Analog to digital converter (ADC) is one of the fundamental building blocks of modern data acquisition system. The main purpose of ADC within the data acquisition system is to convert continuous analog signals into a stream of digital data so that data acquisition system can process them for display, storage and analysis

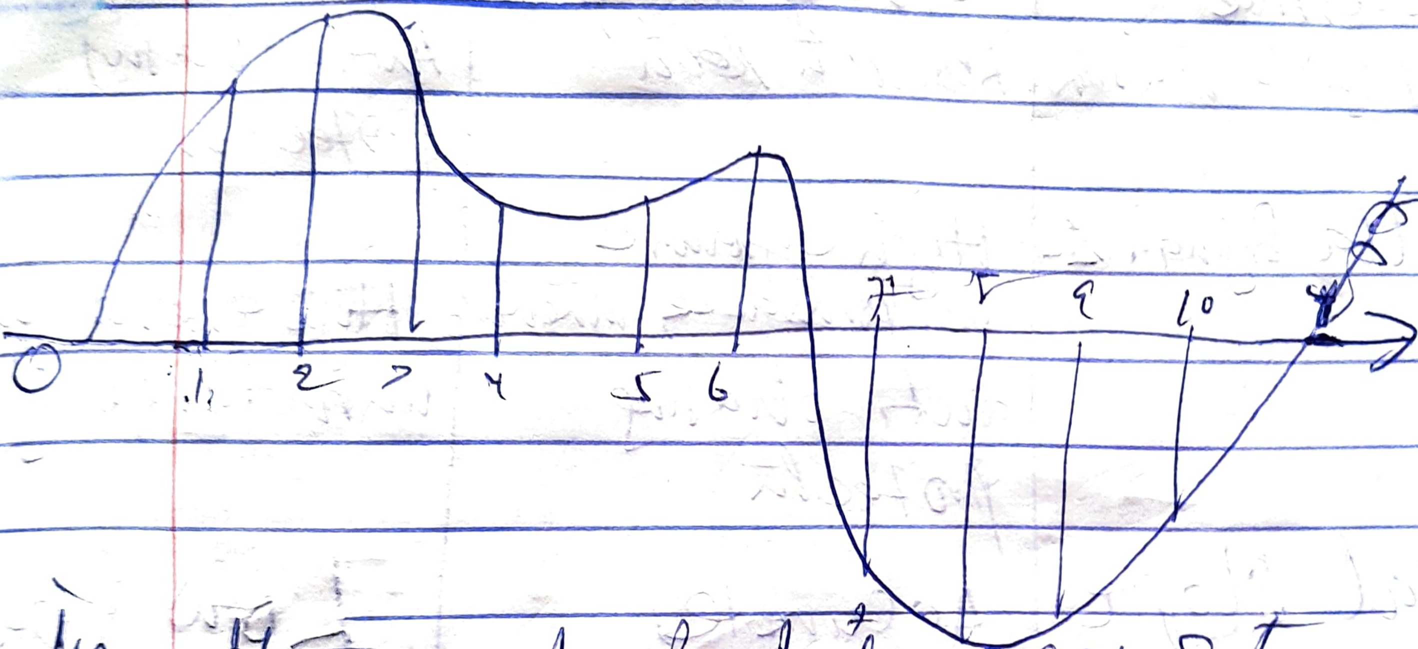
## Main Types of ADC

1. Successive Approximation Converter (SAR) ADC
2. Delta Sigma ($\Delta\Sigma$) ADC
3. Dual Slope ADC
4. Pipeline ADC
5. Flash ADC

# ADC features

1. Sample rate – How fast can an ADC convert analog to digital?
2. Bit Resolution – with how much precision can an ADC convert analog to digital

Sample rate – The rate at which the signals are converted from the analog domain to a stream of digital data is called sample rate, or sampling frequency. e.g. barometric pressure changes slowly over a period of minutes or hrs so you really don't need to sample it more than once per second; on the other hand if you trying to measure RADAR signature, you need to sample hundreds of millions of times per second or perhaps even into billion of samples per second.



