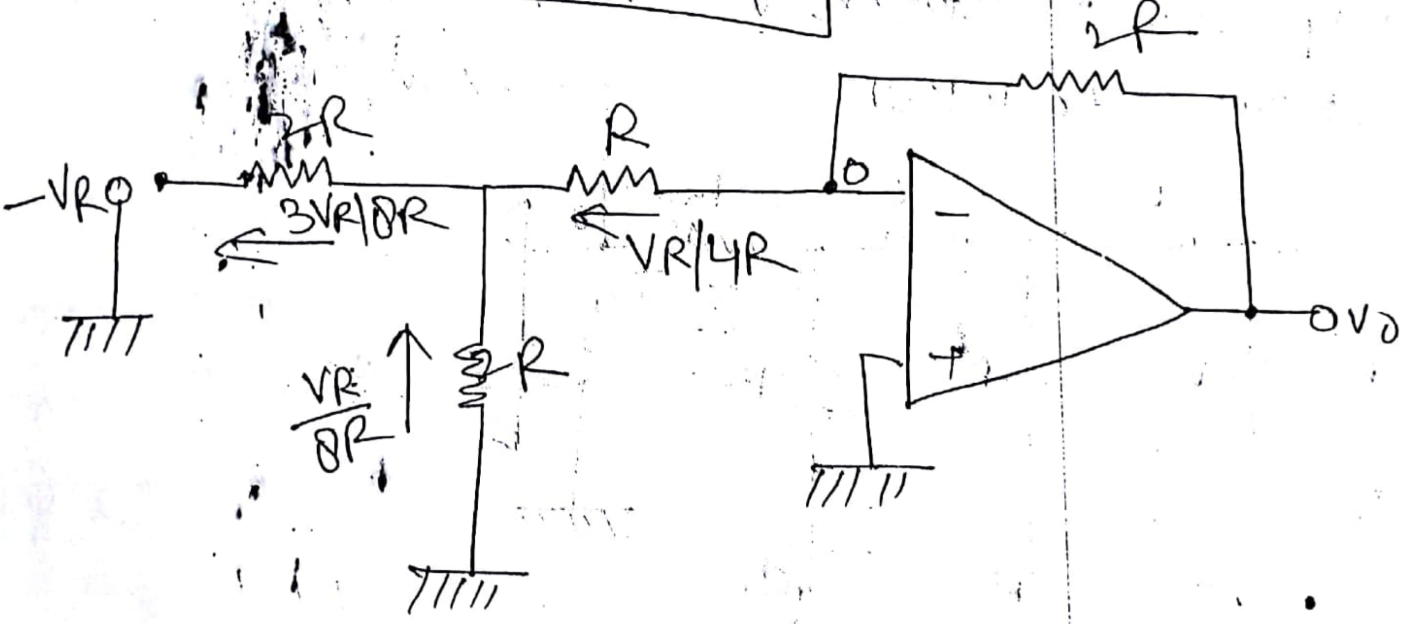
$$I_0 = \frac{V_R}{4R}$$

The o/p voltage

$$V_0 = I_0 \times 2R$$

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

$$\boxed{V_0 = \frac{V_R}{2} = \frac{V_{FS}}{2}}$$



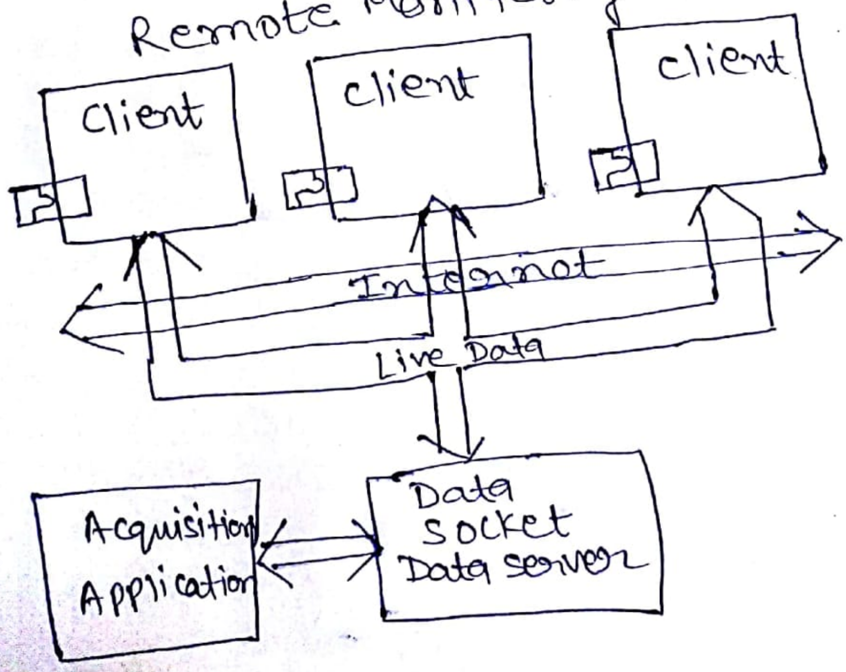
Equivalent ckt

Use of data Sockets in Networked Communication:-

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 internet. Data socket for LabVIEW simplifies live data exchange b/w different applications on one computer or between computers connected through a network.

Although a variety of different technologies exist today to share data b/w applications, including TCP/IP, most of these tools are not targeted for live data transfer to multiple clients. With TCP/IP, you have to convert your data into an unstructured stream of bytes in the broadcasting application and then parse the stream of bytes back into its orginal format in subscribing applications.

Remote Monitoring and Control



- Data socket is a single, unified, end-user application programming interface for connecting to data from a number of sources - local files, files on FTP and data items on OPC servers.
- 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 a Data socket server.