Electrical Engineering and Measurement (EE1101) (Meas. of Resis.)

Presented

by

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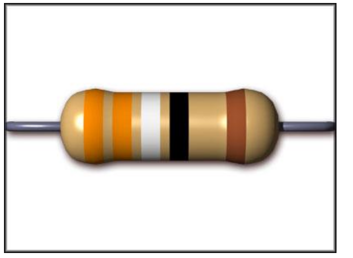
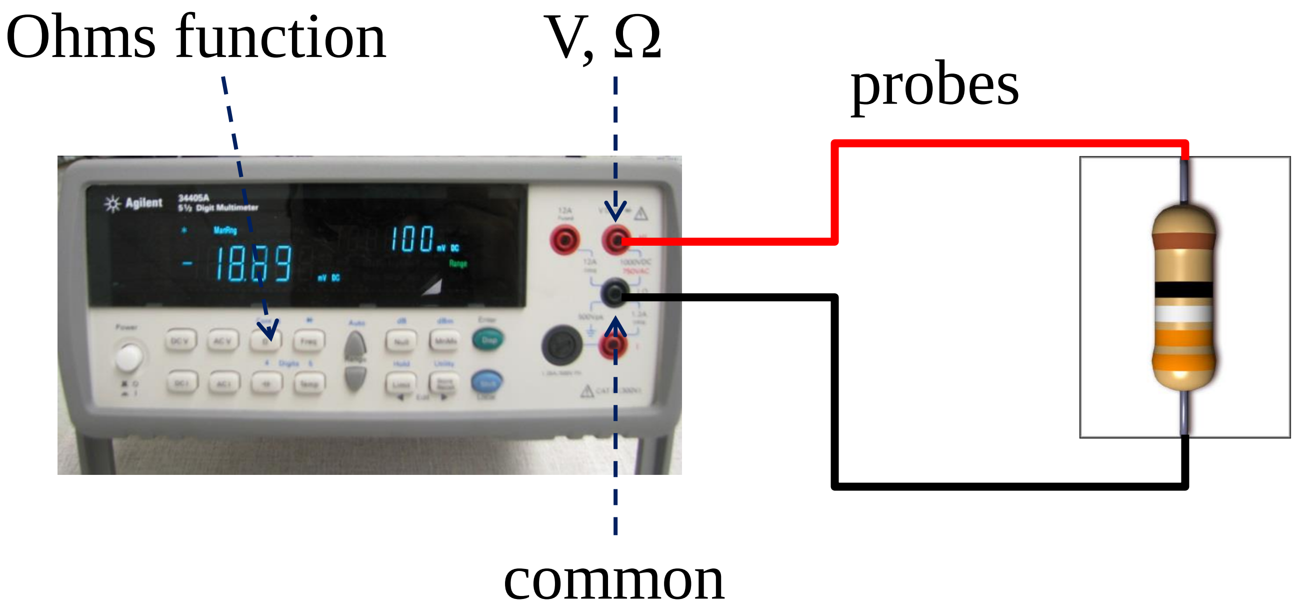
Resistors



Properties:

- Value (resistance)
  - Determined by measurement or color code (next slide)
- Power Rating
  - What is the largest power dissipation before damage or danger?
- Tolerance
  - What is the largest likely variation from the stated resistance value?
  - Your lab kit resistors: 5 %

Resistance Measurement

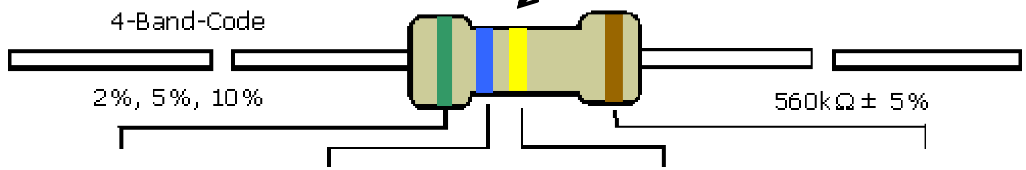


Does polarity matter? Reverse the leads and see.

Measure at least four of your resistors. What is the error in the resistance for each of these?

