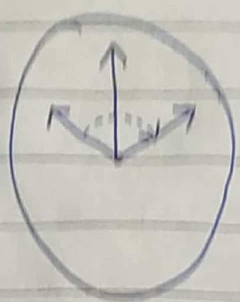
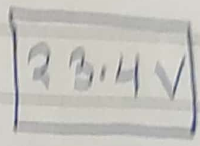
18/01/2021

Unit 5

Electronic Instruments

Analog Instrument | **Digital Instrument**





Electronic Instruments are used to measure different parameters like AC or DC voltage, AC or DC current, resistance, power etc.

There are 2 types of Electronic instruments

1. Analog instrument
2. Digital instrument

1 **Analog Instrument** → The instrument which indicate the parameter with an indicating needle are called analog instrument

2 **Digital Instrument** → The instruments which indicate parameter by means of digits is called ~~Analog~~ digital instrument

Necessary requirement for any measuring instrument :-

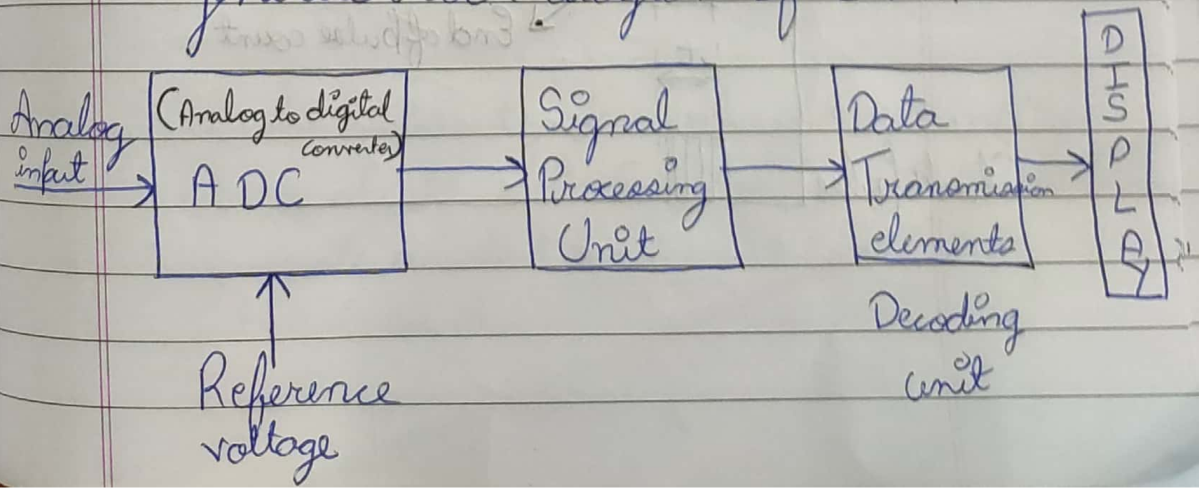
1. with the introduction of instrument in the circuit, parameter should not change (less fluctuation).

2. Power consumed by instrument for their operation should be as small as possible.

DVM (Digital Voltmeter) :-

- A DVM displays the value of AC or DC voltage being measured directly as discrete numeral (usually decimal display).
- The first DVM was invented & ~~introduced~~ produced by Andrew Kay in 1954.
- It is versatile and accurate device which has many laboratory applications.

General block diagram of DVM



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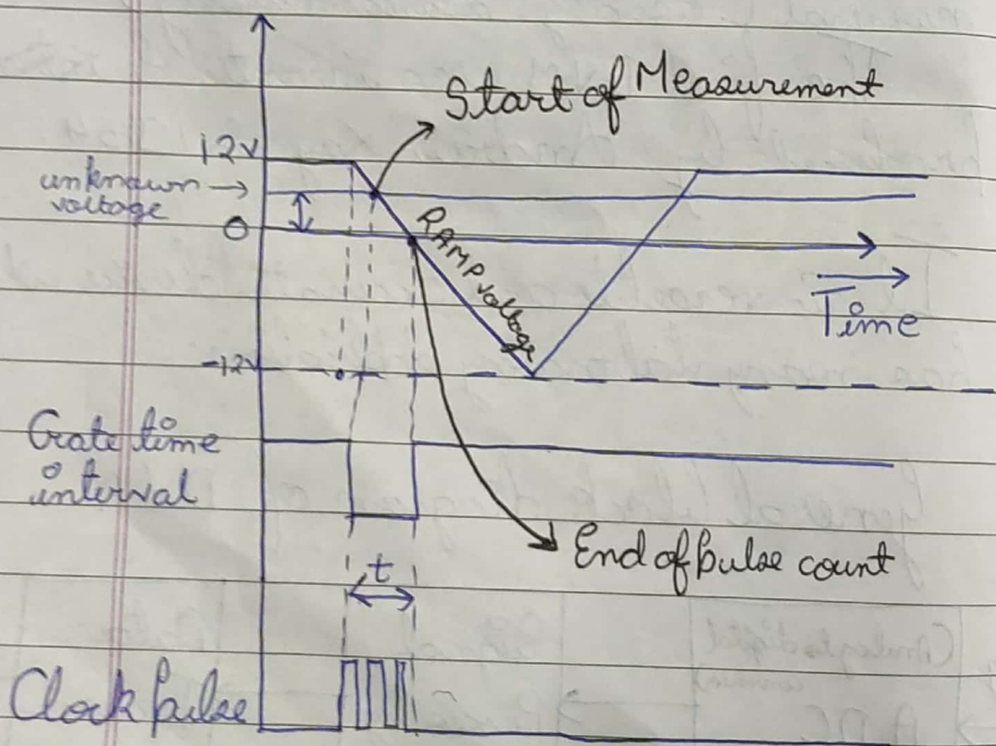
Any digital instrument require ADC as input state. The output of ADC is decoded & processed in decoding stage & output is displayed using digital display device.

