Date _____

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EXPERIMENT-1

AIM: To study the different types of measuring instruments used in the basic electrical engineering lab.

APPARATUS REQUIRED: Electrical & Electronic meters are listed as follows.

1) Ammeter

THEORY:

An Ammeter is a measuring instrument used to measure current flowing through a circuit. The flow of current through a conductor is measured in Amperes (Coulombs per second)

There are several types of ammeters-

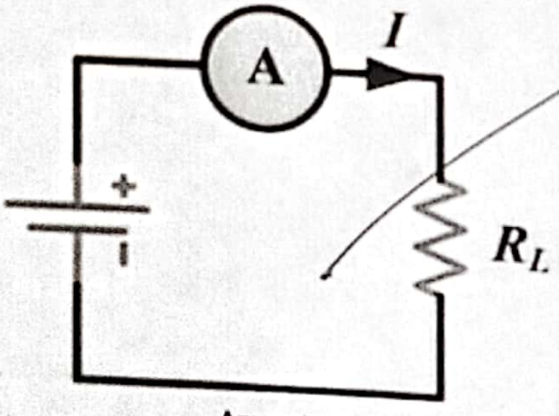
(a) Moving coil ammeter - It uses magnetic deflection, where current passes through coil cause the coil to move in magnetic field.

(b) Electrodynamic Ammeter - An electrodynamic movement uses an electromagnet instead of permanent magnet.

(c) Moving Iron Ammeter - It uses a piece of iron which moves when acted upon by electromagnetic force of a fixed coil.

Teacher's Signature : _____

Ammeter



Ammeter

WORKING PRINCIPLE :

The main principle of ammeter is that it must have very low resistance and also inductive reactance. It has very low impedance because it must have a very low amount of voltage drop across it. it must be connected in series connection because current is same in series circuit. setting the ammeter up in parallel will create a short circuit and will not measure the current correctly.

APPLICATION :-

① Used for measuring current flowing through a closed circuit.

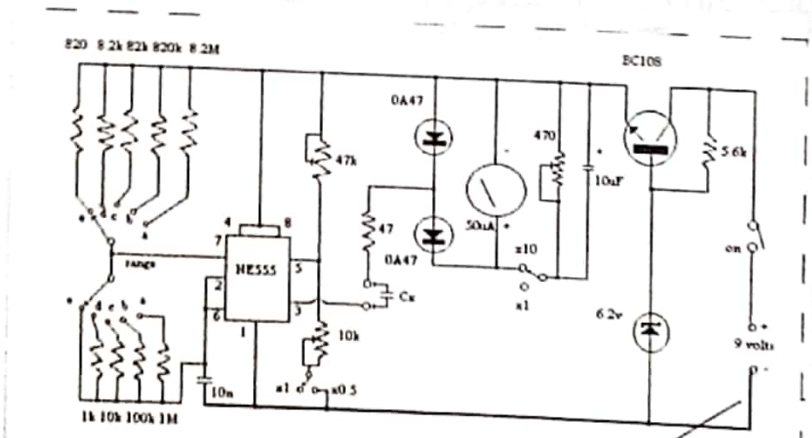
② Ammeter can measure current flowing through both AC & DC circuit.

2.) Capacitance metre

THEORY : The capacitance is equal to the ratio of charge & voltage. It is expressed as $Q = CV$ where C is capacitance,
Q is charge stored, measured in Coulombs (C)
V is the voltage across the capacitor, measured in volts (V)
Most of the electronic devices contain a capacitor to store electrical energy. The storing ability of a capacitor is known as capacitance which is measured in Farad (F)

Teacher's Signature : _____

Capacitance Meter



Capacitance Meter

WORKING PRINCIPLE : At the measured capacitance, the reference excitation voltage is applied for the measurement In the below figure the unknown capacitance is amplified by the amplifier.

APPLICATION :

a) Used for measuring capacitance, usually of a discrete capacitor, in a circuit.

3.) Current Clamp

→ In electrical & electronic engineering, a current clamp, also known as current probe, is an electrical device with jaws which open to allow clamping around an electrical conductor. Used for measuring current flowing through a conductor.

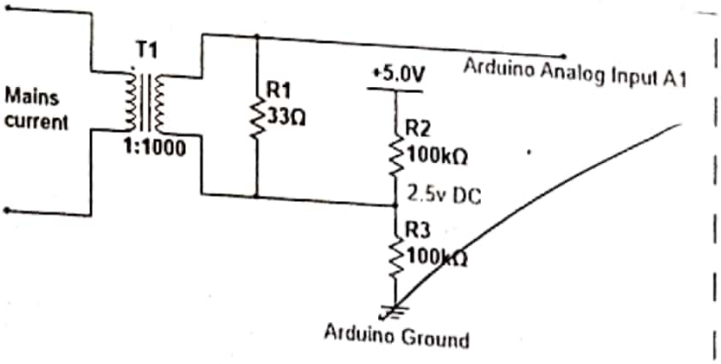
THEORY :

A clamp metre measures the vector sum of the currents flowing in all the conductors passing through the probe, which depends on the phase relationships of the currents.

WORKING PRINCIPLE : Coreless current probes (such as the current clamp) use many magnetic sensors spread around the circumference of the coreless current probe.

Teacher's Signature :

Current Clamp



Current Clamp

Each magnetic field sensor measures the field generated by the current-carrying conductor. The total magnetic field is calculated from the individual sensors, and from there converted into a voltage output signal.

APPLICATION: Current clamps are used for measuring currents in hard-to-access areas. They're often used for monitoring and quality control to ensure current flowing and flowing at the correct magnitude. Used for checking phase and waveform information to check power efficiency in motor testing. Current clamps are used in all kinds of setups where current is flowing, but one cannot easily disconnect or get to the conductor material.

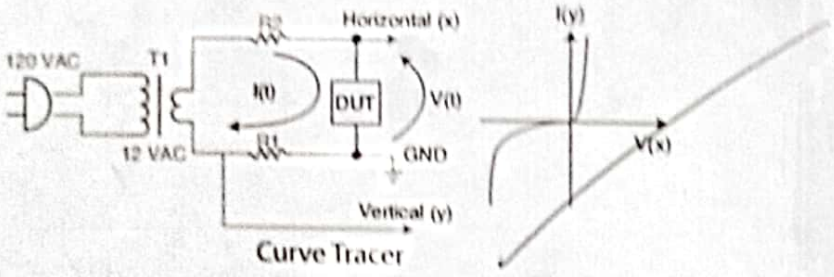
4) Curve Tracer

Used for analysing characteristics of discrete semiconductor devices.

THEORY: Semiconductor curve tracers are lab devices that are used to analyse performance characteristics of semiconductor devices like diodes and transistors. They trace current/voltage values on a single plot, independent of time, which is something that can be difficult to do on a normal oscilloscope.

Teacher's Signature :

Curve Tracer



Curve Tracer

A semiconductor is a material whose conductivity lies between that of conductors and insulator - they conditionally allow the flow of charges through them.

WORKING PRINCIPLE : A curve tracer works by applying a swept voltage, one involving continuous variation over time, to two ~~set~~ separate terminals subjects to testing. It measures the amount of current the DUT allows to flow at each voltage.

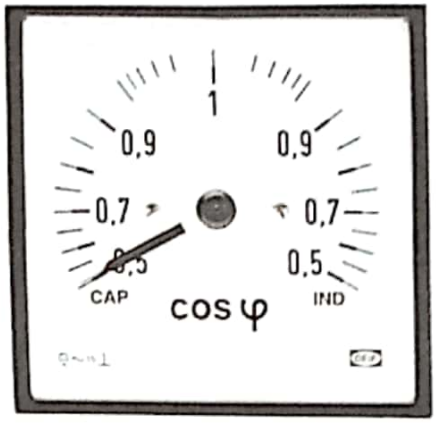
APPLICATION : They are often used in device reliability applications such as failure analysis and parametric characterization.