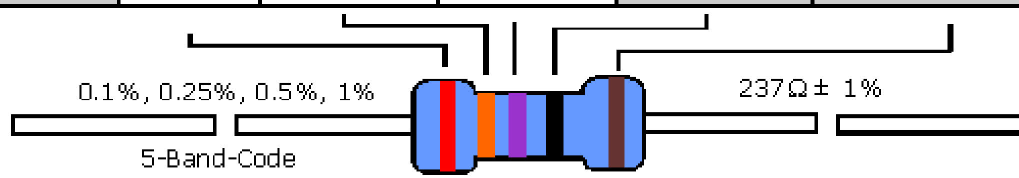
Color Code

We have the 4-band code



Big
Brown
Rats
On
Yellow
Garbage
Bins
Very
Gaily
Whistle

COLOR	1st BAND	2nd BAND	3rd BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	±0.5% (D)
Blue	6	6	6	1MΩ	±0.25% (C)
Violet	7	7	7	10MΩ	±0.10% (B)
Grey	8	8	8		±0.05%
White	9	9	9		
Gold				0.1	± 5% (J)
Silver				0.01	± 10% (K)



Electronix Express / RSR
http://www.elexp.com

1-800-972-2225
In NJ 732-381-8020

Measurement of Resistance

Classification of resistances

(I) Low resistances - Less than 1Ω

(II) Medium Resistance - 1 Ω to 0.1MΩ

(III) High Resistances - greater than 0.1MΩ

Measurement of Resistance

Measurement of medium resistance

(a) Ammeter Voltmeter method

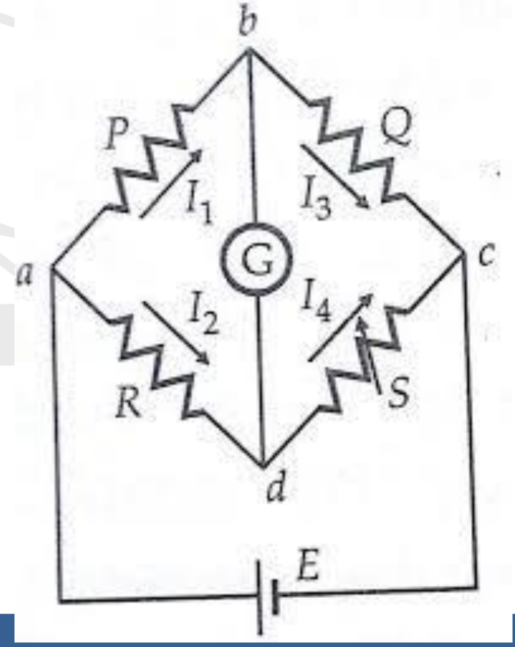
(b) Substitution method

(c) Wheatstone Bridge method

(d) Ohmmeter method

Wheatstone bridge method

- The Wheatstone bridge is **an electrical bridge circuit used to measure resistance**. It consists of a common source of electrical current (such as a battery) and a galvanometer or a multimeter that connects two parallel branches, containing four resistors, three of which are known.
- A very important device for the measurement of medium resistance.
- It is used for making comparison measurements and operates upon null indication principle.
- This makes it a very accurate instrument because the indication is independent of the calibration of the null indicating instrument.



Wheatstone bridge method

- It has four resistive arms, consisting of resistances P, Q, R and S with a source of emf and a null detector, usually a galvanometer G
- The current through the galvanometer depends on the potential difference between points b and d.
- The bridge is said to be balanced when there is no current through the galvanometer or when the potential difference across the galvanometer is zero.
- This occurs when the voltage from point ‘b’ to point ‘a’ equals voltage from point ‘d’ to point ‘a’.
- Under balanced condition,

$$I_1 P = I_2 R \tag{1}$$

For galvanometer current to be zero, following conditions also exist

$$I_1 = I_3 = \frac{E}{P+Q} \tag{2}$$

$$I_2 = I_4 = \frac{E}{R+S} \tag{3}$$

Wheatstone bridge method

❖ Substituting equations (2) and (3) in (1)

$$\frac{P}{P+Q} = \frac{R}{R+S}$$

$$PR + PS = PR + QR$$

$$PS = QR$$

$$\frac{P}{Q} = \frac{R}{S}$$

If three resistances are known then, fourth can be determined by using the equation

$$R = S\frac{P}{Q}$$

where, R = unknown resistance; S= standard arm; P and Q = ratio arms.

Measurement of Resistance

Low resistances - Less than 1Ω

1) AV Method,
2) Kelvin Double Bridge,
3) Potentiometer,
4) Ohmmeter

Measurement of Low resistance

- ❖ Methods used for measurement of medium resistances are unsuitable for measurement of low resistance i.e. resistance <1Ω.
- ❖ The resistance of leads and contacts, though small, are appreciable in comparison to the low resistance to be measured.
- ❖ Hence special type of construction & techniques have to be used to avoid errors due this.

