Analog to Digital ~~Electro~~ Converter

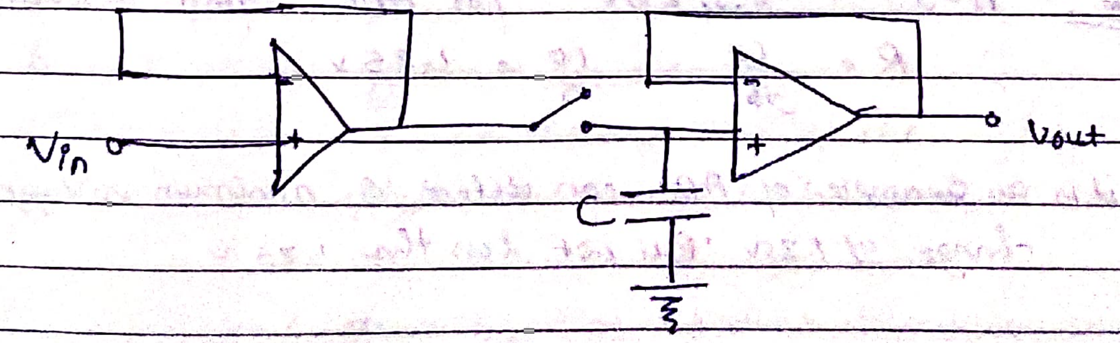
An analog to digital Converter takes an analog input V_A. as input and generates a digital output D where $D \propto V_A$

⇒ Process

If the input signal is sinusodial i.e, changes at every instant of time during Conversion, final Value D may be erroneous. So during the conversion we ~~has~~ use a sample and hold circuit to sample the input voltage and hold it to a constant value.

Sample and hold ckt consist ~~circuit~~ of a switch and a capacitor and two voltages followes op amp.

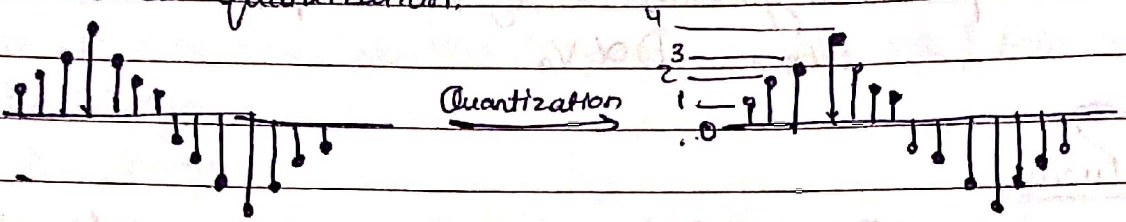
when the switch is closed the capacitor charges upto input voltage Vin and when the switch is opened the capacitor holt that voltage until the switch is closed again. Thus output voltage remains reasonably constant.



Sample & Hold Circuit

Quantization

The process of assigning a sample signal and value for the discrete set of values be nearest possible integer is called quantization.



Here we introduce a term called "resolution" which represents how much the quantised value is close to the actual value It is generally defined in terms of number of bits

Thus "Resolution" defines the minimum change in the input signal that can be detected.

$$\text{Resolution} = \frac{\text{Full scale range}}{2^{(\text{no. of bit})}} = \frac{V_{max} - V_{in}}{2^n} = \frac{V_{ref}}{2^n}$$

where $n =$ ~~bit~~ no. of bits

$2^n =$ No. of discrete levels of quantization

Ex $n = 3$ $V_{ref} = 10V$ for ADC find Resolution

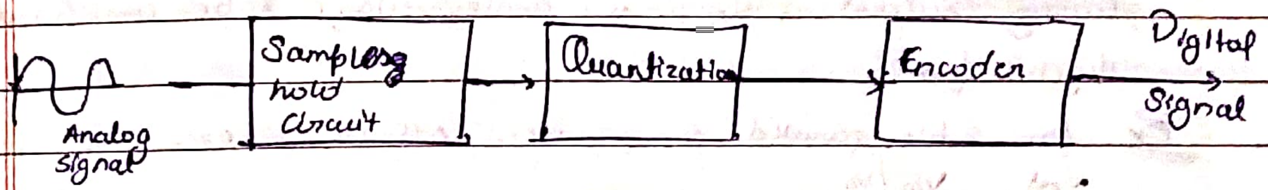
$$R = \frac{10}{2^3} = \frac{10}{8} = 1.25V$$

