Module 3 Special purpose measuring instruments

Single phase electrodynamometer type Power factor meter

It consists a fixed coil (current coil) . This coil split into two parts and carries the current of the circuit under test. Therefore the mag. Field produced by this coil is proportional to the main current. Two identical pressure coils A and B pivoted on spindle constitute the moving system. Pressure coil A has a non inductive resistance R connected in series with it, and coil B has a highly inductive choke coil L connected in series with it. The two coils connected across thee voltage of the circuit. The current through the coil A is in phase with circuit voltage while that through coil B lags the voltage by an angle equal to 90deg . The angle between plane of coils is also made equal to 90deg.

There will be two deflecting torque , one on coil A and other on coil B. The coil windings so arranged that the torques due to the two coils are opposite in direction. Therefore the pointer will take up a position where these two torques are equal.

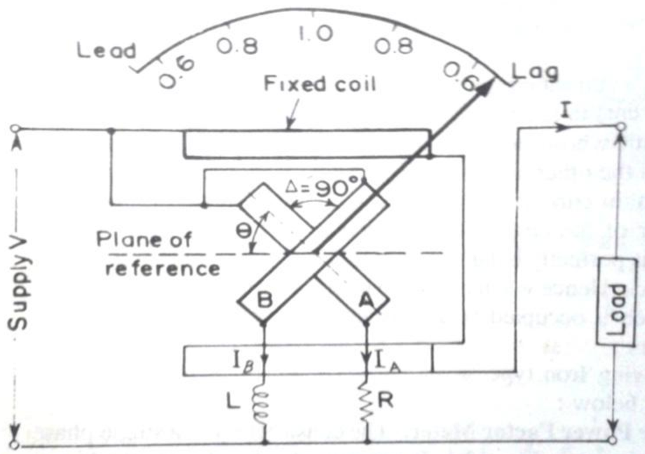


Fig. 13.1. Single phase electrodynamometer type power factor meter.

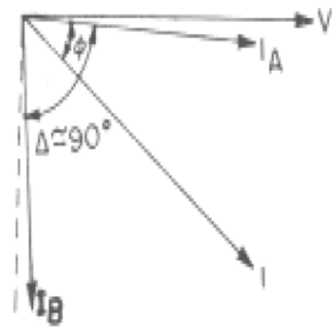


Fig. 2. Phasor diagram of Fig.1

Deflecting torque on coil A

$$T_A = KVIM_{max} \cos\varphi \sin\theta$$

Where M_{max} = maximum mutual inductance

Deflecting torque on coil B

$$T_B = KVIM_{max} \cos(90 - \Phi)\sin(90+\Theta)$$

$$= KVIM_{max} \sin\varphi \cos\theta$$

Hence at equilibrium , $T_A = T_B$

$$KVIM_{max} \cos\varphi \sin\theta = KVIM_{max} \sin\varphi \cos\theta$$

$$\Theta = \Phi$$

Thus the deflection of the instrument is a measure of phase angle of the circuit. The scale of the instrument can be calibrated in directly in terms of power factor

Three phase electrodynamometer type Power factor meter

This meter is only used for balanced load

The two moving coils are so placed that angle between their planes is 120deg. They are connected across two different phases of the supply circuit. Each coil has a series resistance.

Voltage applied across coil A is V_{12} and its current I_A is in phase with V_{12}.

Voltage applied across coil B is V_{13} and its current I_B is in phase with V_{13}.

Φ = phase angle of the circuit

Θ = angular deflection from the plane of reference

V1 = V2 = V3 = V

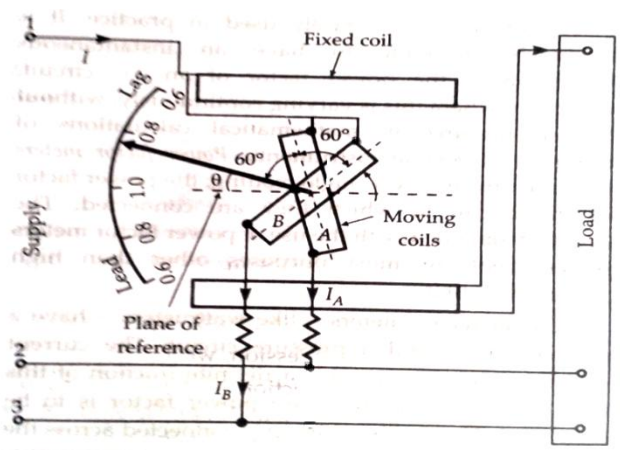
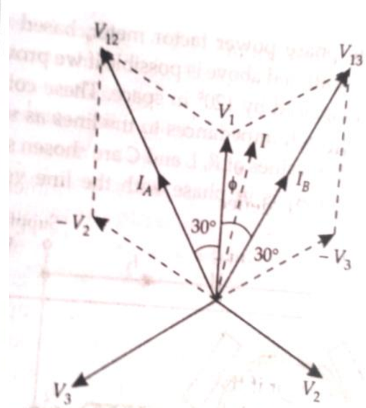


Fig. 13.3 Three phase dynamometer type factor meter.