Measurement of Resistance

Kelvin Double Bridge

- The Kelvin double bridge is one of the best devices available for the precise measurement of low resistances.
- It is the modification of Wheatstone bridge by which the errors due to contact resistance and lead resistances are eliminated.
- This bridge is named double bridge because it contains a second set of ratio arms.
- An interesting variation of the Wheatstone bridge is the Kelvin Double bridge, used for measuring very low resistances (typically less than 1/10 of an ohm)

Measurement of Resistance

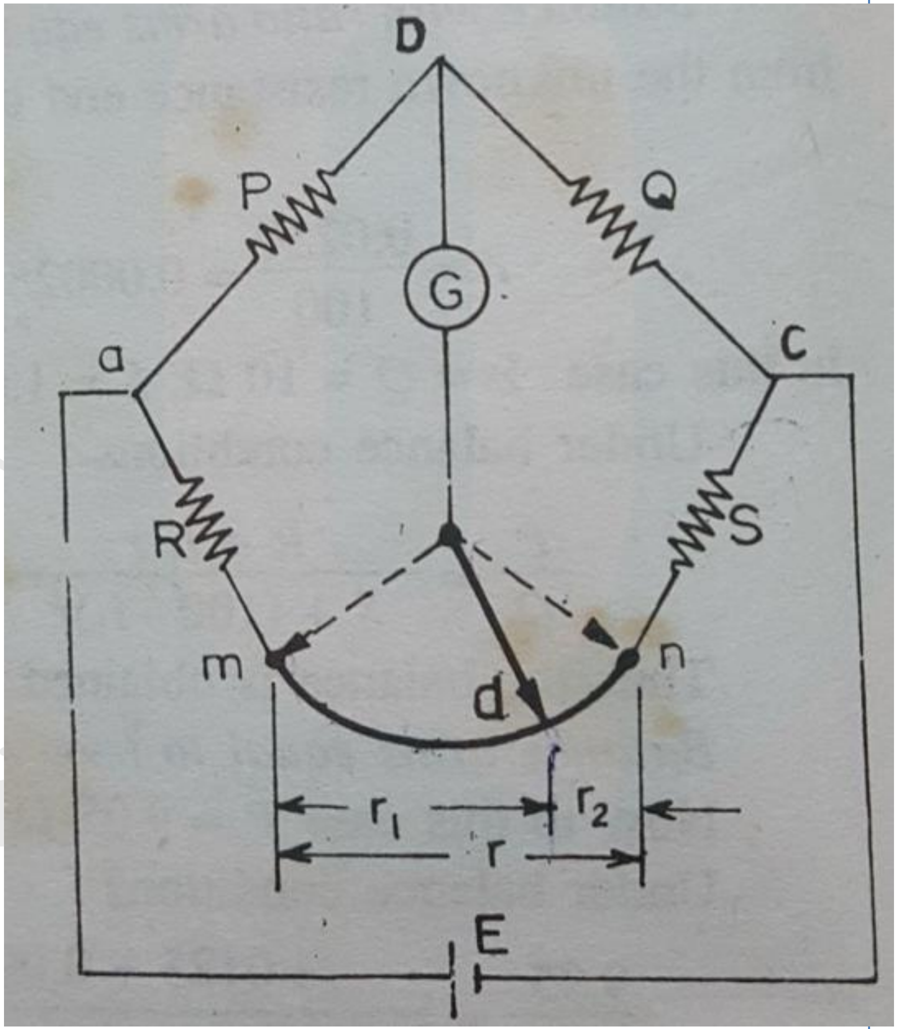
Theory

- Consider the bridge circuit shown in figure below. Here ‘r’ represents the resistance of the lead that connects the unknown resistance ‘R’ to standard resistance ‘S’.
- Two galvanometer connections indicated by dotted lines are possible. The connection may be either to point 'm' or to point 'n'.
- When the galvanometer is connected to point ‘m’ the resistance ‘ r’ of the connecting leads is added to the standard resistance ‘S’ resulting in indication of too low an indication for unknown resistance ‘R’.
- When the connection made to point the resistance ‘r’ is added to the unknown resistance resulting in indication of too high a value for ‘R’.

Kelvin Double Bridge

❖ It is modification of Wheatstone bridge.

