

Operating principle of Electrical Measuring Instruments

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Introduction

- Electrical measuring instruments, or meters, are used to provide a visual indication of the values of voltages and currents in a circuit.
- Electrical measuring instruments are generally of two types:
 - Alternating Current (AC) instruments.
 - Direct Current (DC) instruments.

Types of Measuring Instruments

- The two basic classes of electrical measuring instruments are **analog** and **digital**.
- Modern instruments are largely digital but analog instruments are also used and are still widely manufactured and sold.

Analog meter



Digital meter

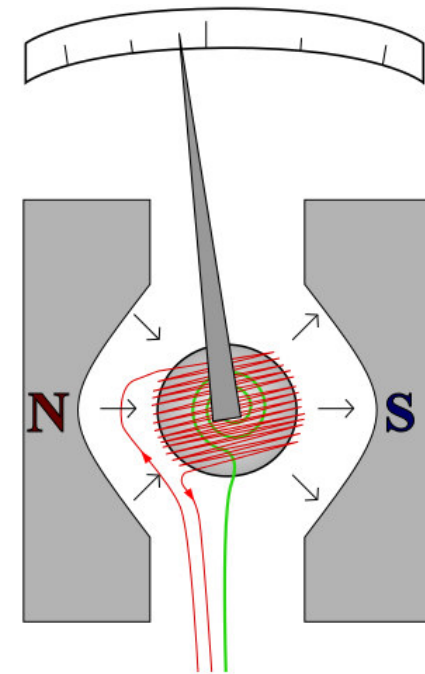


Analog Measuring Instruments

- The most common analog meters work using the interaction of the magnetic field produced by an electric current with a permanent magnet or a piece of iron .
- This results in two types:
 - Moving coil instruments
 - Moving iron instruments

Moving Coil Instruments

- Moving coil meters use the principle of magnetic deflection where current passing through a coil placed in a magnetic field causes the coil to move.
- The magnetic field that the coil is placed in produced by a permanent magnet.
- Only measure direct current (DC).

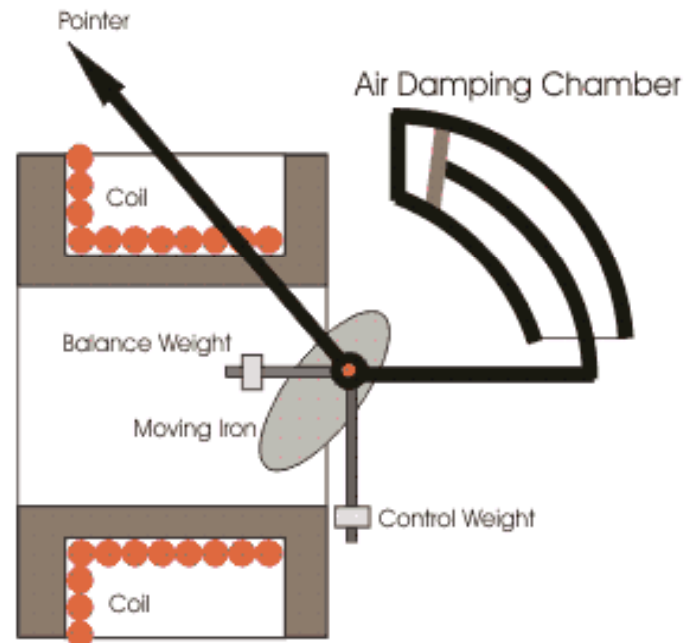


Moving Iron Instruments

- Moving iron instruments give an indication of voltage or current magnitudes by using the effect that their magnetic fields have on a piece of iron.
- Depending on whether the meter is so designed so that there is a magnetic attraction or repulsion we get **attraction type moving iron instruments** or **repulsion type moving iron instruments**.

Moving Iron Instruments

- Moving iron instruments measure AC or DC.



See handout for further theory

Instruments for Basic Quantities

- The basic quantities to measure are voltage, current and resistance.
- The essential requirement of measuring instruments are:
 - that its introduction into the circuit, where measurements are to be made, does not alter the circuit conditions.
 - the power consumed by them for their operation is small.

Ammeters and Voltmeters

- Common analog ammeters and voltmeters depend on a deflecting magnetic torque produced by an electric current.
- In an ammeter this torque is produced by a current to be measured or by a fraction of it.
- In a voltmeter this torque is produced by a current which is proportional to the voltage to be measured.
- Thus all analog voltmeters and ammeters are essentially current measuring devices.

Ammeters

- Ammeters are connected in series with the circuit whose current is to be measured.
- The power loss in an ammeter is (I^2R_a) where I is the current to be measured R_a is the resistance of the ammeter.
- Therefore an ammeter should have low electrical resistance so that they cause a small voltage drop and consequently absorb small power.