Classification of DVM →

1 Ramp type DVM
2 Dual slope DVM
3 Successive approximation DVM
4 Potentiometric Type DVM

1 Ramp Type DVM :-



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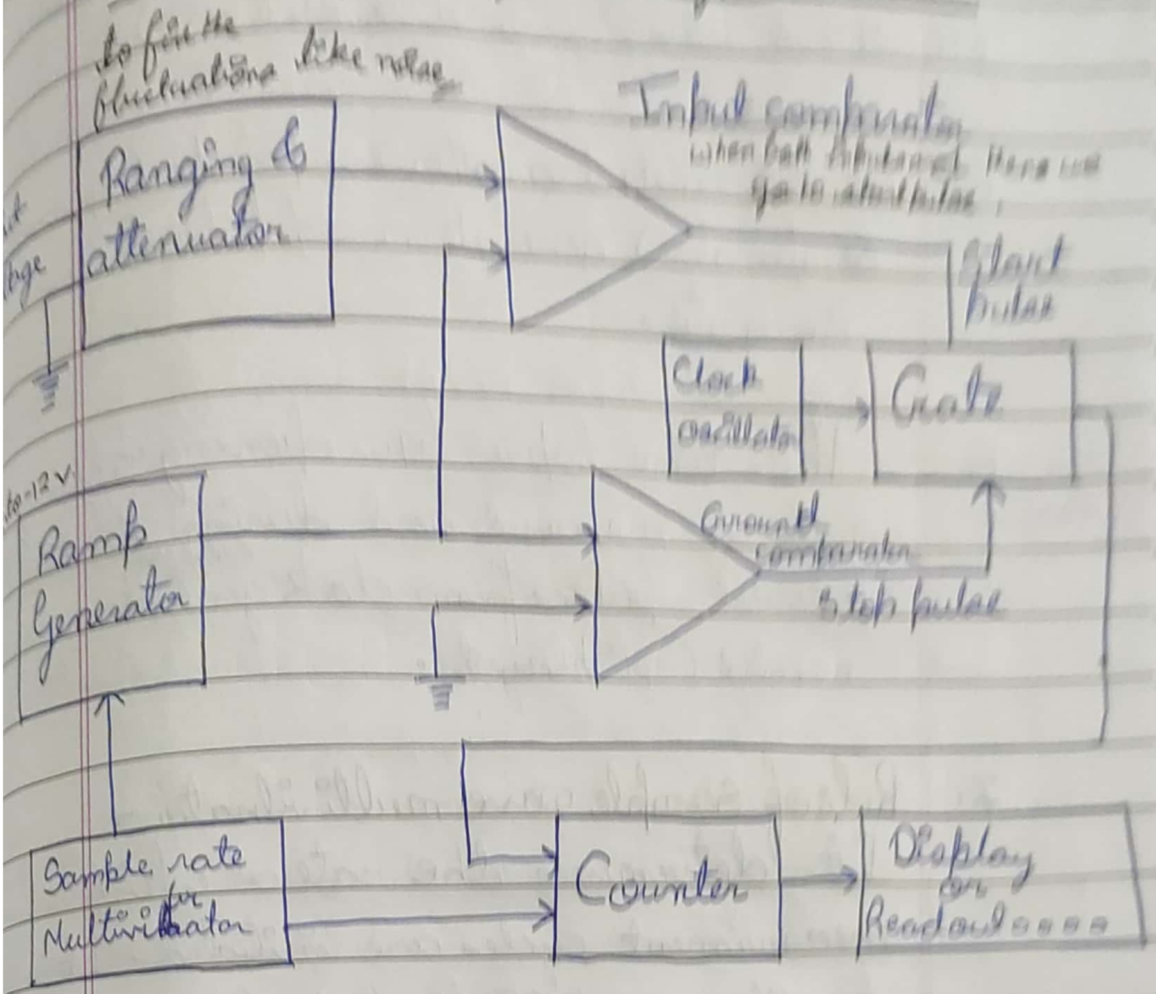
Block diagram of RAMP type DVM :-



1. at the start of measurement RAMP voltage is initiated through RAMP generator.