- ✓ Consider the bridge circuit where r represents the lead that connects the unknown resistance R to standard resistance S.
- ✓ Two galvanometer connections are possible. The connection may be either to point m or to point n.
- ✓ When galvanometer is connected to point m, the resistance r is added to standard resistance S, resulting in the indication of too low an indication for unknown resistance R.
- ✓ When connection is made to point n, the resistance r is added to the unknown resistance resulting in indication of too high a value for R.



Kelvin Double Bridge

- Suppose the connection is made to any intermediate point d. If at point d the resistance is divided into two parts, r1 and r2, such that

$$\frac{P}{Q} = \frac{r_1}{r_2}$$

- Then the presence of r1, the resistance of connecting leads, causes no error in the result.

$$\mathrm{R} + r_1 = \frac{P}{Q}(S + r_2) \quad (1)$$

But, $\frac{P}{Q} = \frac{r_1}{r_2}$

Or $\frac{P}{P+Q} = \frac{r_1}{r_1+r_2}$ since $r = r_1 + r_2$

$$r_1 = \frac{P}{P+Q} r$$

$$r_2 = \frac{Q}{P+Q} r$$

Kelvin Double Bridge

- Substituting r_1 and r_2 in Eq. (1)

$$(R+\frac{P}{P+Q}r)=\frac{P}{Q}(S+\frac{Q}{P+Q}r)$$

$$R+\frac{P}{P+Q}r=\frac{P}{Q}S+\frac{P}{P+Q}r$$

$$R=\frac{P}{Q}S$$

∴By making the connection at d, the resistance of the leads does not affect the result.

- But this is not a practical method as it would be difficult to determine the correct point of galvanometer connection.
- By a simple modification, if two actual resistance units of correct ratio is connected between points m and n, the galvanometer can be connected to the junction of the resistors.

Measurement of Resistance

Measurement of high resistance

There are different methods that can be employed for the measurement of high resistances. Some of the important methods are as follows.

i) Direct deflection method

ii) Loss of charge method

iii) Megohm bridge method

iv) **Megger method**

Megger method

1) Deflecting & Control coil : Connected parallel to the generator, mounted at right angle to each other and maintain polarities in such a way to produced torque in opposite direction.

2) **Permanent Magnets**: Produce magnetic field to deflect pointer with North-South pole magnet.

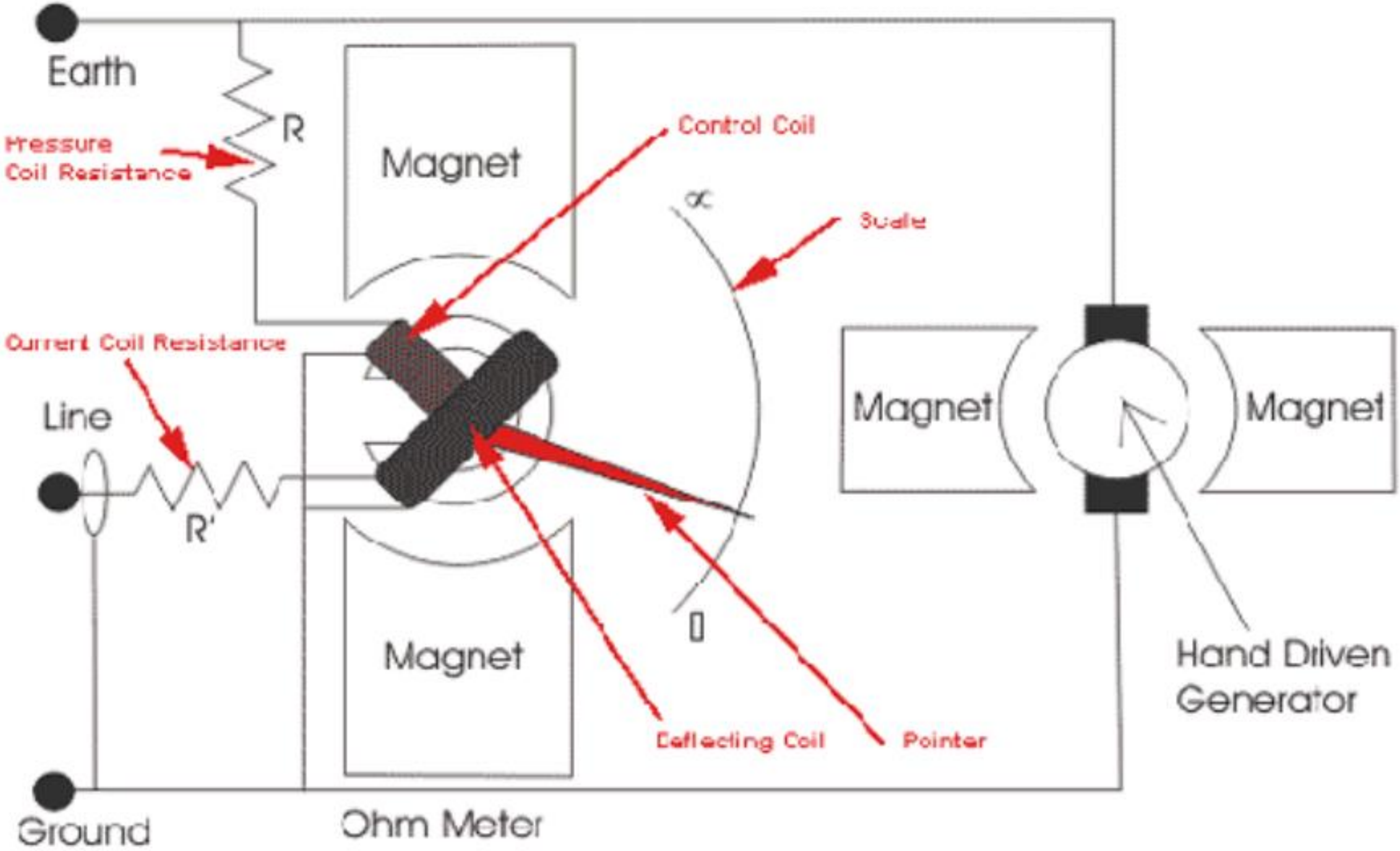
3) **Pointer** : One end of the pointer connected with coil another end deflects on scale from infinity to zero.