5.) Cos Phi Metre :

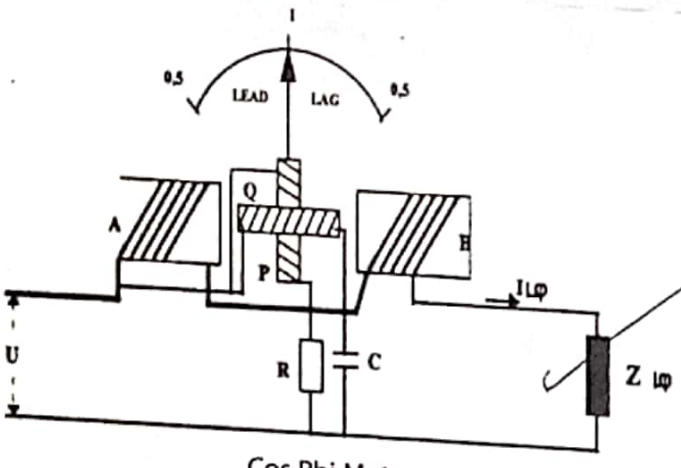
THEORY : Cos Phi indicates how much power is lost during the 'transport' of power. The ratio of actual power is , where represents the angle between voltage and current.

WORKING PRINCIPLE : Cos Phi metre is a working power factor gauge for an ac network that will measure a phase shift between voltage and current on an electrical load.
Instruments measure the peak of the waveforms

Teacher's Signature : _____



Cos Phi Meter



Cos Phi Meter

calculating power factor from voltage and current phases is accurate only if the waves are sinusodial.

APPLICATIONS:
Can be used to determining how much power is lost during the transport of it.

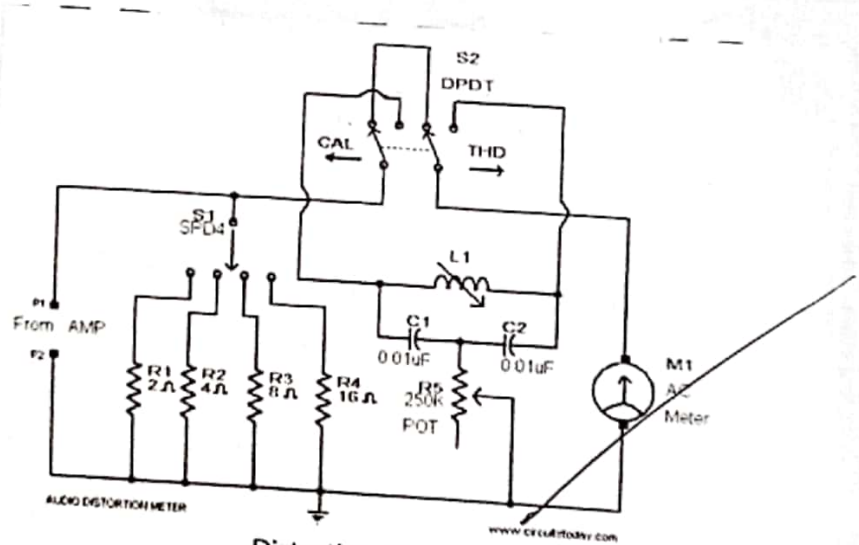
6) Distortion Metre (distortion factor metre)

THEORY: Distortion power factor defines how the total harmonic distortion of a nonlinear load decreases, the total average power delivered to the load.
Total harmonic distortion (THD) is the measure of the deviation of voltage or current waveform from ideal sinusodial shape.
It can also correctly measure the fundamental frequency component of a waveform and its higher-order harmonics.

WORKING PRINCIPLE:-
A distortion meter has two switchable parallel circuits at the input. The first circuit measures the total signal at the output of a system for low distortion levels this will be almost equal to fundamental.

Teacher's Signature : _____

Distortion Meter



Distortion Meter

APPLICATIONS : displays the amount of distortion added to the original signal by an electronic circuit.

7.) Electricity Metre

THEORY :

Electrical Energy is the energy derived from potential energy of charged particles

Electrical energy mathematically is defined as $E = QV$

where $Q \rightarrow$ energy

$V \rightarrow$ Potential ~~energy~~ difference

WORKING PRINCIPLE : On a single-phase AC supply, the electromechanical induction meter operates through electromagnetic induction by counting the revolutions of a non-magnetic, but electrically conductive, metal disc which is made to rotate at a speed proportional to the power passing through the meter.

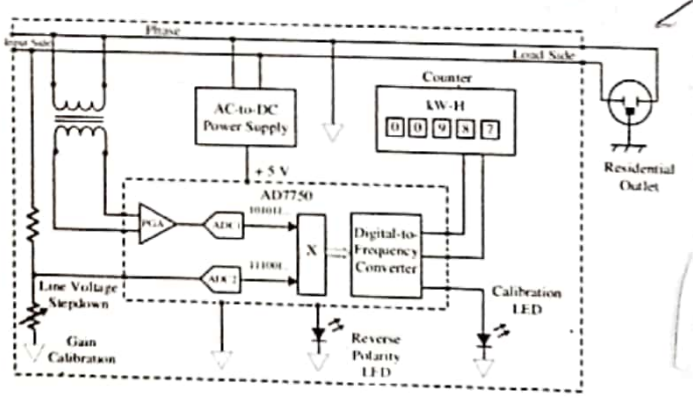
APPLICATION :

Measures the amount of electrical energy consumed by a residence, business, or an electrically powered device.

Usually calibrated to commercial units (kilowatt Hours, KWh)

Teacher's Signature : _____

Electricity Meter



Electricity Meter

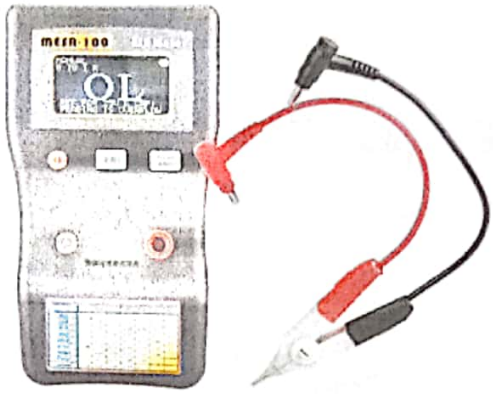
8.) ESR metre

THEORY: Equivalent series resistance (ESR), also known as internal resistance, is a value representing the loss of useful energy in a simple electronic circuit consisting of a resistor and an ideal capacitor Technically speaking, the energy is not lost, but is usually dissipated as undesirable heat.

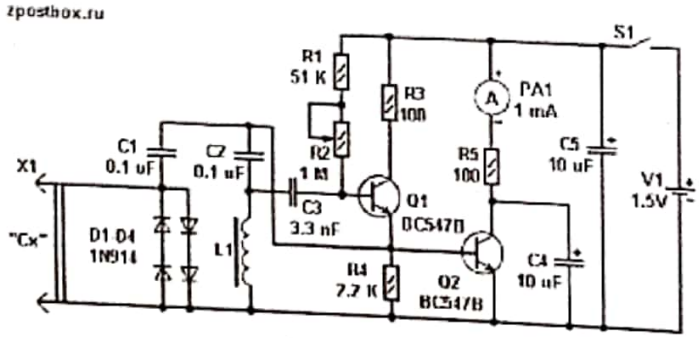
WORKING PRINCIPLE: Most ESR metres work by discharging a real electrolytic capacitor and passing an elatric current through it for short time
This will produce a voltage across the device equal to the product of the current and the ESR; this voltage is measured and its value divided by the current (ie, the ESR) shown in ohms or milliohms on a digital display or by the position of a pointer on a scale The procer is repeated tens or hundreds of thousands of times a second.

APPLICATION
Measures equivalent series resistance (ESR) of capacitor Can be used for measuring any low resistance.