it is an Example of ADC can detect a minimum voltage change of 1.25V But not less than 1.25 V

* To increase resolution increase the ~~$~~ no. of bit and decrease the full scale range (V_{ref})

Encoding : The last process of ADC is encoding in which the quantised values are converted into digital binary numbers i.e in the form of 0 & 1.

Thus the whole process of Conversion of an analog to Digital may be expressed as.



~~Specification of A/D Converter~~

\# Conversion time → of an ADC is the time required by ADC to perform a complete conversion process. The conversion is commonly started by sample ckt.

\# Accuracy → of a converter refers to how many bits from conversion to conversion are repeatable. That is accuracy ~~of~~ reflects how the ADC outputs reflects the actual input.

\# Integral non linearity error (INL) – Offset and gain error, and the accuracy of the voltage reference, temperature effect and AC performance.

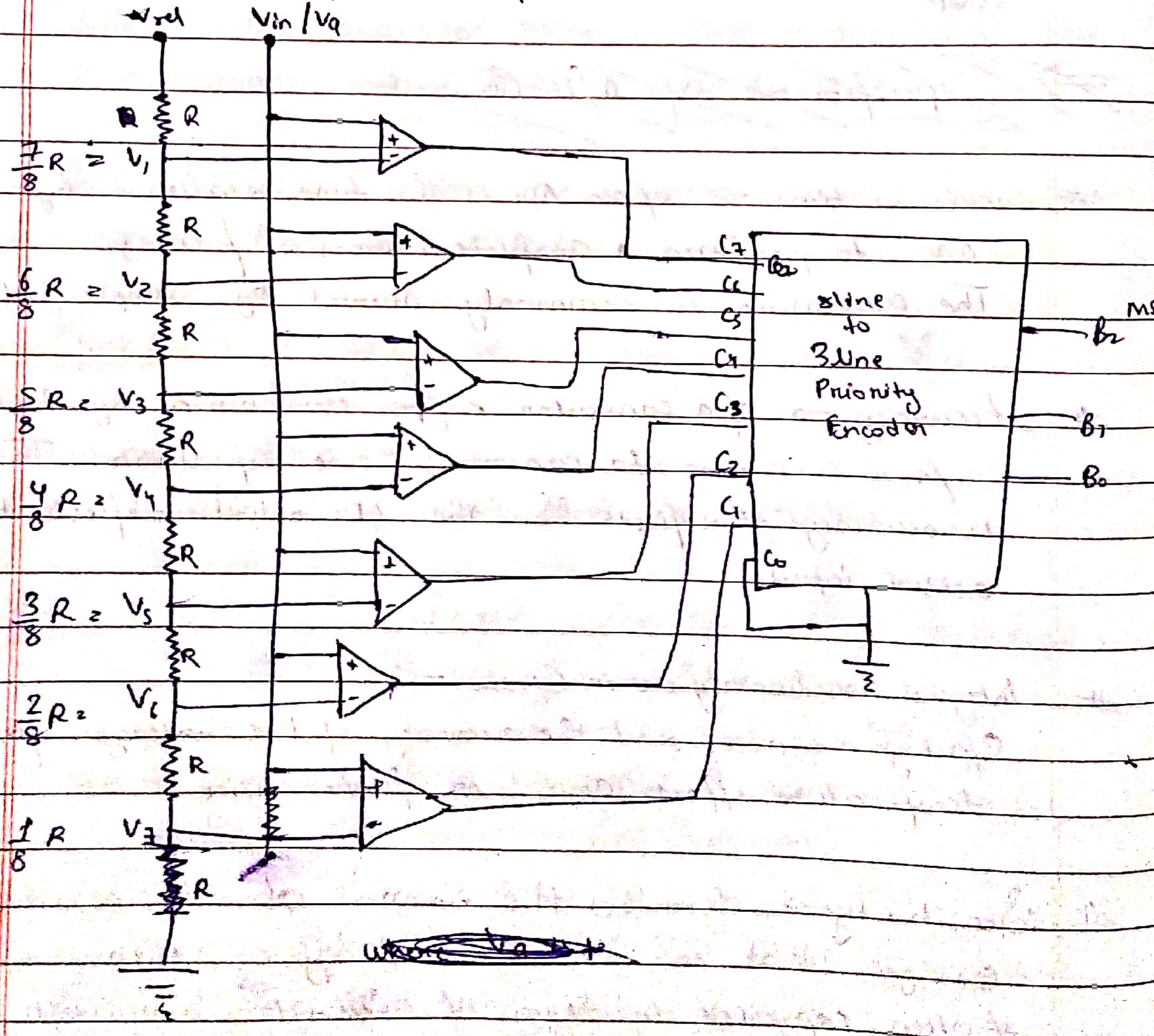
\# Sensitivity → describes the smallest absolute amount of change that can be detected by a measurement ~~of~~ often expressed in terms of millivolts, microvolts.