Voltmeters

- Voltmeters are connected in parallel with the circuit whose voltage is to be measured.
- The power loss in voltmeter is (V^2/R_v) , where V is the voltage to be measured and R_v is the resistance of the voltmeter.
- Therefore voltmeters should have a high electrical resistance, in order that the current drawn by them is small and consequently the power consumed is small.

Ammeters and Voltmeters

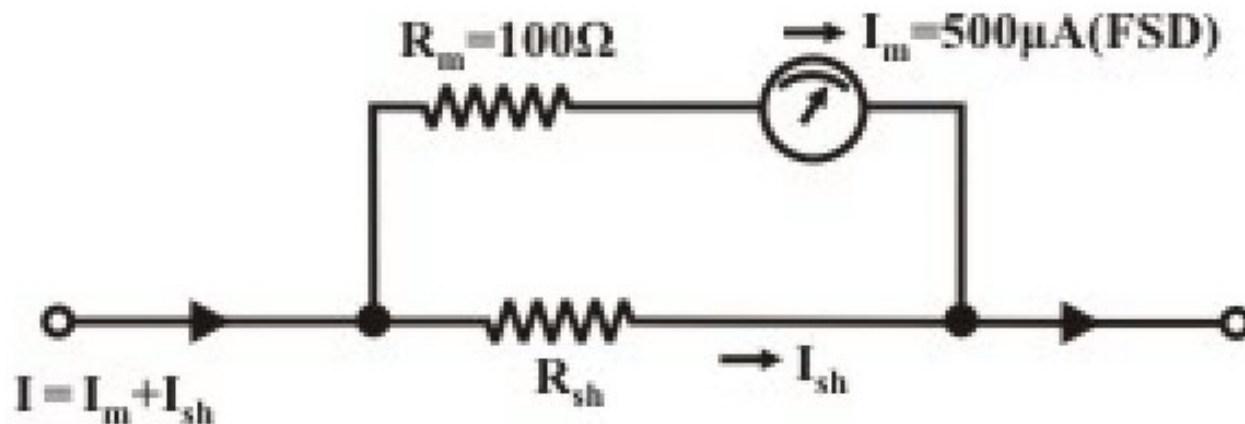
Parameters	Ammeter	Voltmeter
Connection	It is to be connected in series mode	It is to be connected in parallel mode
Resistance	It has comparatively low resistance	It has high resistance
Uses	It is used to find the amount of current flowing in the circuit	It is used to find the potential difference in the circuit
Circuit	Circuit must be disconnected in order to attach the ammeter	Circuit does not need to be disconnected
Accuracy	Considered as less accurate	Considered as more accurate compared to ammeter

Extend range of Analog Meters

- Analog instruments have a maximum deflection that they can make without damaging the moving needle or burning.
- The current that causes the maximum deflection is termed the full scale deflection (FSD) current.

Extend range of Ammeters

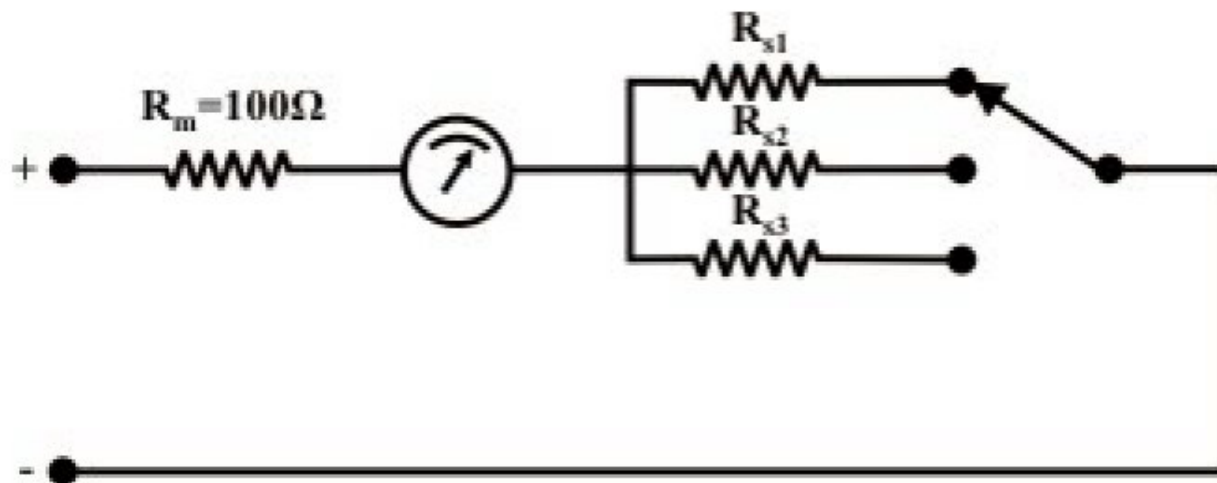
- To extend the range of ammeters a resistor is connected in parallel to the ammeter.
- This resistor is termed a shunt resistor and its value is determined using ohms law and the current divider rule.