Teacher's Signature :



ESR Meter



ESR Meter

9) Frequency Counter

THEORY :- Frequency is a measure of oscillating objects
Frequency refers to the rate per second of a vibration constituting a wave
The SI unit of frequency is Hertz (Hz)
Frequency counters usually measure the number of cycles of oscillation, or pulses per second in a periodic electronic signal

Working Principle

works by using a counter which accumulates events within a specific period of time
Displays the frequency of the current depending on the number of cycles the flow makes per one clock cycle

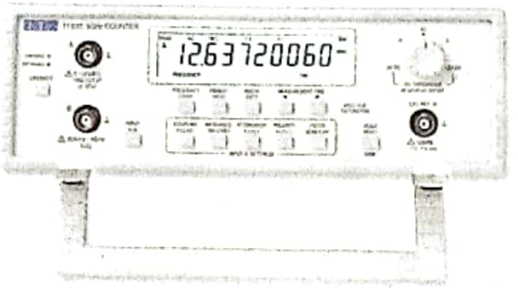
APPLICATIONS

A frequency meter is used for measuring frequency of any electronic signal

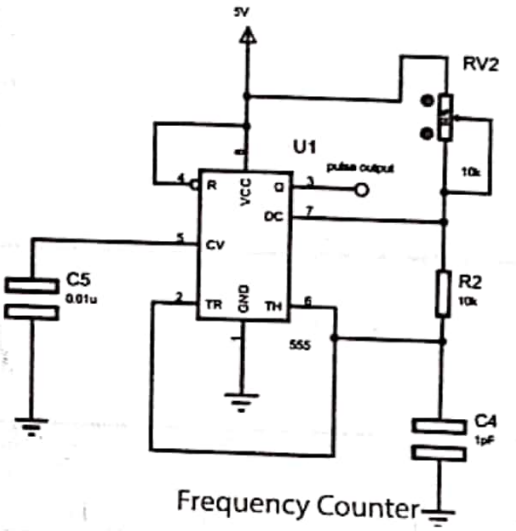
10) Leakage tester (Leakage current tester)

THeary :- Leakage Current is current that flows from an AC or DC circuit to the ground or another Conductor. If the equipment or device is not grounded correctly, it is possible for current to flow through the human body

Teacher's Signature :

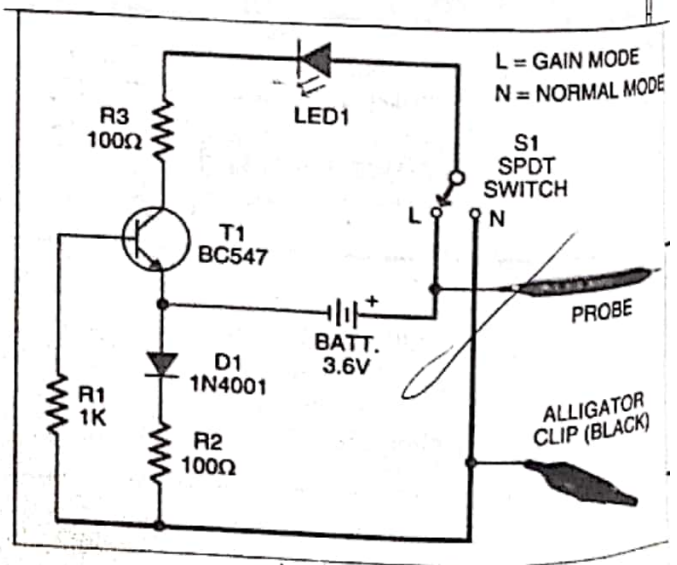


Frequency Counter



Frequency Counter

Leakage Tester



Leakage Tester

The objective of the Leakage Current test is to verify that the electrical insulation used to protect the user from a Risk of Shock is suitable for the application

WORKING PRINCIPIE

The leakage current is measured by ~~app~~ applying a fixed, high votage DC and by measuring the leakage current flowing through the shunt

APPLICATION :.

Measure the leakage across the Plates of capacitors in a circuit

ii) LCR metre

THEORY :. ~~LCR metre refers to the~~ LCR refers to the electrical circuit components - L (inductance), C (capacitance), and R (resistance)

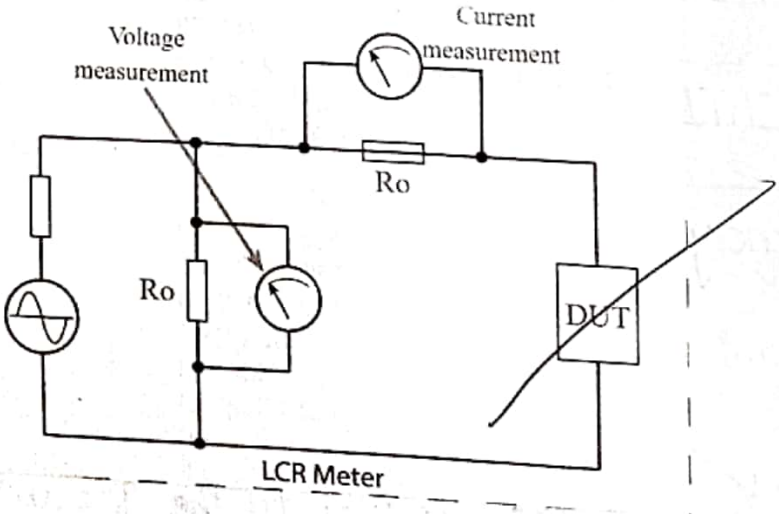
Inductance is the property of an electric conductor that causes an electromotive force to be generated by a change in the current flowing

Capacitance refers to the ability of an electric component to store charge

Resistance refers to the ability of an electric ~~Component to Store Charge~~ Component to resist the flow of electric current through it

Teacher's Signature : _____

LCR Meter


Voltage
measurement
Current
measurement
Ro
Ro
DUT
LCR Meter

Date

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An LCR circuit is one in which the inductors, resistors and capacitors are present - connected in either parallel or series

WORKING PRINCIPLE :.

An LCR metre measures a Physical property known as impedance Impedance, represented as Z, indicates resistance to the flow of an AC current It can be calculated from the current I flowing to the measurement target and the voltage V across the target's terminals

APPLICATION :.

Measures the inductance, capacitance and resistance of a component

12) Megger tester (aka Megohmmeter/insulation resistance tester)

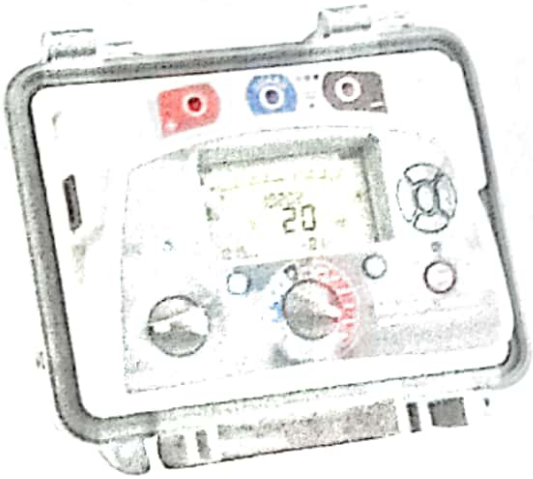
THEORY :. Based on electrical conductivity - materials can either be classified as conductors, semiconductors, or insulators

An insulator is a material which is a bad conductor of electric current and does not allow any flow of charges through it

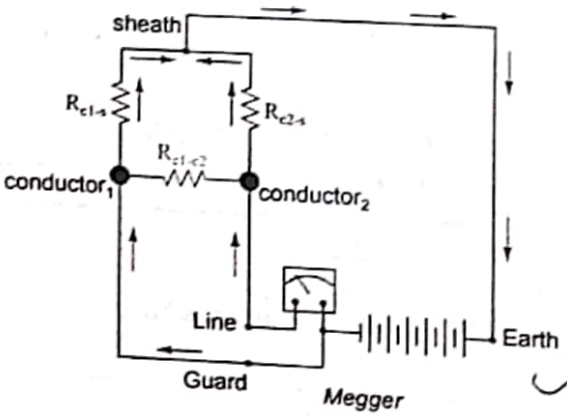
Some examples of insulators include - plastic, styrofoam, paper, rubber, glass, dry air, etc.