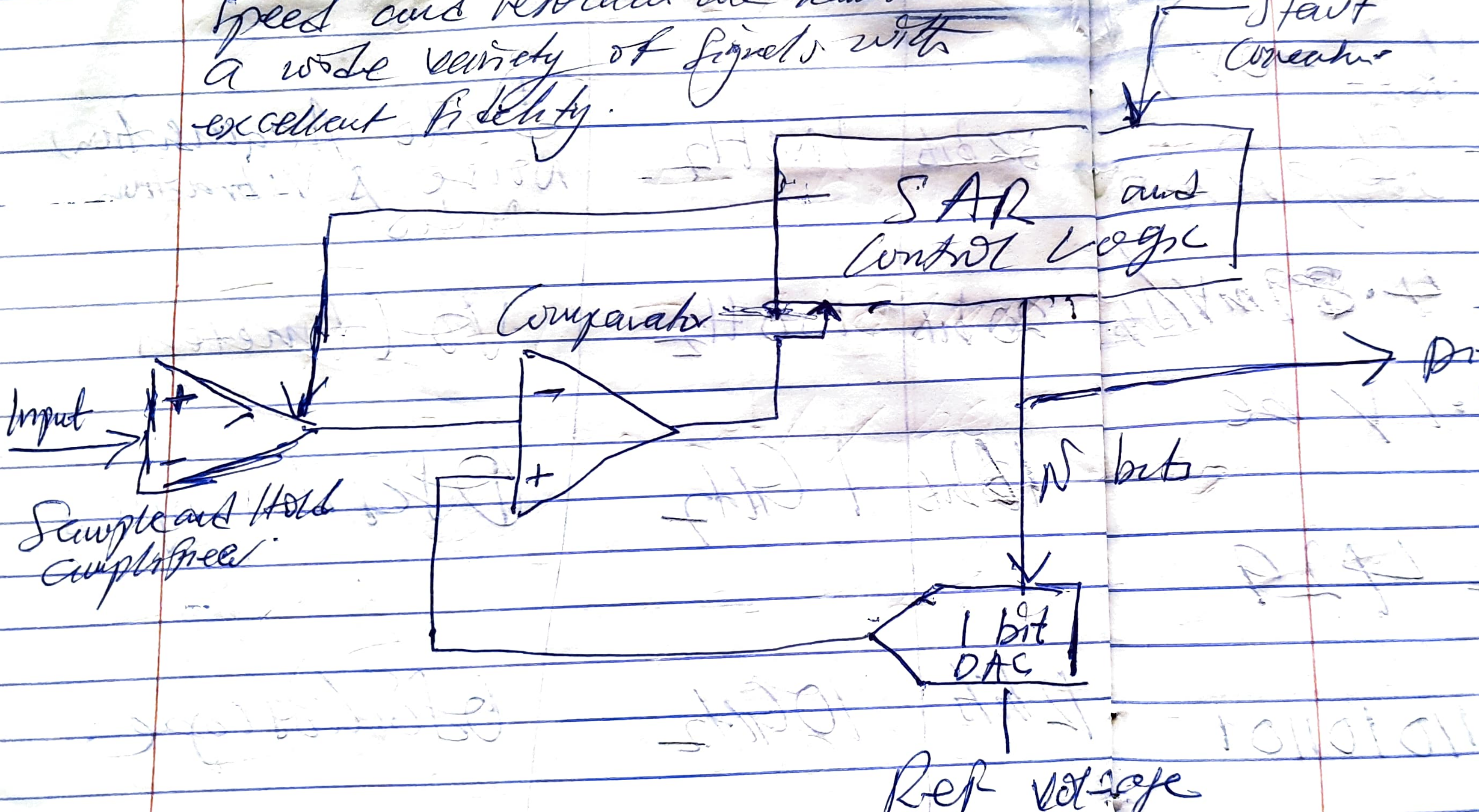

In ~~the~~ world of data acquisition, we measure A.C. voltages, currents, shock vibration, temperature, strain and pressure etc. (Sample rate is blw 200,000 samples per second 200kS/s on average, signal ~~from the~~ & sensor sample value 200kS/s.

# Why Sample Rate Important

# Comparison of Different ADC

| ADC Type | Pros | Cons | Max Res. data | Max Sample Rate | Main Application |
| --- | --- | --- | --- | --- | --- |
| Successive Approximation (SAR) | Good speed/ Resolution Ratio | No inherent Anti-aliasing protection | 18 bits | 10 MHz | Data Acquisition |
| Delta Sigma (ΔΣ) | High dynamic performance, inherent anti-aliasing protection | Hysteresis on unnatural signal | 32 bits | 1 MHz | Data Acquisition, Noise & Vibration, Audio |
| Dual Slope | Accurate, inexpensive | Low Speed | 20 bits | 100 Hz | Voltmeters |
| Pipelined | Very fast | Limited Resolution | 16 bits | 1 GHz | Oscilloscopes |
| Flash | Fastest | low bit Resolution | 12 bits | 10 GHz | Oscilloscope |

Successive Approximation ADC (SAR) - It offers an excellent speed and resolution and handles a wide variety of signals with excellent fidelity.




Block diagram of SAR

A 10 bit ADC is used to sample over the range of 0 to 5 Volts ($V_{ref+} = 5V$, $V_{Ref-} = 0V$)

① What is the step size?
$- 5/2^{10}-1 = 4.89 mV/Step$

② How would 2.1V be encoded?
$- (2.1/4.89mV) = 429$
429 (Binary = 0110101101

③ What voltage would correspond to 321 being returned by ADC?