The easiest way to determine the sensitivity of a device is to look at it performance on its lowest range.

Flash / Parallel ~~ADC~~ Comparator (ADC)

It is formed of a series of comparators, each one comparing the input signal to the unique reference voltage. The comparator outputs connect to the input of a priority encoder ckt. which then produces a binary output. Va is the analog voltage to be converted into digital form.

Eg for 3 bit parallel comparator A/D Converter



~~where Va~~

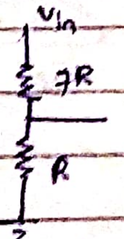
Advantages
- ~~Low cost~~
- ~~Low sensitivity to noise and temp change~~
- Simple and fast procedure
- ~~Good conversion accuracy,~~ only one clock required

Disadvantage

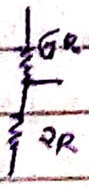
Rapid increase in the no. of comparator ~~with the no~~ with the no. of bit's (2^N-1) comparators' are required for an N bit converter)
- coastly and more resistor is used

⟹ 3 bit flash type ADC

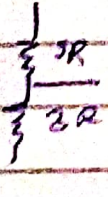
No. of comaparator is used $2^n-1 = 7$
Input of encoder $= 2^n = 8$
No. of resistor $= 2^n = 8$
Encoder $\rightarrow 2^n : 3 \Rightarrow 8:3$
Vin at non inverting terminal
Vref at inverting terminal
if $V_{in} \geq V_{ref} = 1$
if $V_{in} < V_{ref} = 0$