The resistivity of insulators lies in between 10^8 to 10^{18} cm

Teacher's Signature :



Megger Tester



Megger Tester

WORKING RPRINCIPLE :.

Resistance to be measured is connected across the terminals i.e. Connected in series with the deflecting coil and across the generator. when the current is supplied to the coils then they have torque in opposite directions

APPLICATION :.

Measures the resistance of winding of a motor or generator Measures the earthing's resistance Can measures the resistance offered by an insulator

13) Microwave Power meter

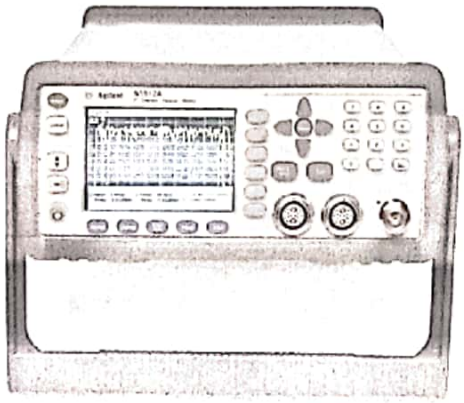
THEORY :. Microwaves are a type of electromagnetic waves that lie on the electromagnetic spectrum For waves with frequencies ranging from 300 MHz and 300 GHz

Microwaves are widely used in communication systems, Cancer treatment, remote sensing and for Cooking Food in microwave ovens

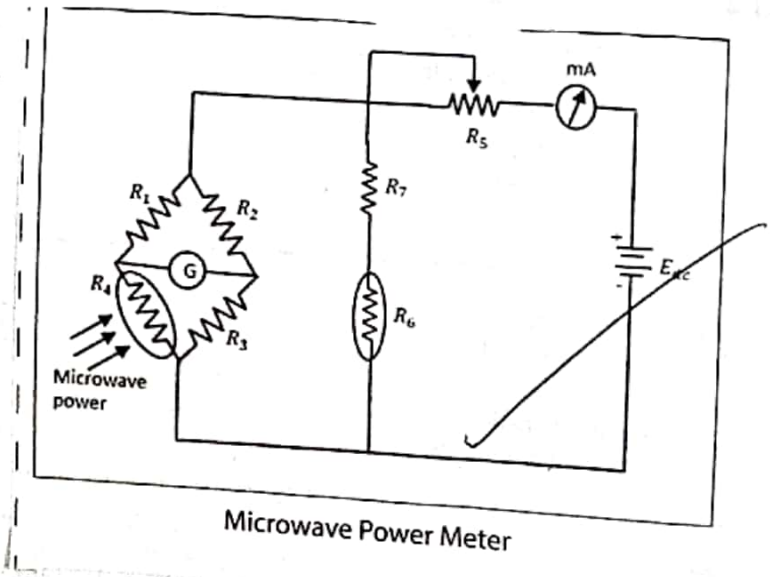
The frequencies that the meter can measure are generally in the range of 100MHz to 40 GHz.

WORKING PRINCIPLE : The microwave Power is absorbed in a load whose temperature rise is measured by the thermocouple

Teacher's Signature : _____



Microwave Power Meter



Microwave Power Meter

The thermocouple outputs the power in analog which is later converted to digital signals for final output
Thermocouple sensors often require a reference Dc for calibration

APPLICATION :- Used for measuring power in microwave frequencies
Used to measure electrical power when no deeper analysis of the measured data is required

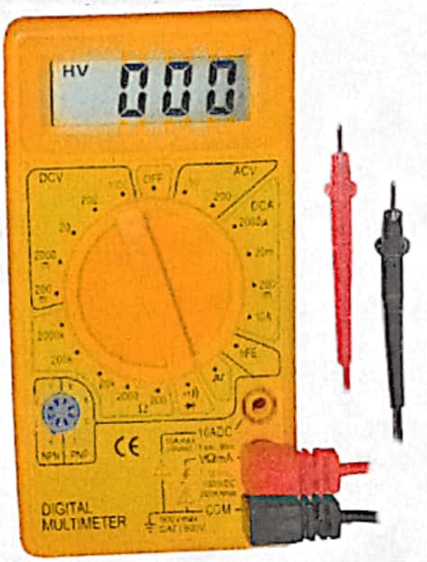
14) Multimeter

THEORY :- It's a measuring instrument that can measure multiple electrical properties of a circuit component
A typical multimeter can measure voltage, resistance, and current
Voltage - electromotive force, expressed in Volts
Resistance - ability to resist current, expressed in ohms ()
Current - flow of charges, expressed in Amperes (A)

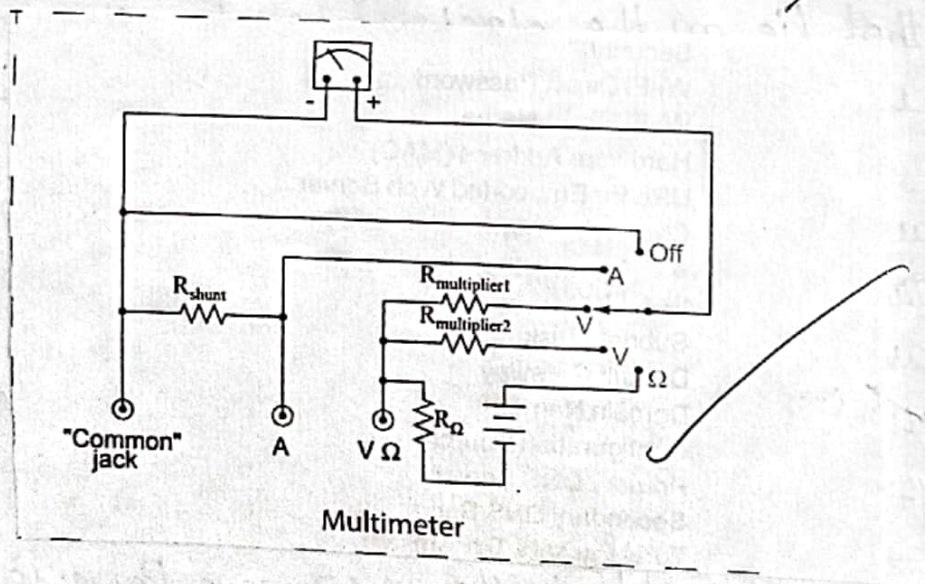
WORKING PRINCIPLE :- A multimeter is the combination of a Dc voltmeter, AC voltmeter, ammeter and ~~switches~~ ohmmeter.
An un-amplified analog multimeter combines a metre movement, range resistors and switches

APPLICATION :- Simultaneously calculate multiple electrical properties

Teacher's Signature :



Multimeter



Multimeter

Date _____

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15) Network analyzer

THEORY :. An electrical network is an interconnection of electrical components (e.g., batteries, resistors, inductors, capacitors, switches, transistors) or a model of such an interconnection, consisting of electrical elements (e.g., voltage sources, current sources, resistances, inductances, capacitances) An electrical circuit is a ~~to~~ network consisting of a closed loop, giving a return path for the current.

WORKING PRINCIPLE :.

The fundamental principle of a vector network analyzer is to measure the amplitude and phase of both incident and reflected waves at the various ports of the DUT (Device under Test)

APPLICATIONS :. Measures network parameters of electrical network

16) ~~Oscilloscope~~ Ohm Meter

THEORY :. Graphically displays varying electrical voltages that may/may not change with time.

The graphs so produced can be used for analysis and calculation of properties such as frequency, amplitude, etc.