4) **Scale** : A scale is provided in front-top of the megger from range ‘zero’ to ‘infinity’, enable us to read the value.

5) **D.C generator or Battery connection** : Testing voltage is produced by hand operated D.C generator for manual operated Megger. Battery / electronic voltage charger is provided for automatic type Megger for same purpose.

6) **Pressure coil resistance and Current coil resistance** : Protect instrument from any damage because of low external electrical resistance under test.

Megger method



Megger method

Working Principle of Megger

- Voltage for testing produced by hand operated Megger by rotation of crank in case of hand operated type, a battery is used for electronic tester.
- 500 Volt DC is sufficient for performing test on equipment range up to 440 Volts. 1000V to 5000V is used for testing for high voltage electrical systems.
- Deflecting coil or current coil connected in series and allows flowing the electric current taken by the circuit being tested.
- The control coil also known as pressure coil is connected across the circuit. Current limiting resistor (CCR & PCR) connected in series with control and deflecting coil to protect damage in case of very low resistance in external circuit.
- In hand operated Megger electromagnetic induction effect is used to produce the test voltage i.e. armature arranges to move in permanent magnetic field or vice versa.
- Where as in electronic type Megger battery are used to produce the testing voltage.
- As the voltage increases in external circuit the deflection of pointer increases and deflection of pointer decreases with a increases of current.

Megger method

Working Principle of Megger

- Hence, resultant torque is directly proportional to voltage & inversely proportional to current.
- When electrical circuit being tested is open, torque due to voltage coil will be maximum & pointer shows ‘infinity’ means no shorting throughout the circuit and has maximum resistance within the circuit under test.
- If there is short circuit pointer shows ‘zero’, which means ‘NO’ resistance within circuit being tested.
- Work philosophy based on ohm-meter or ratio-meter. The deflection torque is produced with Megger tester due to the magnetic field produced by voltage & current, similarly like ‘Ohm's Law’ Torque of the Megger varies in ration with V/I, (Ohm's Law :- V=IR or R=V/I). Electrical resistance to be measured is connected across the generator & in series with deflecting coil. Produced torque shall be in opposite direction if current supplied to the coil.

Megger method

- ❑ High resistance = No current :- No current shall flow through deflecting coil, if resistance is very high i.e. infinity position of pointer.
- ❑ Small resistance = High current :- If circuit measures small resistance allows a high electric current to pass through deflecting coil, i.e. produced torque make the pointer to set at ‘ZERO’.
- ❑ Intermediate resistance = varied current :- If measured resistance is intermediate, produced torque align or set the pointer between the range of ‘zero to infinity’.