2. The RAMP voltage value is continously compared with the voltage being measured (unknown voltage)

3. At the instant, the value of RAMP voltage is equal to unknown voltage. Input comparator generate a start pulse which opens the gate b/w clock & counter.

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4. The RAMP voltage continue ~~dec~~ to decrease till it reaches ground level (0V).

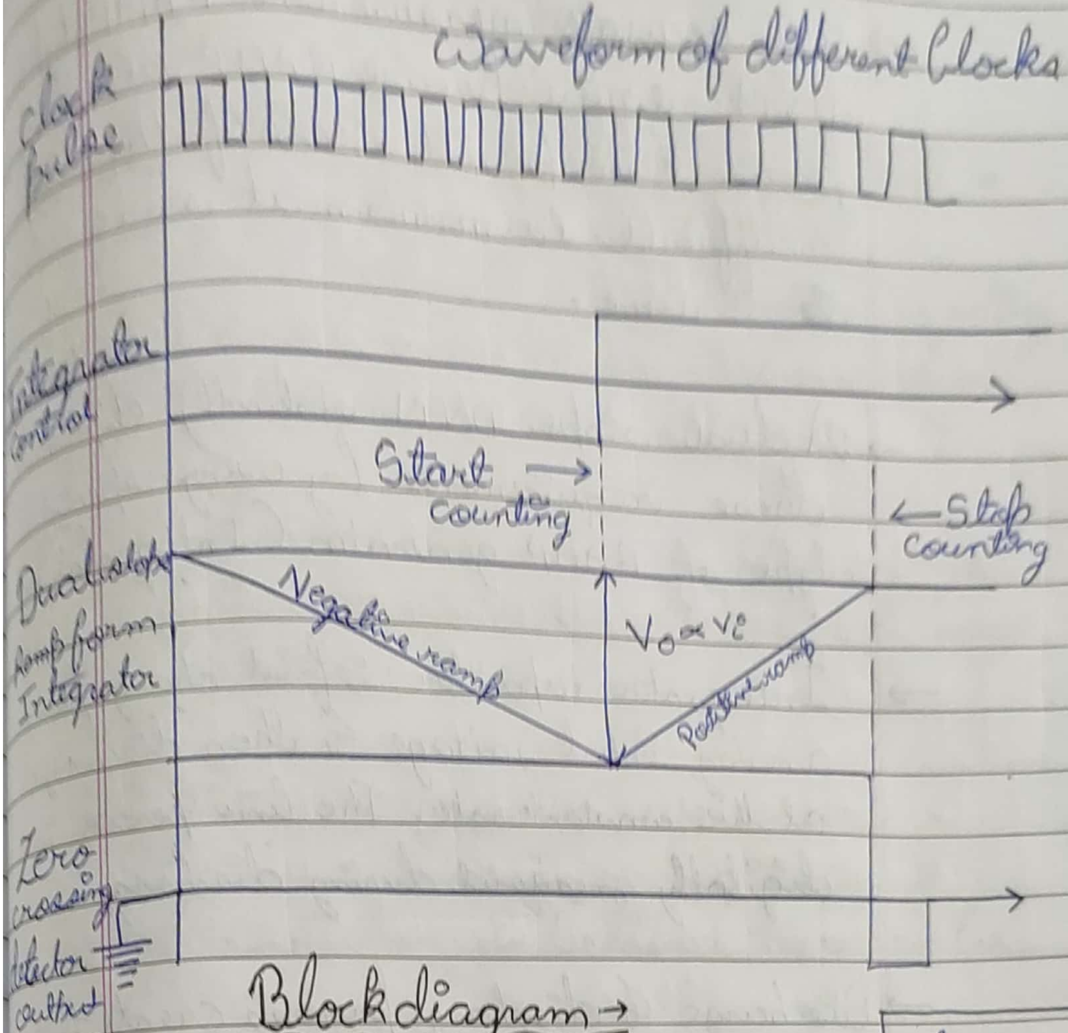
5. at this instant another comparator (ground comparator) generate a stop pulse & close the gate.