$= (321) \times 4.89mV = 1.57V$

## Calculate

$$\text{Resolution} = K = \frac{A_{fs}}{2^n - 1}$$

where $A_{fs}$ = Analog Full Scale voltage
$n$ = number of bits

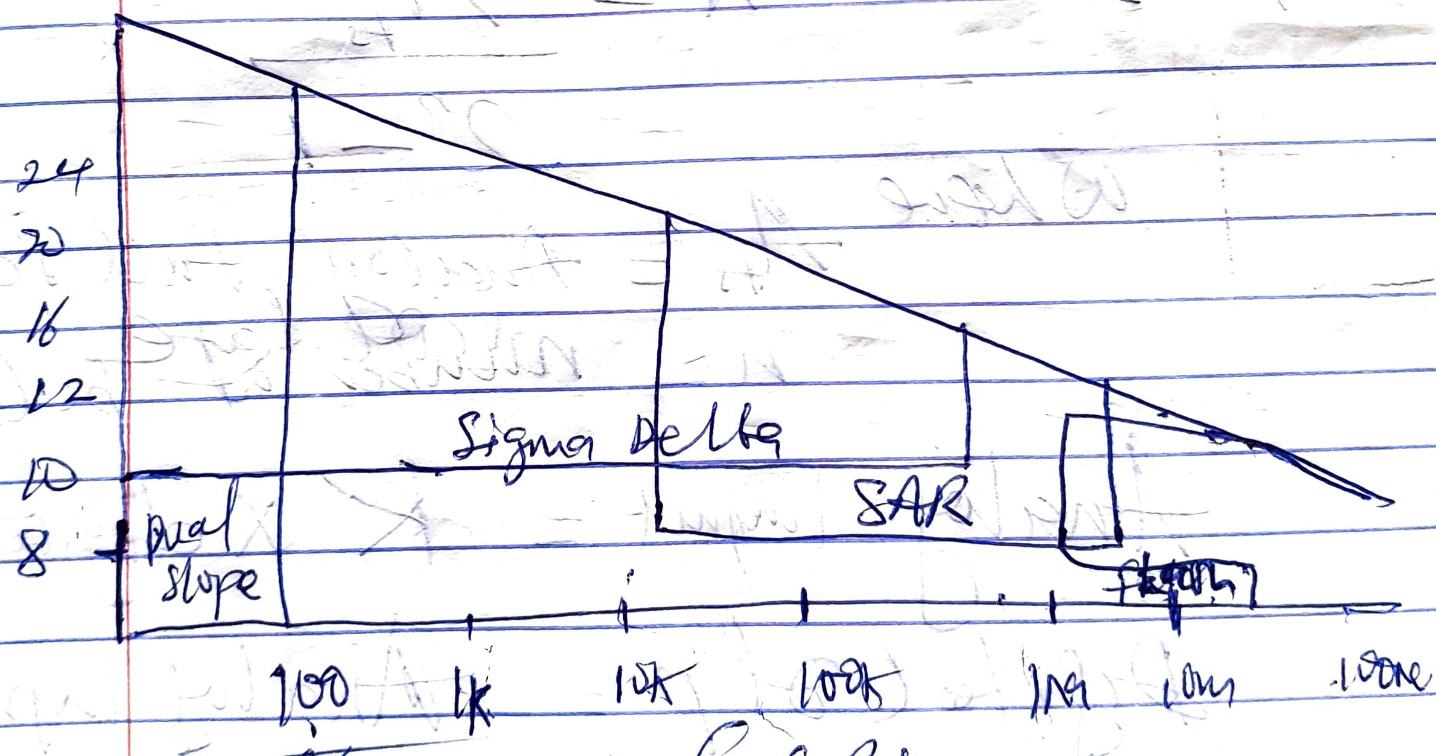
Analog Input = K × digital o/p

$$\text{Digital o/p} = \frac{\text{Analog Input}}{K}$$

Number of voltage level $= 2^n$
Number of voltage steps $= 2^n - 1$

Dynamic Range – It is the ratio of largest (loudest) measurable amplitude

Architecture Vs Bit Bandwidth



A 8-bit is used to sample over the range of 0 to 2 volts. ($V_{Ref+} = 2V$, $V_{Ref-} = 0V$).

1 How would 0.75V be encoded?

2 How would 2V be encoded

3 What voltage would a code of 5 belong to?

4 What voltage would a code of 190 belong to?

Solution

3 A 8-bit ADC is used to sample over a range of 0 to 2V
$V_{Ref+} = 2V$, $V_{Ref-} = 0V$.

1 What is the step size

$$\frac{2}{2^8 - 1} = 7.84mV/step$$

2 How would 0.5V be encoded?

$$\frac{0.5}{7.84mV} = 64$$ (Binary
01000000

~~3 what voltage corresponds to 321~~

3 ~~How~~ would 0.75V be encoded? $= \frac{0.75}{7.84mV} = 96.$

96 (Binary = 01100000)

4 How would 2V be encoded

$\frac{2}{7.84mV} = 255$ (Binary 11111111)

5 What voltage would code 5 belong to $= 5 \times 7.84mV$
$= 39mV$,

6 What voltage would a code of 190 belong to
$190 \times 7.84mV = 1.49V.$

# Flash ADC