4 Phasor diagram for Fig. 13.3.

Torque acting on coil A is

$$T_A = KV_{12}IM_{max}Cos\ (30 + \Phi)\sin(60 + \Theta) = \sqrt{3}\ Kvim_{max}\cos(30 + \Phi)\sin(60 + \Theta)$$

Torque acting on coil B is

$$T_B = KV_{13}IM_{max}Cos\ (30 - \Phi)\sin(120 + \Theta) = \sqrt{3}\ Kvim_{max}\cos(30 - \Phi)\sin(120 + \Theta)$$

At equilibrium position

$$T_A = T_B$$

$$\sqrt{3}\ Kvim_{max}\cos(30 + \Phi)\sin(60 + \Theta) = \sqrt{3}\ Kvim_{max}\cos(30 - \Phi)\sin(120 + \Theta)$$

Solving above equ.

We have $\Theta = \Phi$

Thus the angular deflection of pointer is equal to the phase angle of the circuit. The scale of the instrument can be calibrated in directly in terms of power factor

Synchroscope

Electrodnamo meter type Synchroscope – (Weston type)

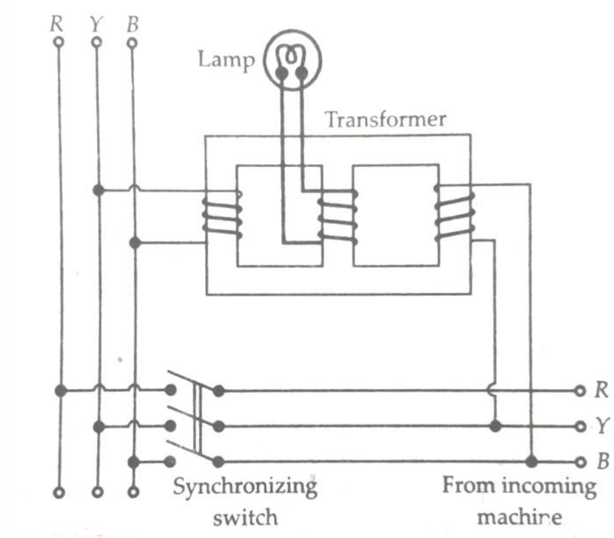


Fig. 13.19 Weston type synchroscope.

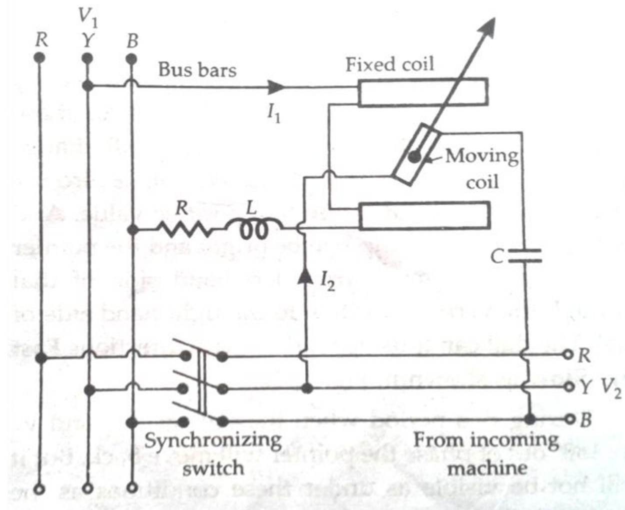
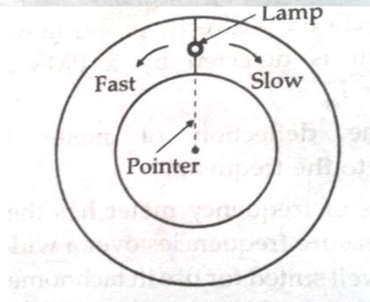


Fig. 13.20 Weston type synchroscope.



Dial of Weston synchroscope.

Condition for synchronizing a machine with bus bar

1, machine voltage are equal in magnitude

2, both are same frequency

3, should be inphase

Working

When the bus and incoming machine voltage are in phase , the two flex s through centre limp are additive . Thus the emf induced in centre limp winding is maximum , hence the lamp glow with maximum brightness.