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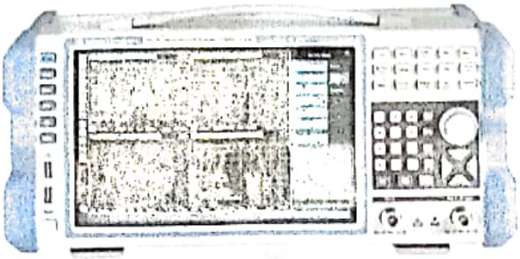
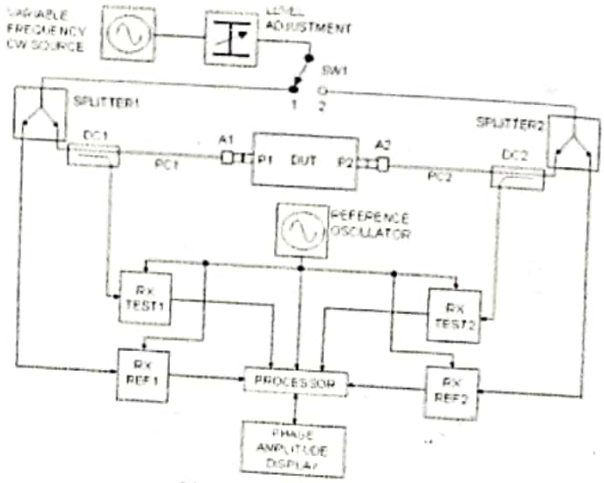
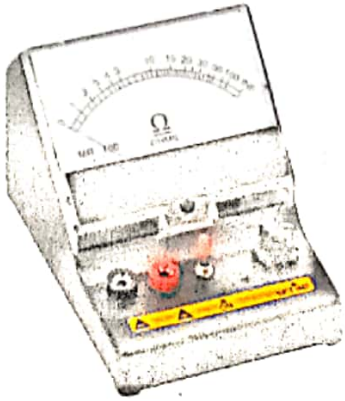


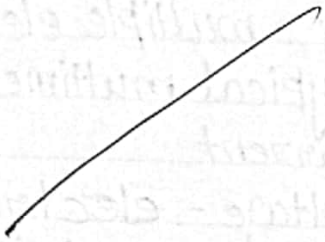
Network Analyzer

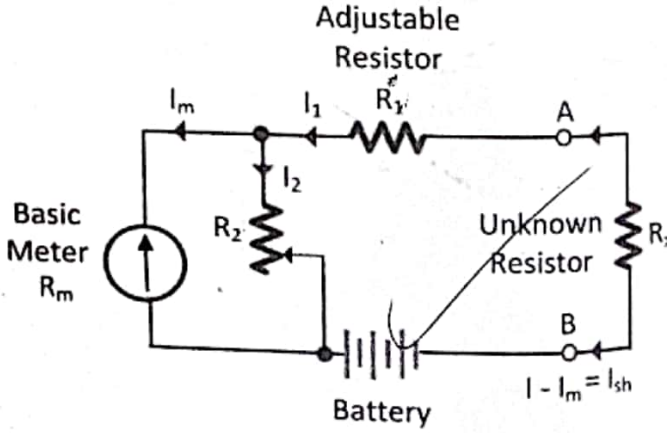


Network Analyzer



Ohmmeter





Series Type Ohmmeter

Ohmmeter

WORKING PRINCIPLE:.

Is based on the Ohm's law for calculation of resistance offered by the Component An chmmeter applies currents ~~to the~~ to the circuit or Component whose resistane using ohm's law

~~Ohm's Law~~ ⟹ Ohm's Law -> V=IR

APPLICATIONS:. Can be used in an electric circuit to finds the resistance offered by an electrical Component -> ohmmeter circuit symbol

(7) Oscilloscope

THEORY:. Graphically displays varying electrical voltages that may/may not change with time

The graphs so produced can be used for analysis and calculation of Properties such as for Frequency, amplitude, etc.

WORKING PRINCIPLE:. The displayed waveform for the electrical voltage that was probed by the oscilloscope is analysed for properties such as amplitude, Frequency, rise time, time interval, distortion, and others.

APPLICATIONS:. The main purposes are to display repetitive or single waveforms on the screen that would otherwise occur too briefly to be perceived by the human eye

Teacher's Signature : _____

Oscilloscopes are used in the Sciences medicine, engineering, automotive and the telecommunications industry.
Special-purpose oscilloscopes may be used to analyze or to display the waveform of the heartbeat as an electrocardiogram, for instance

18) Psophometer

THEORY :- Measures AF signal level and noise
AF refers to Audio Frequency i.e. the general bandwidth of frequencies which humans perceive as sounds (20Hz - 20KHz)
Noise is a general term in signal processin, which refers to unwented modifications that a signal may suffer from

WORKING PRINCIPLE :- The core of the metre is based on a true RMS voltmeter
A true RMS reading voltmeter gives a meter indication by sensing the heating power of waveform
which is proportional to the square of the RMS value of the voltage
The RMS voltmeter measures the level of the the noise signal

APPLICATIONS :- Psophometers can be used to record and quantitively evaluate the noise and vibration of electrical or acoustic signals

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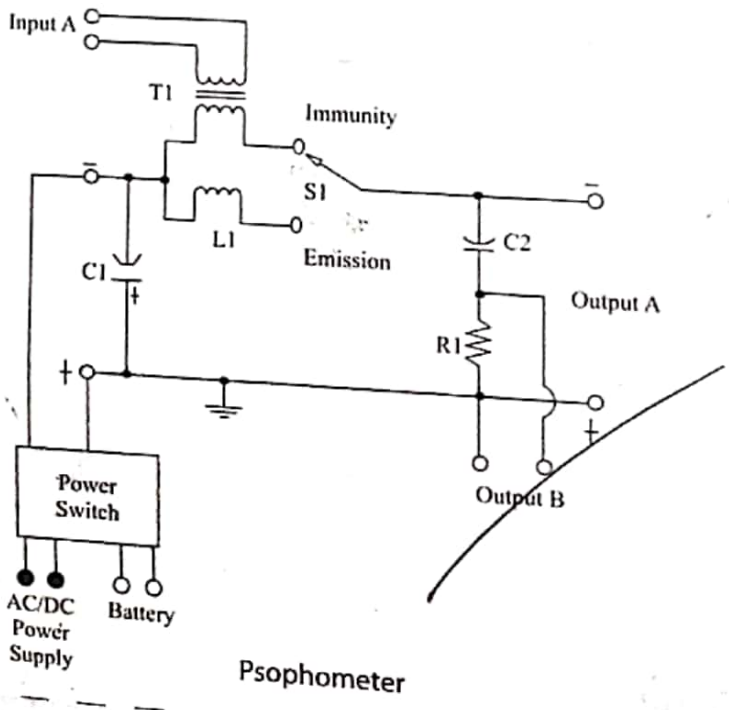
Psophometer



Psophometer

Date _____

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19) Q meter

THEORY :- Measures Quality Factor (Q) of RF (Radio Frequency) Circuits.

Radio waves are a part of the EM wave spectrum whose frequency ranges from 3KHz to 300 GHz.