$V_7 =$


$V_7 = \frac{V_{ref}\times R}{7R+R} = \frac{V_{ref}}{8} = \frac{V}{8}$

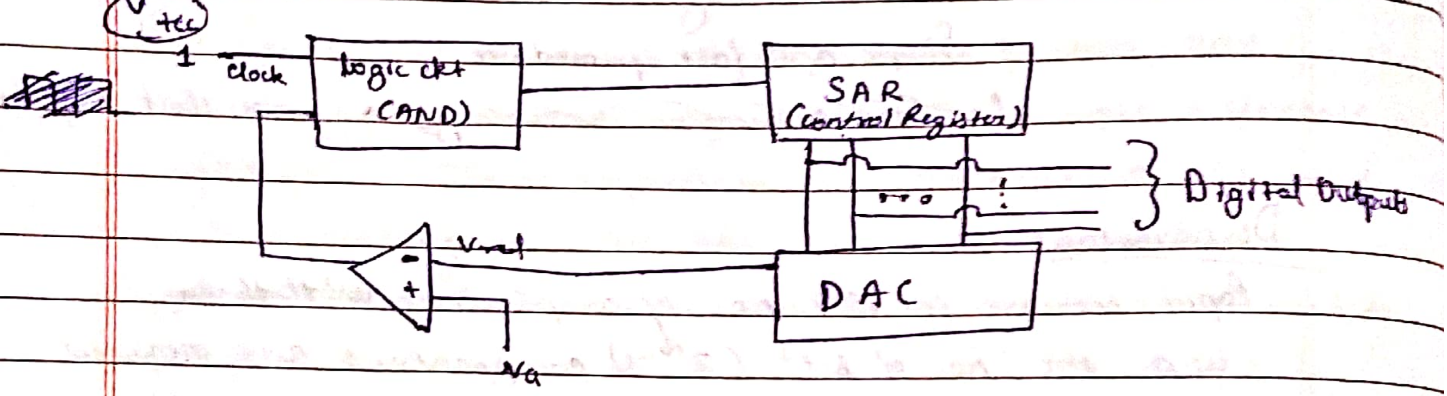
$V_6 =$


$V_6 = \frac{V_{ref}\times 2R}{8R} = \frac{2V}{8R} = \frac{1}{4}V$

$V_5 =$


$V_5 = \frac{V_{ref}\times 2R}{8R} = \frac{3V}{8}$

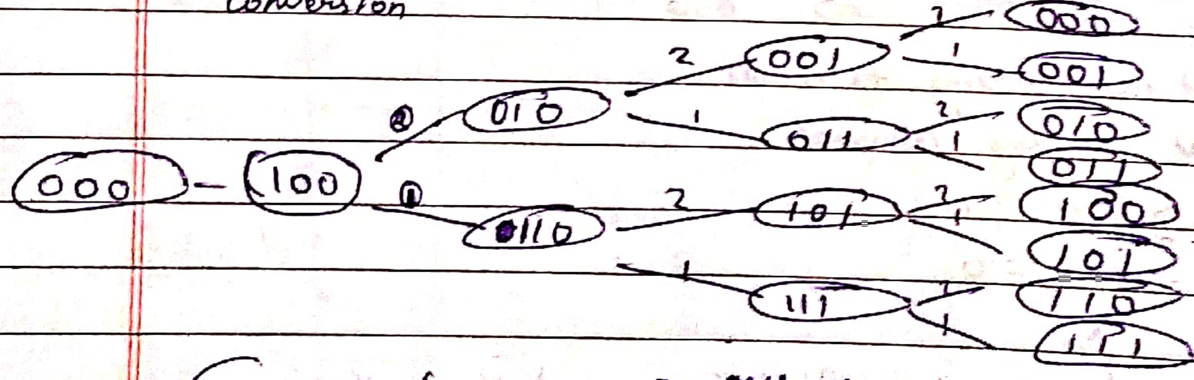
Successive- Approximation A/D Converter



If $V_a > V_{ref}$ = high (1) case 1

$V_a \leq V_{ref}$ = low (0) case 2

A successive Approximation ADC is a type of analog to Digital Converter ~~co~~ that converts a continuous analog waveform into a discrete digital representation using a binary search through all possible quantization levels before finally converging upon a digital output for each conversion