When two voltages are 180deg out of phase , the resultend flux is zero. Hence no emf induced and lamp does not glow.

If the frequency of incoming machine is different from that of the bus bar , the lamp will flicker.

The correct instant of synchronizing I when lamp flickering at very slow rate and at maximum brightness.

If V1 and V2 are in phase , difference between current I1 and I2 become 90deg , at that instant

Torque = $i_1 i_2 \cos 90$ = 0 ie, no torque acting on the moving coil. Ie the pointer will be in central position.

If incoming machine is too fast V2 will lead V1 by some angle Θ and torque = KI1I2cos (90+ Θ) similarly if machine is too slow V2 lags V1 by Θ deg and hence torque = KI1I2cos (90 - Θ). Ie a torque acting on moving coil, hence the pointer indicates slow or fast position.

Phase sequence indicator

Rotating type

It consists 3 coil mounted 120deg apart and the coils are star connected and are excited by the supply whose phase sequence is to be determined. An aluminium disc is mounted on top of the coil. The coil produce a rotating magnetic field and eddy emf induced in the disc, this emf cause eddy current to flow in the aluminium disc. A torque is produced with the interaction of eddy current with mag. Field. The revolution of disc depends on the phase sequence of the supply . An arrow indicates the direction of rotation of disc. If the direction of rotation same as that indicated by the arrow head , the phase sequence of supply is same as marked on the terminals of the instrument.

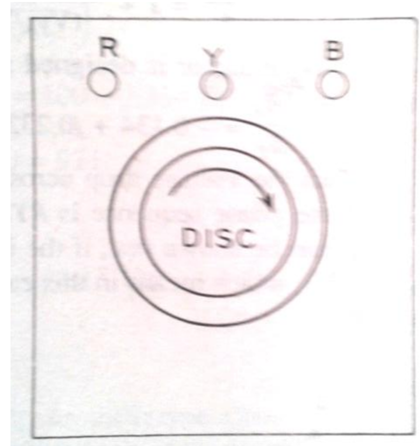


fig. Phase sequence indicator

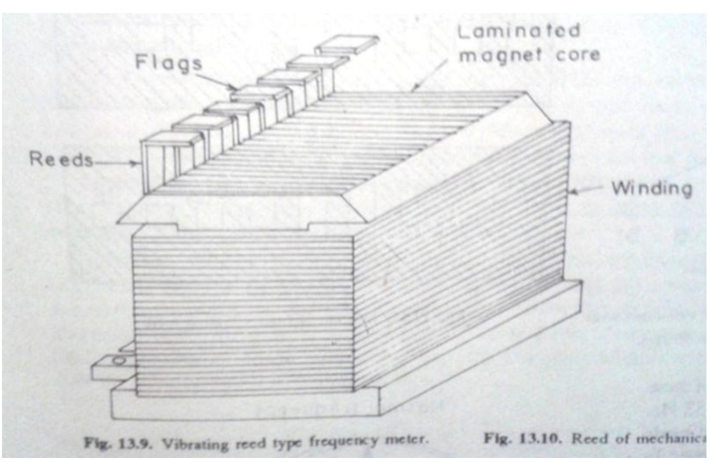
Frequency meters

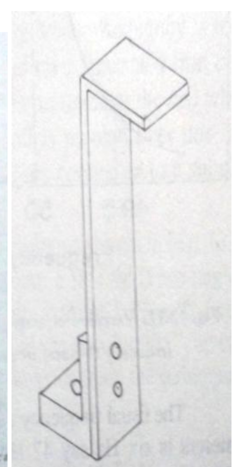
1, Mechanical resonance type (Vibrating reed type)

2, Electrical resonance type

Mechanical resonance type

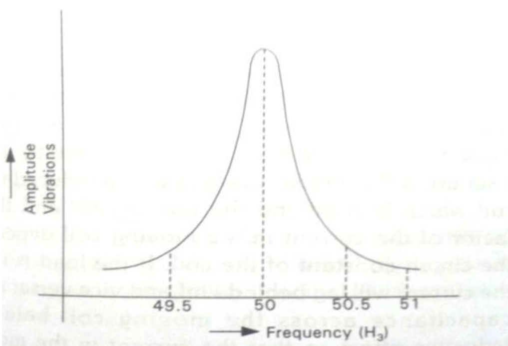
Vibrating reed type frequency meter





In this meter many thin and flat steel rods or strips called reeds are arranged along side and close to an electromagnet. The normal dimensions of the reed are 4mm wide and 0.5mm thick and differ in size with one another in length.