6. The time lapse b/w opening & closing gate is measured and during this time interval pulses from clock generator are counted & displayed.

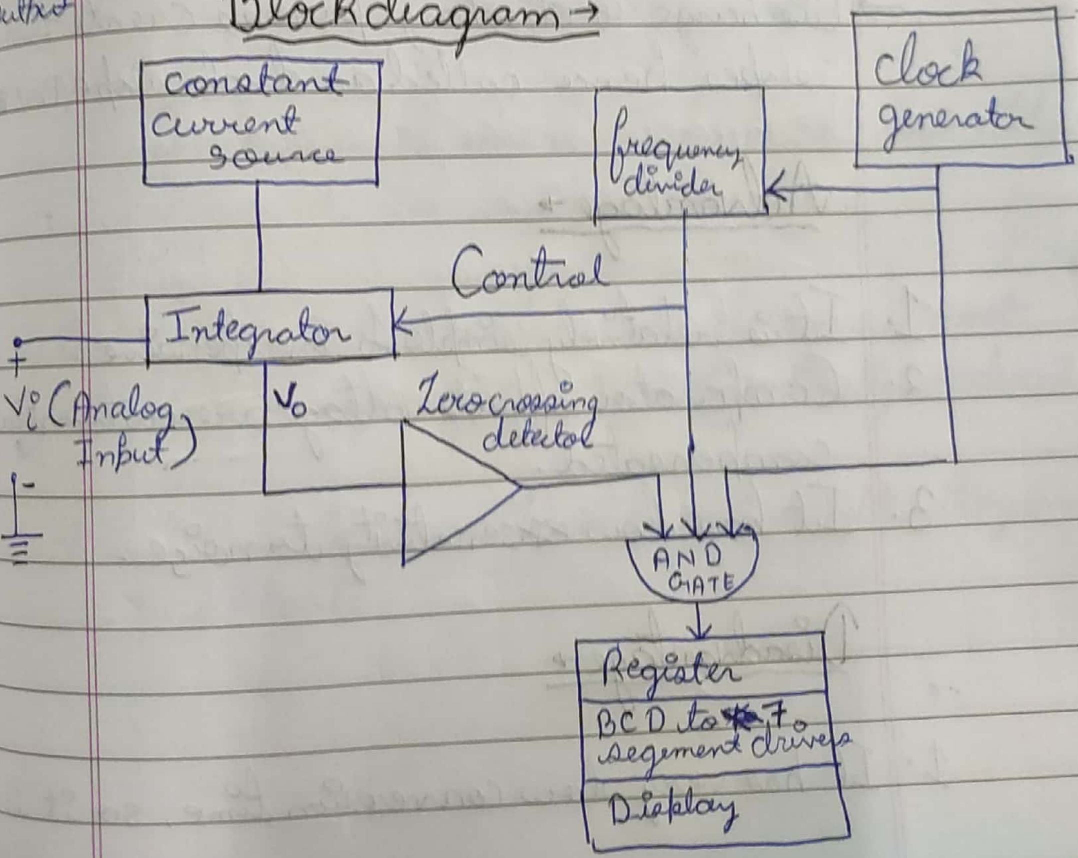
oscillator

7. Role of sample wave multivibrator →
It determines the rate at which measurement cycles are initiated. It provide an initiating pulse for RAMP generator circuit to start ~~RA~~ next RAMP voltage & simultaneously it sends a pulse to reset the counter.

Dual Slope DVM →



Blockdiagram →



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→ For accurate measurement RAMP type DVM require precise RAMP voltage & precise time period. Both of them are difficult to maintain at same time.

→ A dual slope DVM virtually eliminates these requirements by using special type of RAMP generator (Integrator).

→ Integrator capacitor is first charge from analog input voltage & then discharge at the constant rate. The time period is digitally measured during discharge.

→ Discharge & discharge process create two slopes hence called as dual slope DVM

Advantage →

1. It is relatively simple & inexpensive.
2. Comparator offset voltage are automatically compensated.
3. It has low ~~ss~~ sensitivity to noise.

Disadvantage →

1. It has very slow conversion time, so it is

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used only where fast conversion time is not require.

General Advantage of digital voltmeter →

1 due to digital display Human reading errors, parallex errors and incollation errors are reduced.

2 It has wide range of input voltage (1v to 1000v) with automatic range selection.

3 Accuracy is high (±0.005%)

4 Resolution is better (1 μv (micro volt) can be measured on 1 volt range).

5 Input impedence is high approximately equal to 10 Mega ohm.

6 with the development of IC's coast and size of DVM is drastically reduced.

7 Due to small size and weight they are portable.

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Digital Multimeter (DMM) →

- The name of the instrument itself suggest that it is used to measure multiple parameters.