Conversion time = [redacted] n Tclk

= 3 Tclk

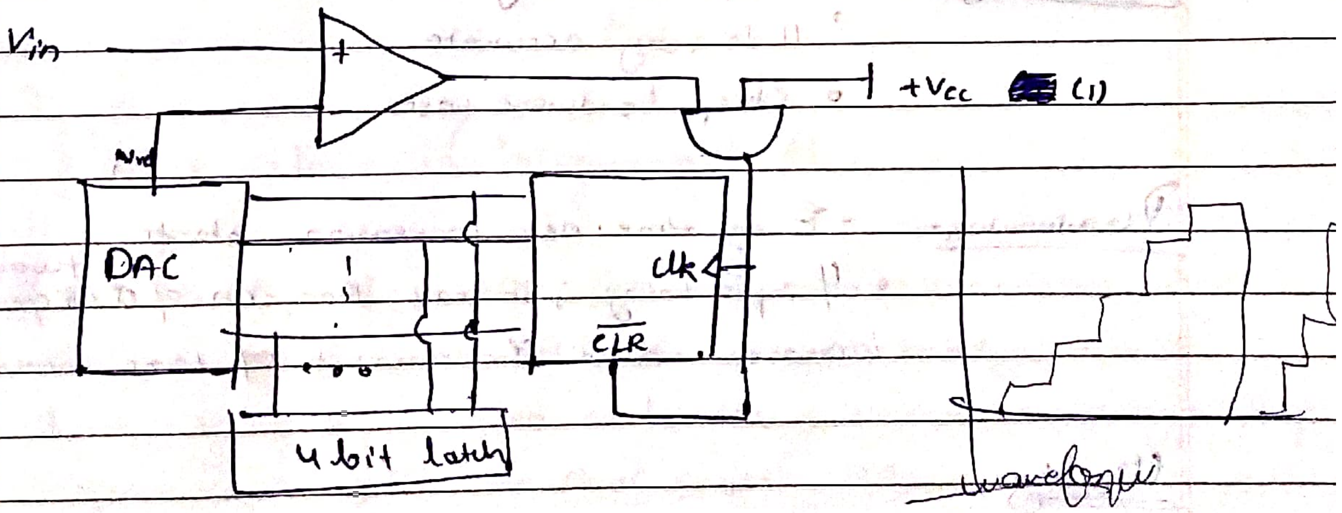
$T = (2^{n}-1)T_{clk}$

Advantages
- Faster than Counter type A/D Converter
- Not effected by amplitude of input voltage
- Low power consumption

Disadvantages
- Ckt is complex in comparison to counter type
- low ~~&~~ Speed (slow) than flash type ~~DAC~~ ADC

Working - If Vin is greater than the output of ~~comparator~~ the DAC (Vref- the most significant bit will stay as it is and the nex bit will be set for a new comparision otherwise If the Vin is less than DAC value the of MSB will set to zero and next bit set to 1 for a new comparasion.

Counter type ADC



A counter type ADC produces a digital output which is approx equal to analog input by using counter operation internally.

- Comparator used in ~~two~~ open loop configuration than it can be used as comparator
  If V_{in} greater than V_{ref} V_{in} at non inverting terminal V_{ref} at inverting terminal So the output of comparator is high.

- Clock generator – generates the clock pulse

- Control logic – ~~logic gate~~ here ~~used~~ work as a ~~clock generator~~ ~~and~~ are reset the Counter and enable the clock signal and send to the counter
- latch – used to store the output of Counter
- DAC – converts the recieved ~~an~~ digital Input and converts into an Analog signal.

Advantages
- Simple and easy to use
- It is very accurate
- Cheap hardware cost

Disadvantages
- Every time new conversion starts
- If input voltage is Increase than no. of ~~clock pulse~~ turns increases. and the amount of time Increases

Working

During the start of conversion the output of DAC is zero So whether input voltage Vin is applied at the +ve terminal of comparator the output of Comparator is high

Since it is high the AND gate is enable and it allow clock pulse to pass. The counter then start counting the clock pulse. The output of Counter is feed to the DAC ~~and~~ which converts the decimal equivalent of its binary input. Now the output of DAC is in form of stair case and Compare with the input V_{in}