When the instrument is connected across the supply, an alternating current flux is setup and produce attractive force for every half cycle. The reed whose natural frequency corresponding to supply frequency respond and vibrate with maximum amplitude. The variation of amplitude of vibration with frequency for 50Hz is shown in figure.



. 4.2 Variations of Amplitude of Vibration for 50 HZ

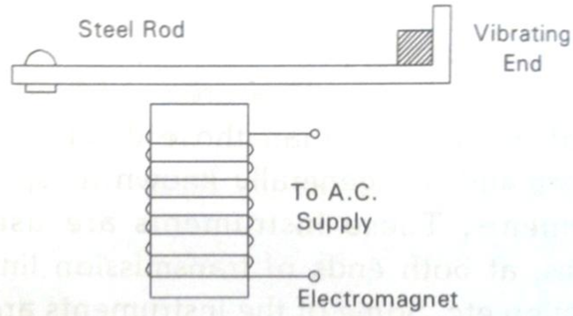


Fig. 4.1 Arrangement of Reeds

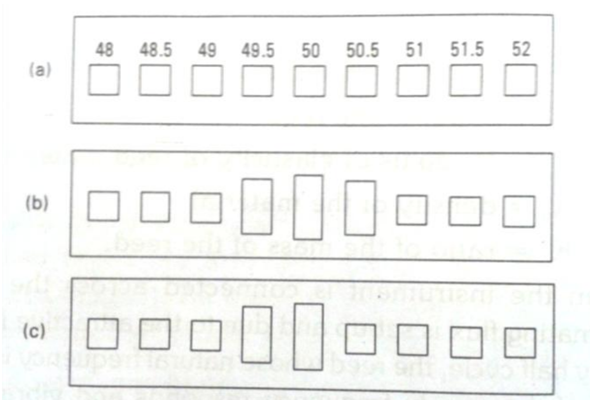


Fig. 4.3 Readings of Frequency

Electrical resonance type frequency meter

Ferrodynamic type frequency meter

It consists a fixed coil (magnetizing coil) which is connected across the supply whose frequency is to be measured . This coil is mounted on a laminated iron core , the iron core has a cross section which varies gradually over the length, maximum at the end where magnetizing coil is mounted and minimum at the other end . A moving coil is pivoted over the iron core and a pointer is attached to the moving coil. The terminal of the moving coil are connected to suitable capacitor.

At resonance condition inductive and capacitive reactance are equal ie $X_L = X_C$. In such condition circuit is purely resistive. So the reflecting torque = zero(Td = 0). If frequency less or greater than normal frequency (resonance frequency) there is a deflecting torque produced in moving coil , which tries to pull the moving coil to an equilibrium position, that is a position where $X_L = X_C$

$X_L = 2\pi f L$ ie. $X_L \sim f$

$X_C = \frac{1}{2\pi f C}$ ie $X_C \sim 1/f$

Case 1

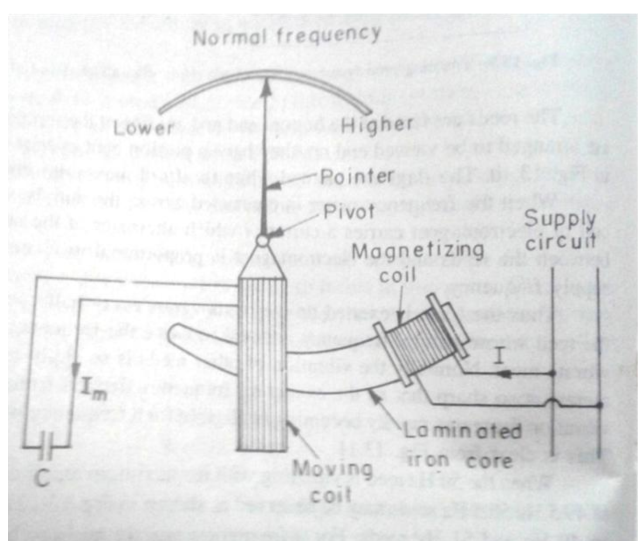


Fig. 13.13. Electrical resonance frequency meter (Ferro-dynamic).

If f > fn (normal frequency)

In such condition X_L will be greater than X_C ($X_L > X_C$), Hence there is a torque produced on moving coil this torque moves the coil to a position inductive reactance tends to become lesser and equal to capacitive reactance . That is moving coil move towards the shorter cross section region of the iron core.