- usually multimeter measures the following quantities → 1) AC / DC voltage
  2) AC / DC current
  3) resistance
  4) It can also be used to test capacitor, diodes & transistors.

- All DMM' employ some kind of ADC (analog to digital convertor) and have a visible readout display and output.

- It can also be interfaced to other suitable devices.

- The basic circuit of DMM is always a digital voltmeter.

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Photo → 20/1/21

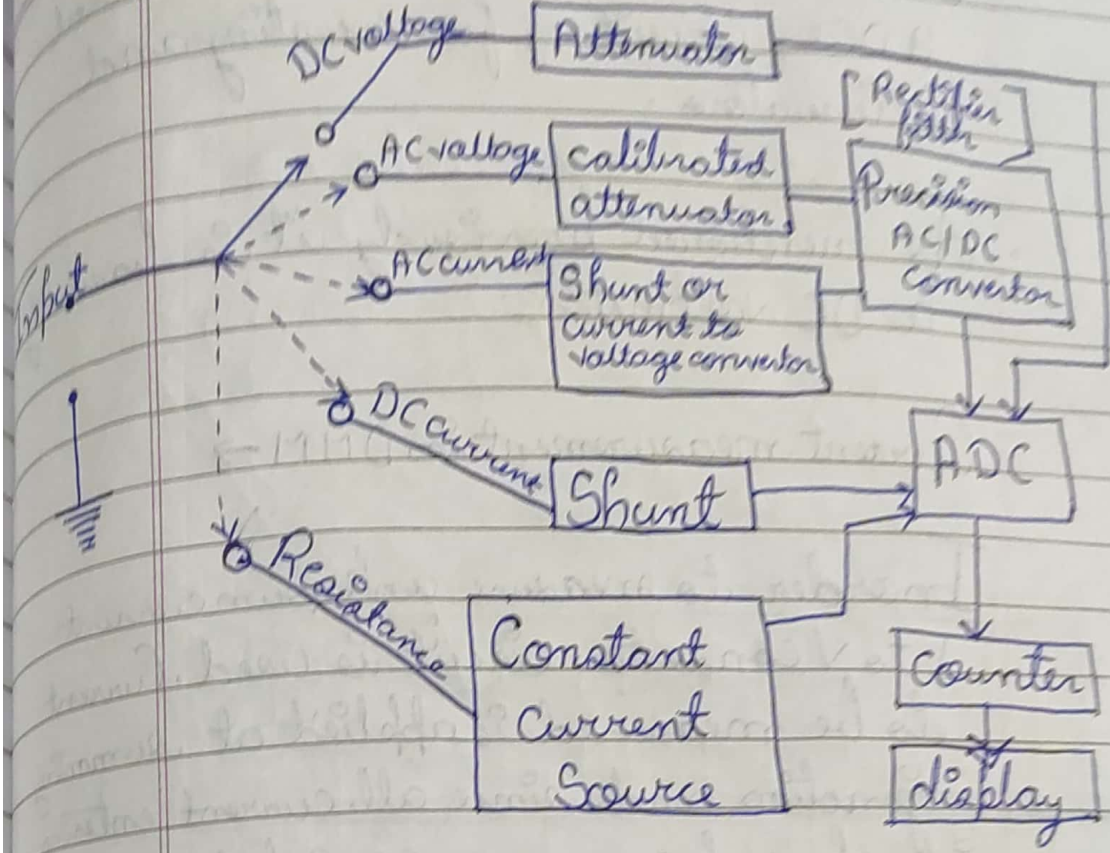

fig:- Block diagram of DMM

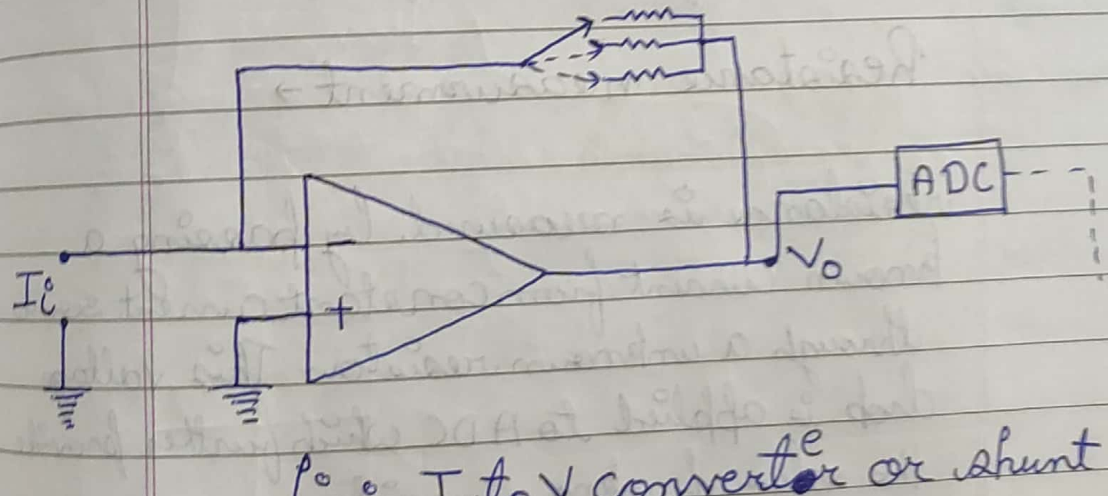

fig:- I to V converter or shunt

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- A basic DMM is made with several ADCs, circuitary for counting and attenuators.

- As mentioned previously it is basically a DC valtmeter.

Current measurement in DMM →

Inorder to measure unknown current I to V converter circuit is used. Current to be measured is applied at summing junction and since all current entering into op-amp are zero, so input current is equal to feedback current ($I_i = I_f$) which cause voltage drop across resistance. This voltage drop is given to ADC