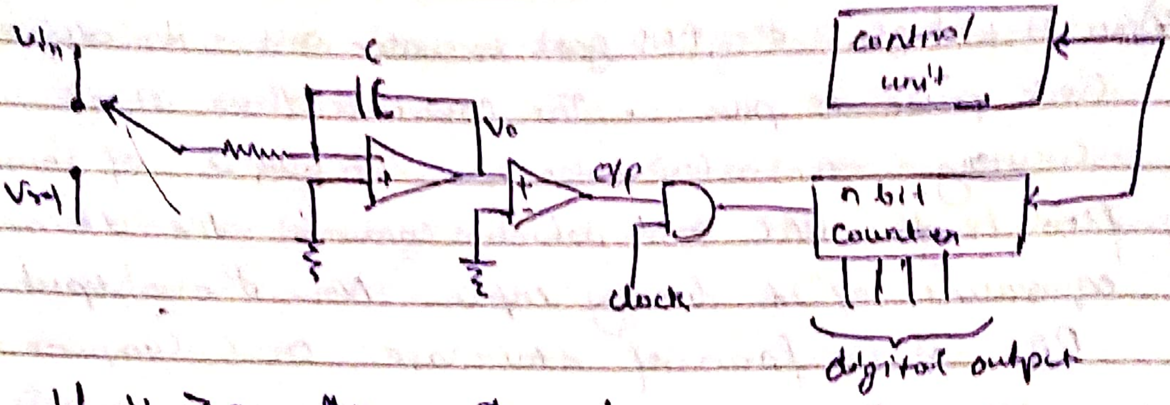
As long as $V_{in} > V_{ref}$ the counter keep countings
If $V_{in} < V_{ref}$ the ~~op~~ output of comparator is low then and gate is disable and clock is o therefore counting will stop and ~~t~~

Conversion time is defined as the time taken by it to convert a given analog to digital signal
$= (2^n - 1) T_c$

Double slope (Integrating) ADC

In Double slope type ADC the integrator generates two different ramps, one with the known analog input Voltage V_A and another ~~and~~ with a reference voltage $-V_{ref}$ Hence it is called as dual slope ADC

In this method one voltage is ~~two~~ in inverse polarity
If V_{in} is +ve then V_{ref} is −ve and vice versa



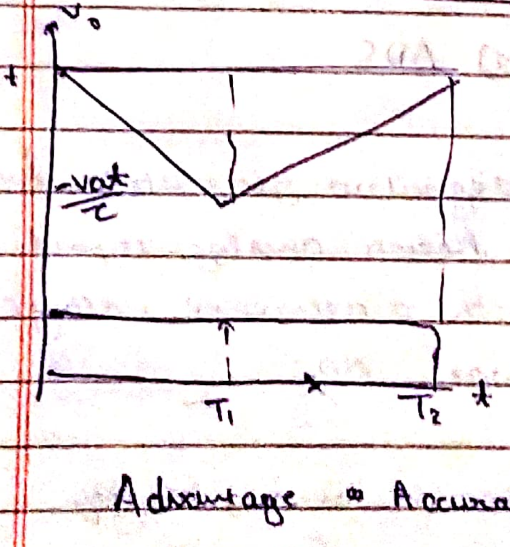
If $V_0 > 0$ ~~[illegible]~~ 1
 $V_0 < 0$ 0

It is consist of Reference voltage, comparator, Integrator, binary counter

$$V_0 = \frac{-1}{RC}\int_0^t V_{in}\,dt = -\frac{V_{in}}{RC}[t]$$

Let $V_{in} = V_a$

$$\boxed{V_0 = -\frac{V_a t}{RC}}$$



$T = 2^{N+1} T$

Advantage • Accuracy Good • Low cost • low sensitivity to noise

Disadvantage • ~~Slowest~~ this process the slowest conversion time

Specification A/DC

1) Range of Input Voltage
2) Input Impedence
3) Accuracy
4) Conversion time
5) Format of Digital output

Example of ICs

ADC 0801
ADC 0802
ADC 0803
ADC 0804 ← Common used range 0 – 5V 8 bit
ADC 080