Case 2

If f < fn

The inductive reactance X_L become less than X_C ($X_L < X_C$) hence there is a torque produced, this torque moves the coil to a position where inductive reactance tends to become larger and equal to capacitive reactance, therefore moving coil deflects towards the magnetizing coil.

Earth tester

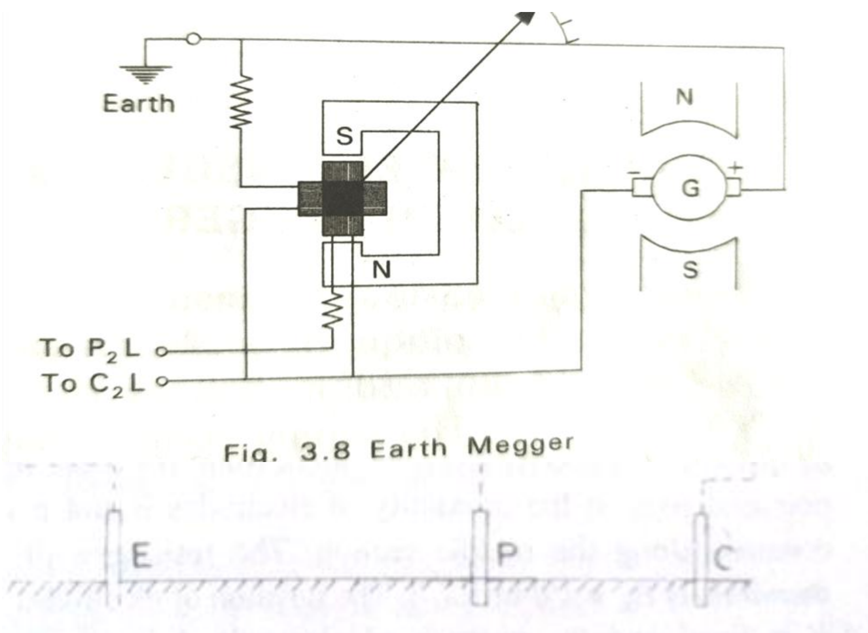


Fig. 3.8 Earth Megger

Earth tester is a special type of megger. it is used to measure earth resistance. it has hand driven DC Generator and Ohm meter.

Earth tester has 3 terminals Earth,,P2, &C2. Earth point is connected to earth electrode "E". Other two terminals P2 and C2 connected to auxiliary terminals P and C electrodes respectively.

Indication of the earth tester depends upon the ratio of voltage across the pressure coil and current through the current coil.

Quantity of pressure coil α V and that of current coil α I

Therefore deflection of ohm meter $\alpha \frac{V}{I} = R_E$

The deflection of the pointer indicates the resistance of the earth directly.

Megger – Insulation tester

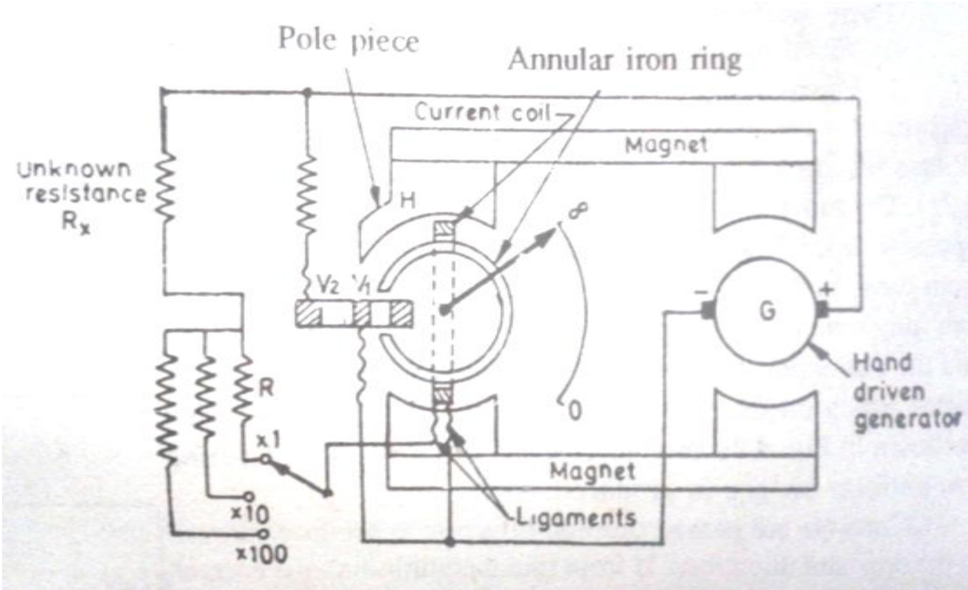


Fig. 9.23. Megger.