Q factor expresses how much energy is dissipated per cycle in a non-ideal reactive circuit

$Q = 2 \frac{\text{Peak energy stored}}{\text{Energy dissipated per cycle}}$

WORKING PRINCIPLE :- Internally, a minimal Q metre consists of a tunable RF generator with a very low (Pass) impedance output and a detector with a very high impedance input

APPLICATIONS :- Used in testing of radio frequency circuits

Unknown impedance or characteristic impedance of a ~~transim~~ transmission Line can be measured using a Q meter

20) Tachometer

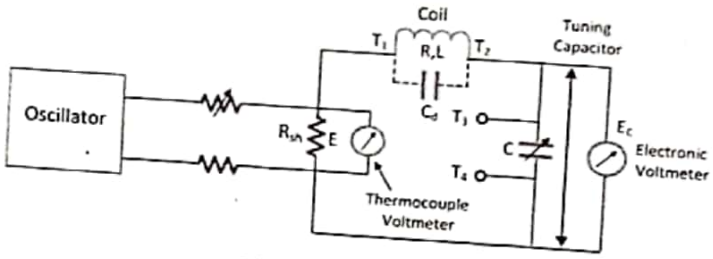
THEORY :- Instrumen for measuring rotation speed of a shaft or a disk

Rotation speed or the frequency of rotation around a fixed axis

WORKING PRINCIPLE :- A Tachometer works on the

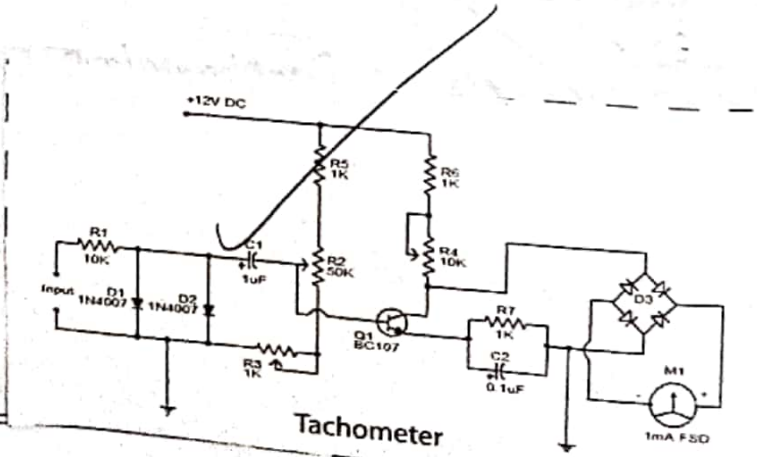
Teacher's Signature : _____

Q Meter



Circuit of Q meter

Tachometer



Tachometer

Principle of relative motion. The device operates between the shaft of the device and the magnetic field
It works as a generator and produces the voltage as per the velocity of the stick. The device counts the number of rotations that the shaft make per minute

APPLICATIONS :: Used in automobiles for showing car speed, engine revolutions etc.
Indicates the safe range of revolution for rotation of the engine's crankshaft in various machines

21) Signal analyzer

THEORY :: Measures both the amplitude and the modulation of a RF (Radio Frequency) signal
Radio waves are a part of electromagnet wave. Spetrum whose frequency ranges from 3 KHz. up to 300 GHz
Amplitude of a RF signal can be thought of as the power of the signal, it is represent by the positive crests and negative troughs of the wave
Modulation is the process of converting data into radio waves by adding information to an electronic or optical carrier signal

WORKING PRINCIPLE :: Modern signal analyzers down-convert a portion of the signal spectrum for analysis

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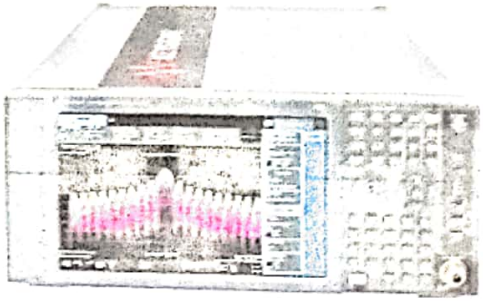
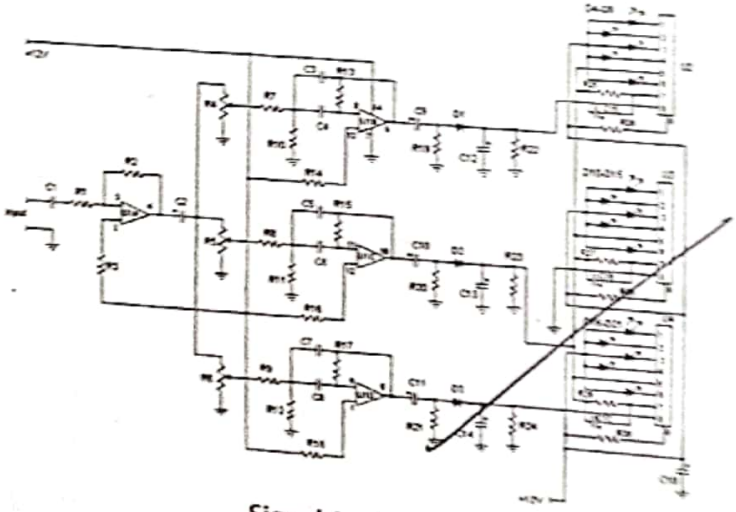


Signal Analyzer



Signal Analyzer

The signal and is first converted to an intermediate frequency signal and prevent aliasing
Aliasing in telecommunication refers to the misidentification of a signal frequency or introducing distortion or error

APPLICATIONS :- The Primary use is to measure the power of the spectrum of known and unknown signals

22) Signal generator

THEORY :- Generates signals for testing Purposes
Generates signals can be of varying frequency, amplitude waveform, etc.

WORKING PRINCIPLE :- Analog impulses are generated which are later converted into digital signals

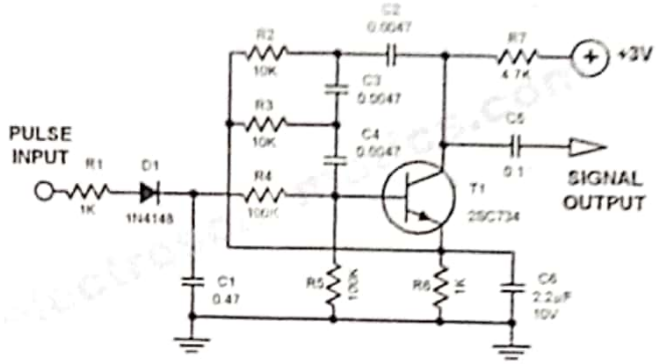
APPLICATIONS :- typically used in designing, testing, troubleshooting, and repairing electronic or electroacustic devices, though it often has artistic uses as well

23) Spectrum analyzer

THEORY :- Displays frequency spectrum
The electromagnetic spectrum is the range of frequencies of electromagnetic radiation and their respective wavelengths

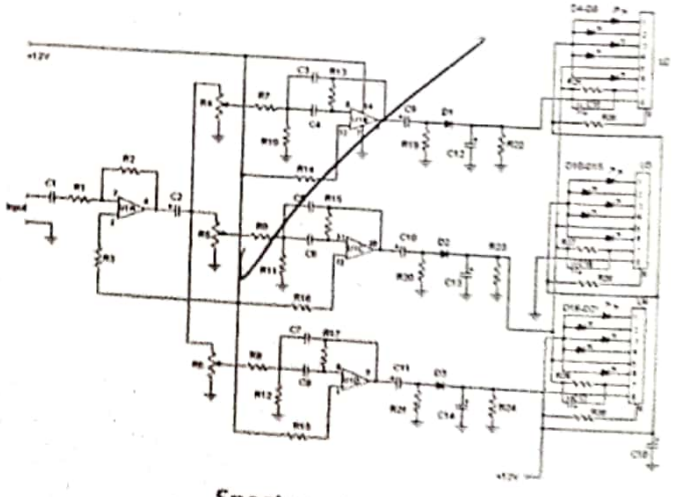
Teacher's Signature :

Signal Generator



Signal Generator

Spectrum Analyzer



Spectrum Analyzer

and Photon energies

WORKING PRINCIPLE :- measures the magnitude of an input Signal versus frequency within the full frequency range of the instrument

APPLICATIONS :- Used in telecommunications industry to determine occupied bandwidth and track interference sources

23) Sweep generator

THEORY :- Creates constant-amplitude variable frequency sine waves to test frequency response
A sine wave is a mathematical curve defined in terms of the sine of a trigonometric function, of which it is the graph. It is a type of continuous wave and also a smooth periodic function