Resistance measurment →

resistance is measured by passing a known current from constant current source through a unknown resistor. This voltage drop is applied to ADC which further provide the value of unknown resistance.

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AC voltage measurement →

To measure AC voltage precision AC to DC convertor stage is added, which is made with combination of rectifier and filter. The DC output is then applied to ADC.

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Cathode Ray Oscilloscope (CRO) →

- CRO is very useful & versatile laboratory ~~memory~~ equipment used for analysis of measured wave form.

- CRO is very fast X-Y plotter it display input signal v/s another signal wrt time.

- The "Stylus" of this plotter is a luminous spot which move over display area in response to the input signal.

- The luminous spot is produced by a beam of electrons striking fluorescent screen.

- This spot moves very fast on the screen

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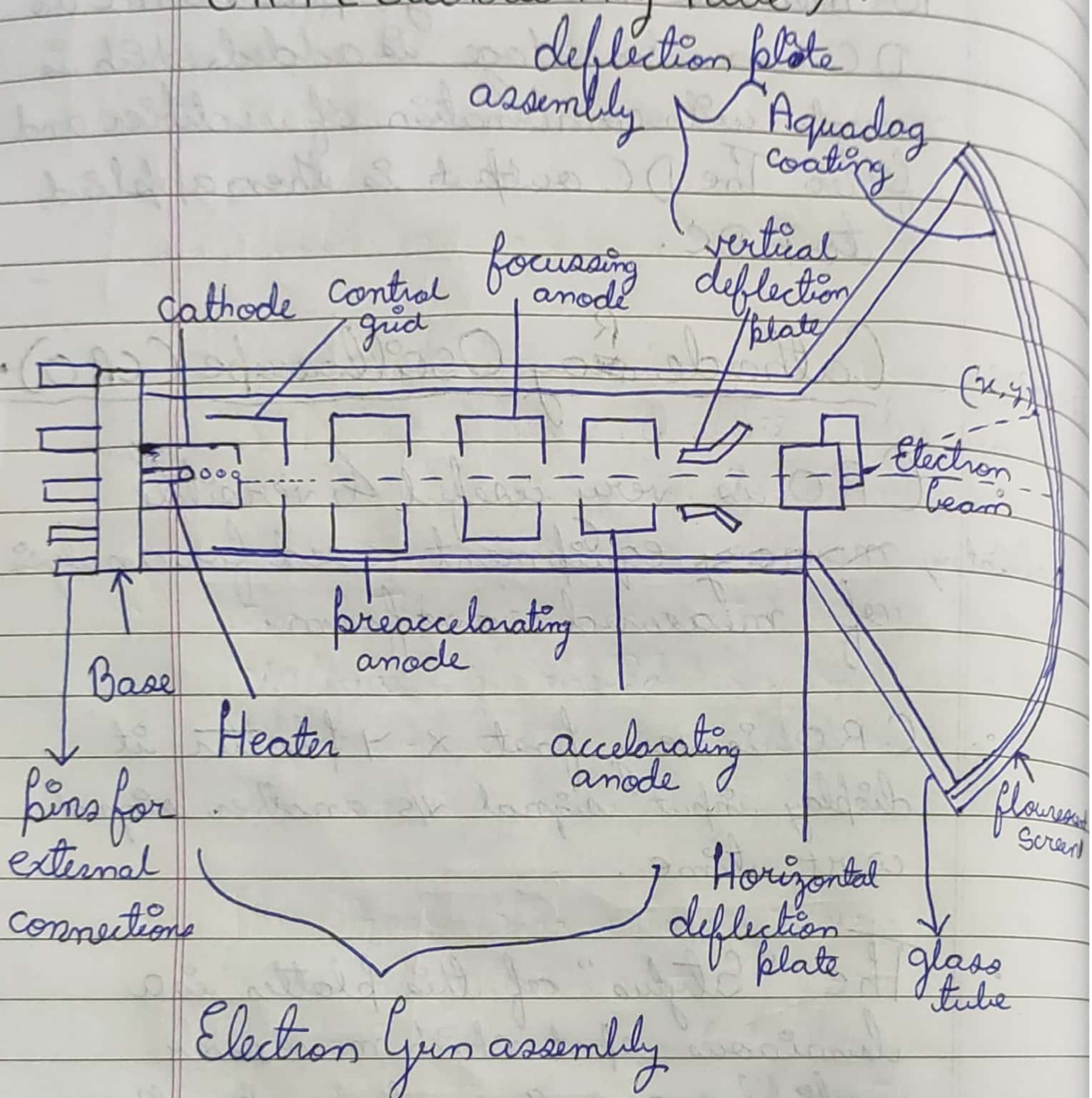
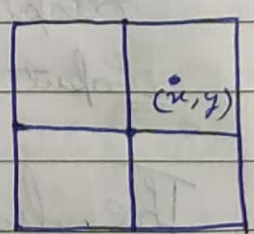
So we feel that a continous wave form is being displayed.