It is used to measure high resistance (insulation resistance). it consists a hand driven DC generator and ratio meter ohm meter. Ratio meter ohm meter consist a current coil and two volt coil (V_1 and V_2). Moving system deflected with a torque proportional to the ratio of the quantities of the volt coil to the current coil.

$$\text{Deflecting torque } \alpha \frac{V}{I} \alpha \text{ R}$$

$$\text{ie } \Theta \alpha \text{ R}$$

Test voltages are 500, 1000, 2500V are generated by hand driven DC generator. This test voltage is selected by using selector switch. Breakdown or short circuit are indicated by sudden movement of pointer to the zero end.

Digital Voltmeter

Ramp type DVM

It consists a ramp generator , input comparator, ground generator, oscillator, gate, counter and sample rate multivibrator

Ramp generator : it generate ramp voltage

Input comparator : it compare input voltage with ramp voltage and give start pulse to gate when both voltages are equal.

Ground comparator : it compare ramp voltage with ground (zero) and generate stop pulse to gate

During the gating time interval , counter count the pulses from the oscillator. The number of pulses proportional to the input voltage

Sample rate multivibrator : it is used to trigger random generator after completion of one cycle and reset the counter.

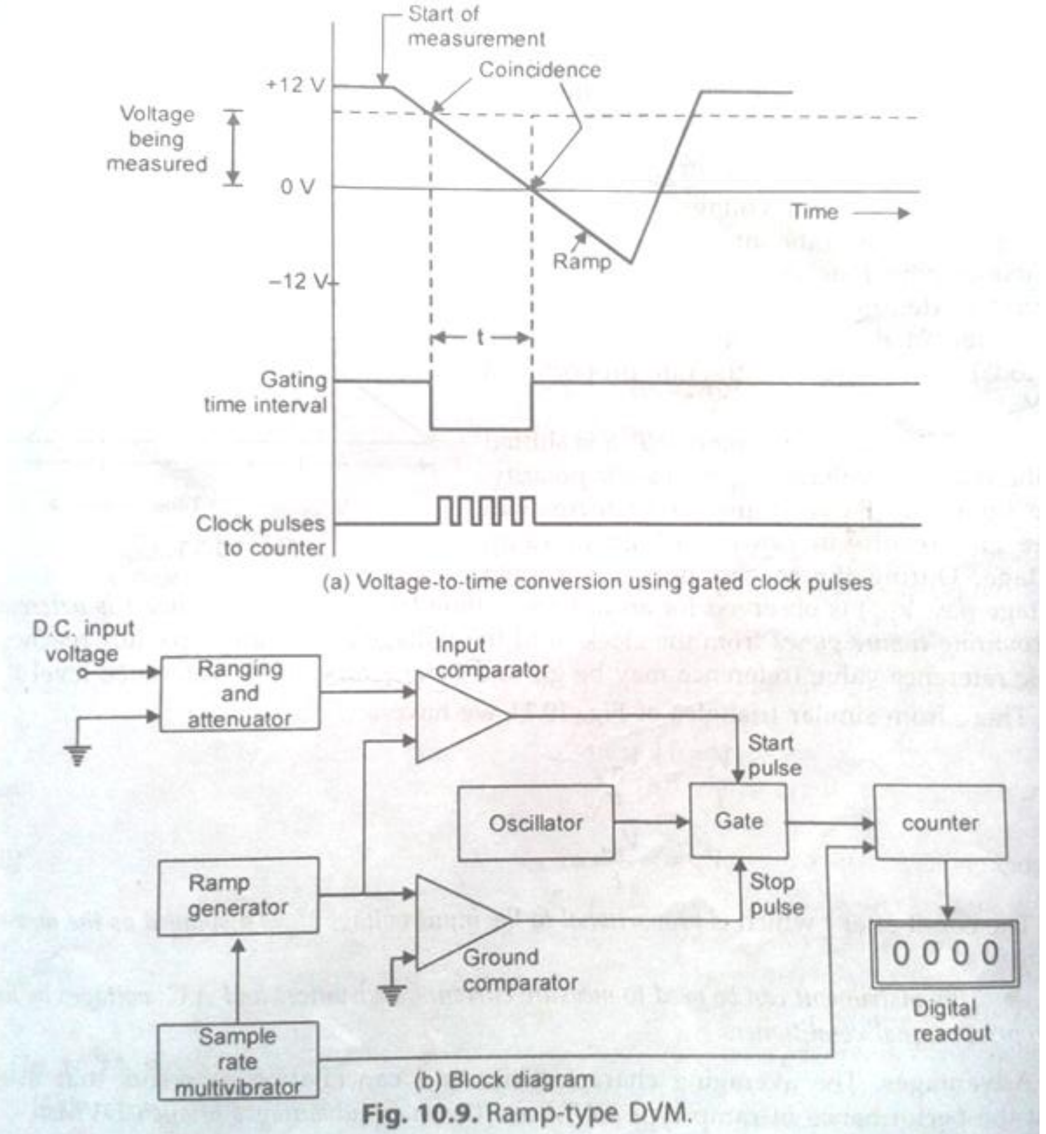


Fig. 10.9. Ramp-type DVM.

Digital Frequency Meter

It consists input signal conditioning block, time base oscillator, time base divider, gate, counting register and display. Time base oscillator generate pulses with pre defined frequency. Main gate compare the cycles of input signal and reference signal . Counting register measure the frequency of input signal and displayed it

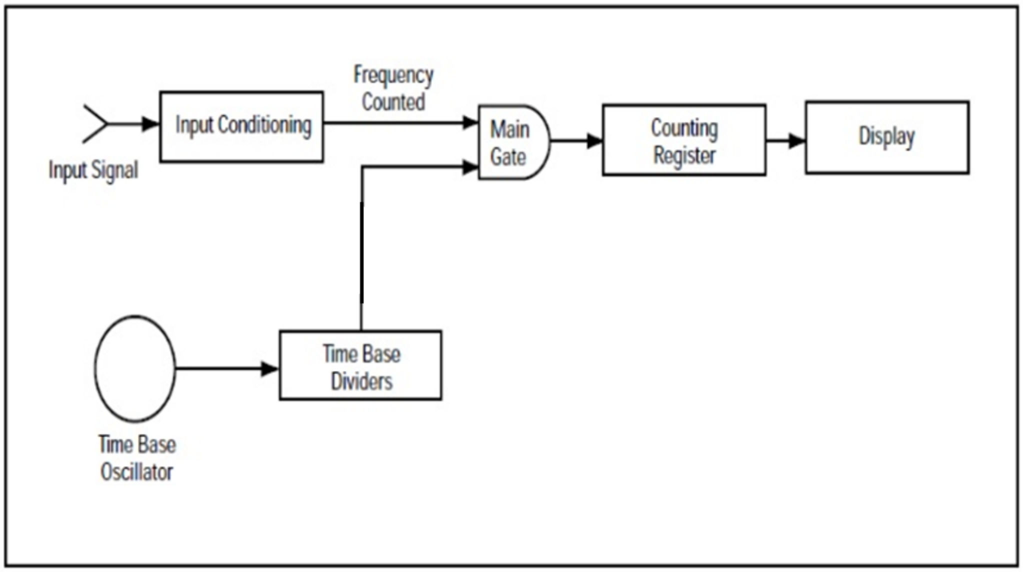


Figure 1. Basic block diagram of the conventional counter in its frequency mode of measurement.

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Cathode Ray Oscilloscope - CRO

CRO is a device that allows the amplitude of the electrical signals whether they be voltage, current , power etc. To be displayed primarily as a function of time.

It consists

1, Cathode ray tube (CRT)