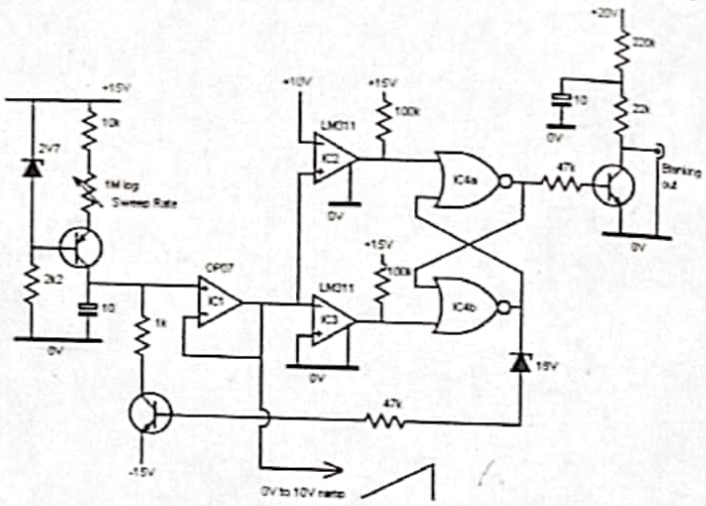
WORKING PRINCIPLE :- These circuits are mostly transistor circuits with inductors and capacitors to create linear characteristics which are used to create the waves as required

APPLICATIONS :- Commonly used to test the frequency response of electronic filter circuits

24) Transistor tester

Teacher's Signature : _____

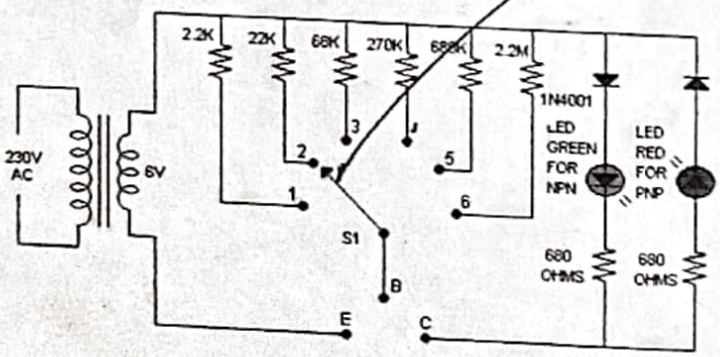
Sweep Generator



Sweep Generator

Transistor Tester

Transistor Tester Circuit



Transistor Tester

Date

Expt. No.

THEORY:-

Used for testing transistors

A transistor is a device made of semiconductors - it is one of the most basic building blocks of modern electronics

WORKING PRINCIPLE:- The Principle behind the test lies in the fact that little or no current will flow in a transistor between emitter and collector until the emitter - base junction is forward biased

APPLICATIONS:- Used for testing ~~elec~~ electrical behavior of transistors and solid - state diodes

25) Tube tester

THEORY:- Tests vacuum tube (triodes, tetrodes, etc.)

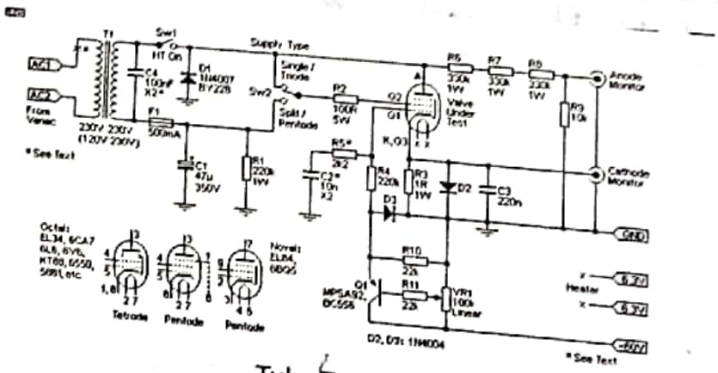
A vaccuum tube is a device that controls electric current flow in a high ~~vacuu~~ vacuum between electrodes to which an ~~electric~~ potential difference has been applied

WORKING PRINCIPLE:- The mutual conductance tester tests the tube dynamically by applying bias and an AC voltage to the control grid, and measuring the current obtained on the plate, while ~~meintaining~~ maintaining the correct DC voltages on the plate and screen grid

APPLICATIONS:- Used for testing characteristics of vacuum

Teacher's Signature : _____

Tube Tester



Tube Tester

tube

26) Wattmeter

THEORY :- Measures power in a circuit

The wattmeter reads the average value of the Product P = VI, where.

P is the power in the Circuit

V is the Voltage

I is the Current Flowing in the Circuit

WORKING PRINCIPLE :- The induction wattmeter Consists of two laminated electromagnets viz. Shunt Magnet and Series Magnet

The Shunt magnet is Connected across the Supply Voltage

The Coil of the Shunt magnet is made highly inductive so that the current in it lags the Supply Voltage by 90°

The Series magnet is Connected in Series with the Supply and Carries the load current

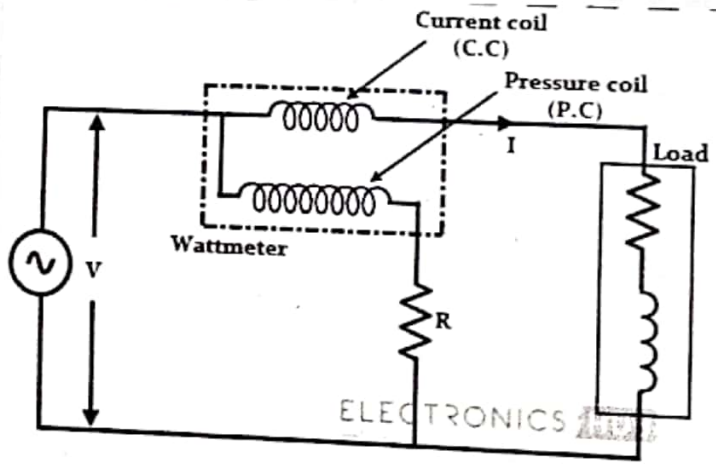
The Coil of Series magnet is made highly non inductive

A thin disc (made up of aluminum) mounted on a spindle is placed between the two magnets so that it cuts the flux of the two magnets

APPLICATIONS :- Electromagnetic wattmeters are used for measurement of utility frequency and audio frequency power; other types are required for radio frequency measurements

Teacher's Signature : _____

Wattmeter



Wattmeter

27) Vectorscope

THEORY :- Displays the phase of the colours in color TV special type of oscilloscope used in both audio and video applications

A vectorscope is used to visualize chrominance.

Chrominance (chroma or C for short) is the signal used in video systems to convey the color information of the picture

Working Principle :- A vectorscope uses an overlaid circular reference display, or graticule, for visualizing chrominance signals, which is the best method of referring to the QAM (Quadrature amplitude modulation) Scheme used to encode color into a video signal

APPlications :- Used to measure and display the level, or voltage, of a video signal with respect to time

Used for visualizing chrominance

28 Video signal generator

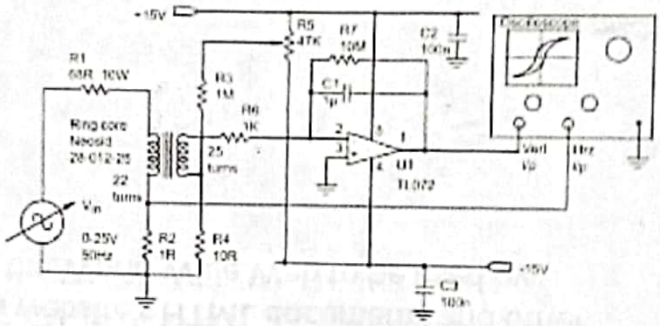
Theory :- Generates video signal for testing Purposes

Working Principle :- Analog impulses are generated which are later converted into digital signals for video output