Extend range of Voltmeters

- To extend the range of voltmeters a resistor is connected in series with the voltmeter.
- The value of this resistor is determined using ohms law and the voltage divider rule.

Multi-range Voltmeter

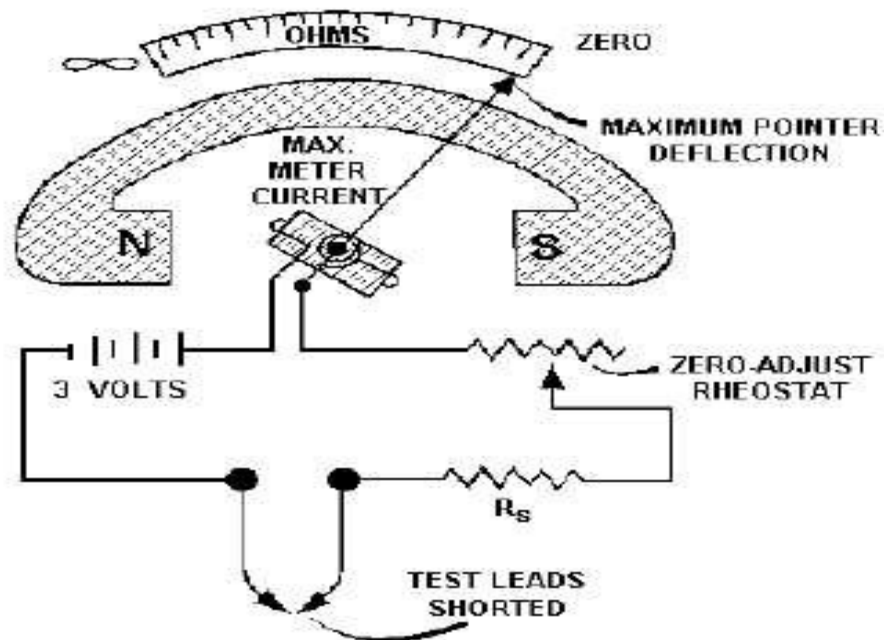


Ohmmeter

- The basic method to measure resistance in ohms is to supply a constant voltage to the unknown resistance and measure the current through it.
- This is done by an ohmmeter, which is effectively an ammeter with its own built-in battery.
- The battery provides a voltage of known size.

Ohmmeter

- The current produced by the battery is inversely proportional to the resistance of the resistor being tested therefore the ammeter, with its built-in battery, can be constructed to provide a reading in ohms.



Digital Meters

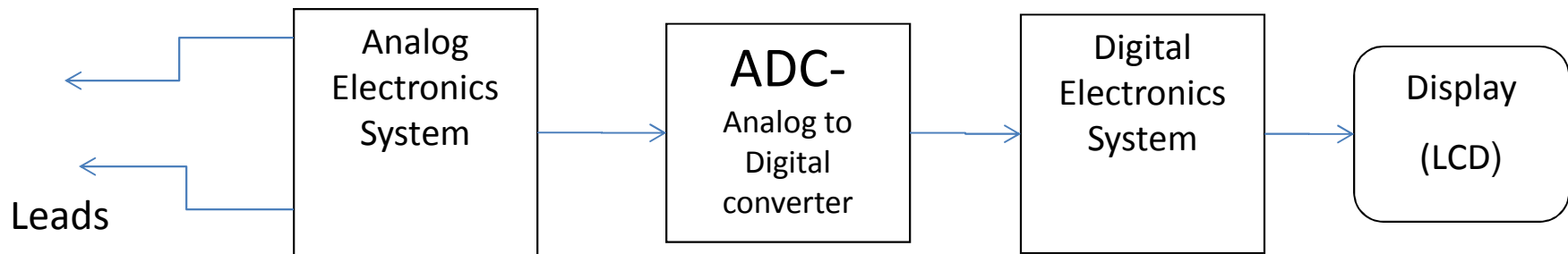
- The advance in solid state electronics and integrated circuits made possible the measurement of electrical quantities using digital electronics.
- A single digital meter is generally capable of measuring voltage, current and resistance along with other electrical quantities.
- Such meters are termed multi-meters.

Digital Meters

- Digital meters are generally more accurate and reliable than their analog counterparts.
- Digital meters can also have advanced features such as logging multiple readings, interfacing to a computer, wireless transmission of readings, more advanced calculations, etc.

Digital Meters

- The general block diagram of a digital meter is shown below:



Thank you
for Listening