2, Vertical amplifier

3, Horizontal amplifier

4, Sweep generator

5, trigger circuit

6, high and low voltage supply

7, Delay line

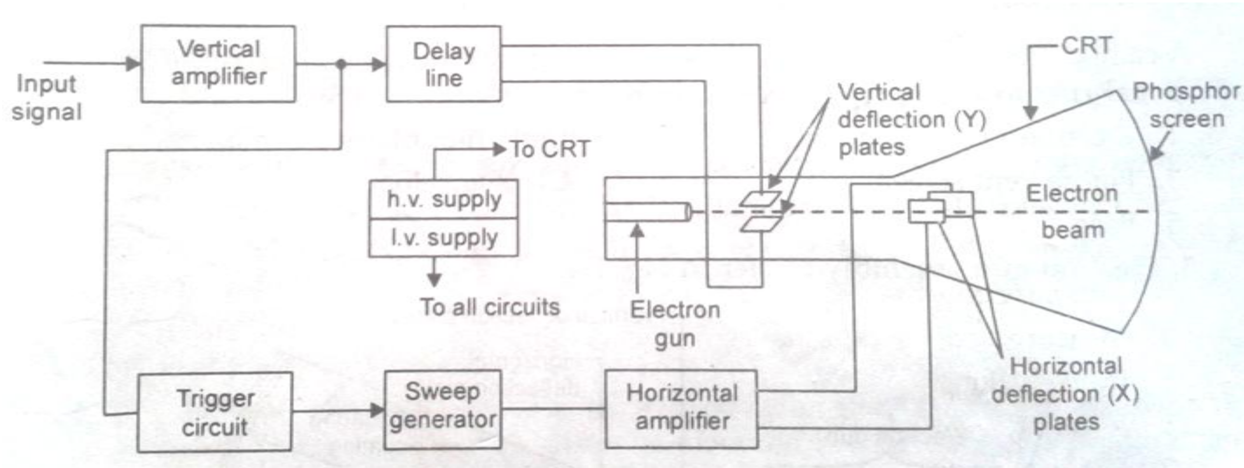


Fig. 11.1. Block diagram of a general purpose CRO.

CRT : it generate electron beam , accelerate the beam to high velocity . It has vertical and horizontal deflection plate and contain a phosphor screen.

Vertical amplifier : it amplifies the signal waveform to be viewed

Horizontal amplifier : it is fed with saw tooth voltage which is then applied to horizontal deflection plate

Sweep generator : it produces saw tooth voltage waveform . Time period of saw tooth waveform = time period of input signal

Trigger Circuit : it produces trigger pulses to start horizontal sweep

High and Low voltage supply : high voltage supply is required to CRT and low voltage for all other circuit

Delay line : it is used to delay the vertical signal enough to give it from reaching the CRT vertical deflection plate before the horizontal sweep circuits are running

Applications of CRO

1, tracing actual waveform of current or voltage.

2, determination of amplitude of variable quantity

3, measurement of capacitance and inductance

4, comparison of phase and frequency

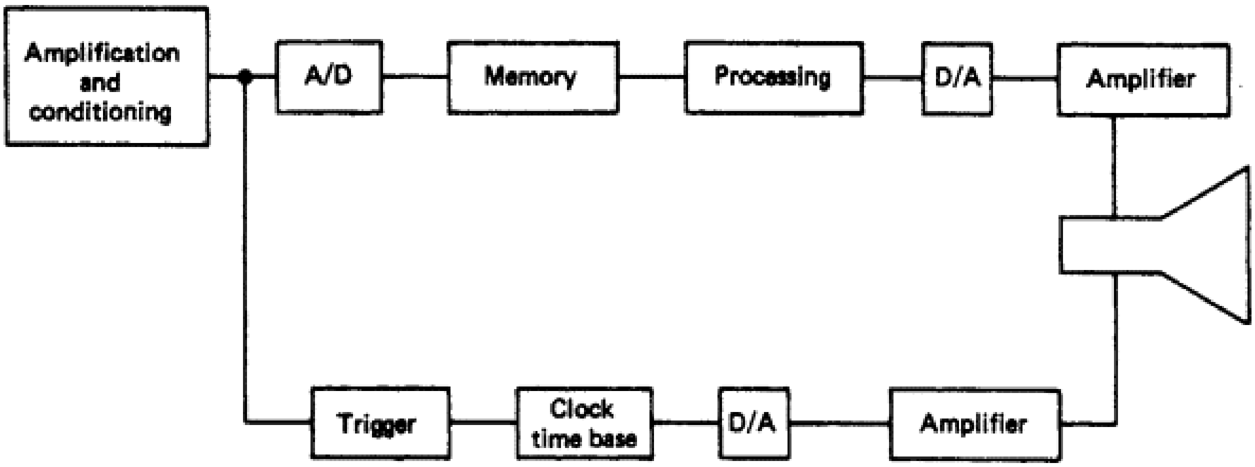
5, for finding BH curve

6, for studying heart beat

7, for tracing transistor curve

DSO – Digital Storage Oscilloscope

It is a waveform analyser. The **digital storage oscilloscope** is defined as the oscilloscope which **stores and analysis the signal digitally**, i.e. in the form of 1 or 0. The digital oscilloscope takes an input signal, store them and then display it on the screen. The digital oscilloscope has advanced features of storage, triggering and measurement. Also, it **displays** the signal **visually** as well as **numerically.** The digital oscilloscope digitises and stores the input signal. This can be done by the use of CRT (Cathode ray tube) and digital memory. The block diagram of the basic digital oscilloscope is shown in the figure below. The digitisation can be done by taking the sample input signals at periodic waveforms.



Smart Energy Meter

This product is designed for Smart Energy Metering for Electrical Power Network. These energy meters are suitable for Advanced Metering Infrastructure (AMI) and are compatible with Smart Grid Communication Technologies and supports Distributed Generation (DG).