APPlications :- Used in the synchronization of television devices and to stimulate faults measurements of, television and video systems

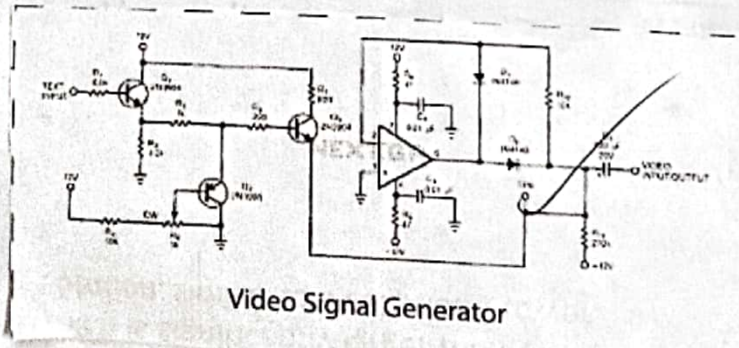
Teacher's Signature : _____

Vectorscope



Vectorscope

Video Signal Generator



Video Signal Generator

28) Voltmeter

Theory:- Measures the potential difference between two points in a circuit

Potential difference refers to the difference in electric potential between two points

In static electric field, it refers to the work required to be done to move a test charge from one point to another

SI unit of potential difference is Volts (V)

Working Principle:- A voltmeter must be connected in ~~to~~ parallel to the circuit in which the voltage has to be measured. A Parall connection is used because a ~~voltage~~ voltmeter is built in such a way that it has a very high resistance value (infinity for an ideal voltmeter)

APPLICATIONS:- Used for measuring potential difference between 2 points in an electric circuit

29) VU meter (Volume Unit meter)

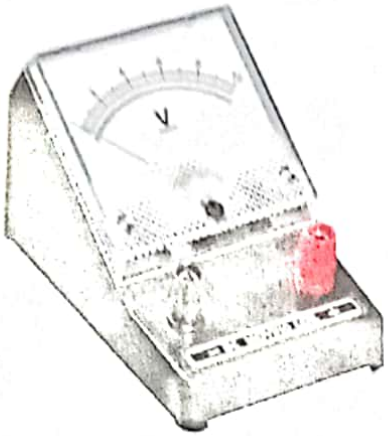
THEORY:- Measures the level of Audio frequency signals in volume units (Decibels - dB)

Audio frequency refers to the range of waves which are audible to humans (20Hz to 20kHz)

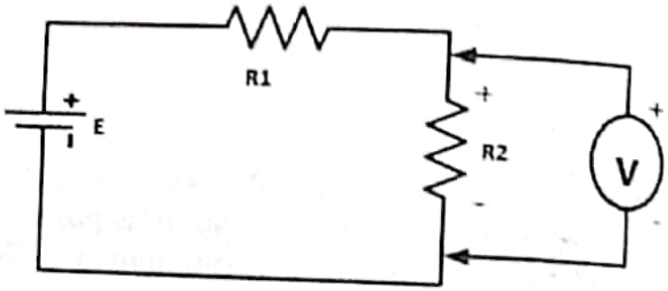
This range of frequency is represented by waves with wavelengths around 17m to 1.7cm

Working Principle:- The passive electromechanical device, runs fed from an ammeter and a full-wave CuO rectifier

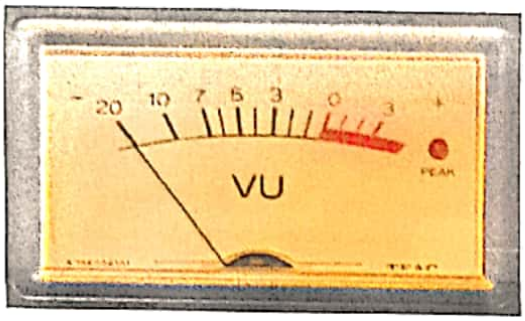
Teacher's Signature : _____



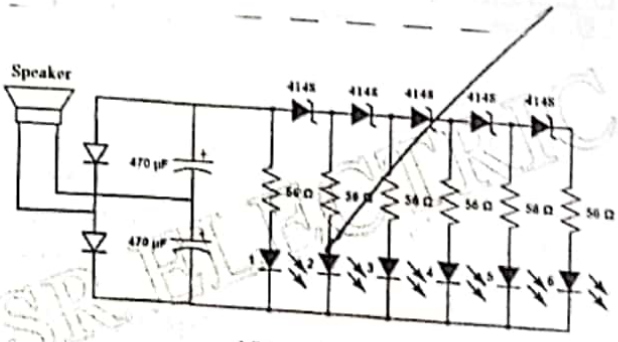
Voltmeter



Voltmetre



VU meter



VU meter

APPlication :.

Used in consumer audio equipment such as playback devices, recording equipment, etc.

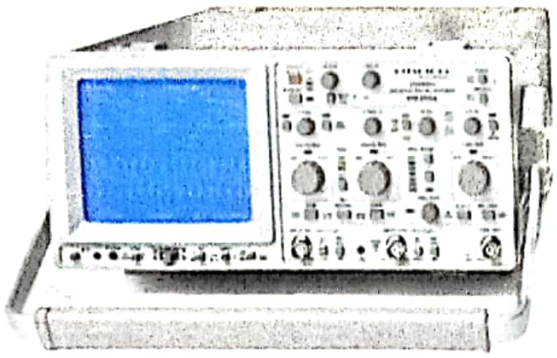
30) CRO (Cathode Ray Oscilloscope) :.

THEORY :. The cathode-ray oscilloscope (CRO) is a common laboratory instrument that provides accurate time and amplitude measurements of voltage signals over a wide range of frequencies
Its reliability, stability, and ease of operation make it suitable as a general purpose laboratory instrument
The Cathode ray is a beam of electrons which are emitted by the heated cathode (negative ~~ele~~ electrode) and accelerated toward the fluorescent screen

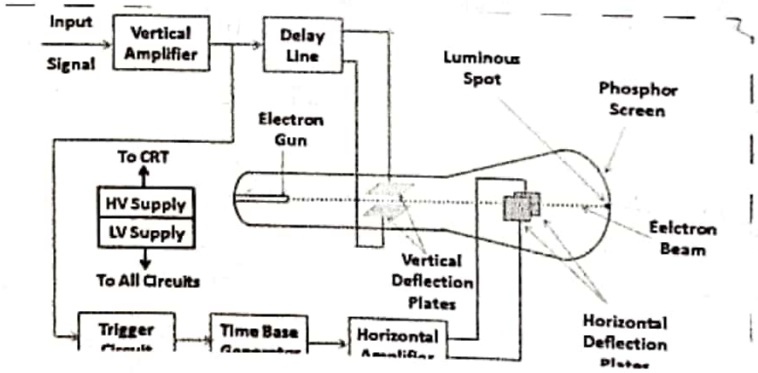
Working Principle :. The signal to be displayed is amplified by the vertical amplifier and applied to the vertical deflection plates of the CRT
A portion of the signal in the vertical amplifier is applied to the ~~vertical deflection~~ sweep trigger as a triggering signal
The sweep trigger then generates a pulse coincident with a selected point in the cycle of the triggering signal

This pulse turns on the sweep generator, initiating the sawtooth wave form
The sawtooth wave is amplified by the horizontal amplifier and

Teacher's Signature : _____



CRO


Input
Signal
Vertical Amplifier
Delay Line
Luminous Spot
Phosphor Screen
Electron Gun
To CRT
HV Supply
LV Supply
To All Circuits
Eelctron Beam
Vertical Deflection Plates
Trigger
Time Base
Horizontal
Horizontal Deflection

CRO

applied to the horizontal deflection Plates

APPLICATIONS:- It is used to measure voltage and current and control the analog signal

It can measure Frequency, waveform, and other characteristics of a particular signal

In radio stations, the CRO is used to observe signals and their properties.