CRT (Cathode Ray Tube) →





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- CRT is a heart of CRO it performs following functions →

1. it generates an e^- beam
2. It moves the e^- beam vertically & horizontally.
3. It displays the input wave form on CRO screen

- The main part of CRT are - 1. e^- gun assembly, 2. deflection plate assembly 3. flourescent screen. 4. glass angular

1. Electron gun assembly → it provides a sharply focused e^- beam directed towards flourescent coated screen.

- This section start from thermally heated cathode. It emits e^-.

- The control grid has -ve potential w.r.t cathode. This grid controls the no of e^-s in the beam going towards screen.

- The e^- beam is then passed to a set of accelarating & focussing anodes. The e^- beam is accelorated through high +ve voltage applied to anode.

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Focussing anode sharpens the e^- beam.

2. Deflection Plate assembly →

- accelarated & focussed e^- beam is then passed through vertical & horizontal deflection plate.

- The deflection system of CRT consist of 2 pairs of parallel plate referred as horizontal or vertical deflection plate.

- An internally generated saw tooth voltage is applied to the horizontal deflection plate to deflect the beam in x- direction.

- The signal which is to be displayed is applied to vertical deflection plate.

- The simultaneous force is exerted in x and y direcⁿ will deflect the beam towards screen.

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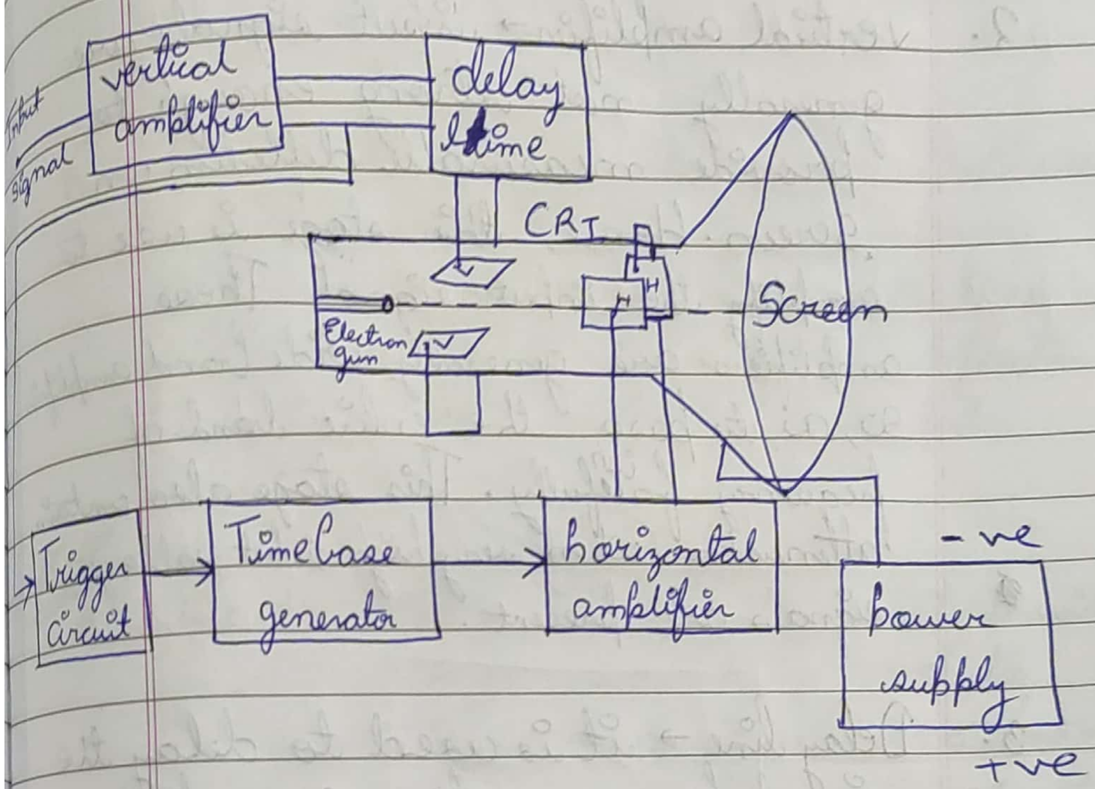
Block diagram of CRO →



- The major blocks of CRO are →

1. CRT [cathode Ray Tube]
2. vertical amplifier
3. delay line
4. Trigger circuit
5. Time base generator
6. Horizontal amplifier
7. Power Supply.

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1. CRT → it is use to emit e^- required to strike the phosphor screen to produce a luminous spot for visual display of waveform.

2. vertical amplifier → input signals are generally not strong enough to provide measurable deflection on screen. Hence, this stage is use to amplify the input signal. These amplifiers are generally wide band amplifier so, as to pass the entire band of frequency faithfully. This stage also contain attenuator when very high input voltage signals are present.

3. Delay line → it is used to delay the signal for some time in vertical section when delay line is not used part of signal may get lost.

4. Trigger circuit → It is necessary that horizontal deflection start at the same point of the input at vertical section. For this syncronization trigger circuit is required.

5 Time base generator → it generate saw-tooth voltage require to deflect the beam in the horizontal direction this voltage deflects the spot at a constant time dependent rate. Thus x-axis on the screen can be represented as time with the help of time base generator.

6 Horizontal amplifier → The saw-tooth wave produced by time base generator may not be ~~of~~ of sufficient strength. Hence before giving it to horizontal deflection plate it is amplified by horizontal amplifier.

7. Power Supply → The power supply provides the voltage required by CRT to generate and accelerate an e^- beam and voltage required by other circuits of oscilloscopes like, horizontal & vertical amplifiers, time base generator etc.

CRO Measurement →

1 voltage measurement → The most direct voltage measurement with the help of CRO is peak to peak voltage (V_{PP}). The RMS value of the voltage is given by dividing V_{PP} by $2\sqrt{2}$ following steps

are used to measure voltage from CRO:-

Step① observe the selection of volt per division from the front panel.

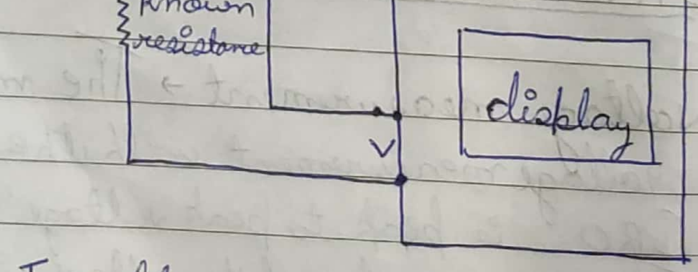
Step② adjust signal on screen so that it became easy to count no of division correspond to signal.

Step③ peak to peak value of voltage is computed as (no of divisions) × $\left(\frac{\text{volt}}{\text{division}}\right)$

$$V_{pp} = (\text{no of divisions}) \times \left(\frac{\text{volt}}{\text{division}}\right)$$

$$\boxed{V_{rms} = \frac{V_{pp}}{\sqrt{2}}}$$

2 Current Measurement →



$$I = \frac{\text{voltage measured at CRO}}{\text{known resistance}}$$

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A CRO is basically a valtoge indicating device hence to measure the current it is passed through a known resistan-ce. The valtoge drop across resistance is measured by CRO.

$$I = \frac{\text{Valtage measured at CRO}}{\text{known resistance}}$$

3 Time period & frequency Measurement →
Time period and frequency of a periodic signal are easily measured with a CRO. The wave form must be displayed such that the complete cycle is present on screen. The time period and frequency are measured by following formula's →

$$\text{Time Period } (T) = \left(\begin{matrix}\text{no of divisions} \\ \text{in one cycle}\end{matrix}\right) \times \left(\frac{\text{Time}}{\text{division}}\right)$$

$$\text{Frequency } (f) = \frac{1}{T}$$

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