DEPARTMENT OF ELECTRICAL ENGINEERING

HARIKISSHORE SINGH

GOVERNMENT POLYTECHNIC SHEOHAR

(Department Of Science,Technology & Technical Education)

LAB MANUAL

BASIC ELECTRICAL ENGINEERING

SUBJECT CODE :- P2420104

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GOVERNMENT POLYTECHNIC

SHEOHAR (843329)

Practical/Lab Session Outcomes (LSOs)

S.NO	Laboratory Experiment	Lab Session Outcomes
01.	Identification of Resistor.	Identify the Resistor Component available in the Laboratory.
02.	Effect of different load conditions on terminal voltage of a source.	Plot the terminal voltage of a source starting from no load to different load (Current) conditions.
03.	Measurement of current and voltage in a branch of the given electric circuit.	Measure current and voltage in branch of the given electric circuit.
04.	Measurement of resistances in series and combination in an electric circuit.	Connect resistors in series and parallel combination on bread board and measure resistance using digital multimeter.
05.	Value of color-coded resistor.	Calculate the value of color-coded resistor and verify it by measuring the value of resistor using digital multimeter.
06.	Measurement of the value of Inductor in series and parallel combination in a circuit.	Calculate the value of equivalent Inductance in series and parallel combination and verify by measuring the value of capacitance using suitable meter (Digital Multimeter/LCR Meter).
07.	Measurement of the value of capacitor in series and parallel combination in a circuit.	Calculate the value of equivalent capacitance in series and parallel combination and verify it by measuring the value of capacitance using suitable meter (Digital Multimeter/LCR Meter).
08.	Phase difference (lag) between voltage and current waveform in a given inductor.	Verify the Phase difference (Lag) between current and voltage waveform for an inductor connected to an AC source with respect to time (using CRO).
09.	Voltage across each element in a given linear circuit.	Calculate voltage across each element in a given circuit applying principles of ohm's law.

10.	Measurement of current in the given electric circuit.	Determine currents in a given electric circuit using KCL and verify it by conducting experiment.
11.	Measurement of voltage in a given electric circuit.	Determine currents in a given electric circuit using KCL and verify it by conducting experiment.
12.	Phase difference(lead) between voltage and current waveform in a given capacitor.	Verify the Phase difference (lead) between current and voltage waveform for a capacitor connected to an AC source with respect to time using CRO).
13.	Demonstration of self and mutual inductance.	Demonstrate self and mutual inductance using experimental set up available in the Laboratory.
14.	BH curve of a magnetic material.	Plot BH curve of a magnetic material.
15.	Demonstration of statically and dynamically induced emf.	Demonstrate statically and dynamically induced emf.
16.	Demonstration of Faraday's laws of electromagnetism.	Demonstrate Faraday's laws of electromagnetism.
17.	Demonstration of Flemings right hand and left- hand rules.	Demonstrate Flemings right hand and left-hand rules.
18.	Demonstration of Lenz's law.	Demonstrate Lenz's law.

LIST OF EXPERIMENTS

01.	Identification of Resistor.
02.	Effect of different load conditions on terminal voltage of a source.
03.	Measurement of current and voltage in a branch of the given electric circuit.
04.	Measurement of resistances in series and combination in an electric circuit.
05.	Value of color-coded resistor.
06.	Measurement of the value of Inductor in series and parallel combination in a circuit.
07.	Measurement of the value of capacitor in series and parallel combination in a circuit.
08.	Phase difference (lag) between voltage and current waveform in a given inductor.
09.	Voltage across each element in a given linear circuit.
10.	Measurement of current in the given electric circuit.
11.	Measurement of voltage in a given electric circuit.
12.	Phase difference(lead) between voltage and current waveform in a given capacitor.
13.	Demonstration of self and mutual inductance.
14.	BH curve of a magnetic material.
15.	Demonstration of statically and dynamically induced emf.
16.	Demonstration of Faraday's laws of electromagnetism.
17.	Demonstration of Flemings right hand and left- hand rules.
18.	Demonstration of Lenz's law.

EXPERIMENT NO:- 01

AIM:

Identification of resisitor.

Apparatus Required:

- Carbon resistors of different values
- Digital multimeter
- Resistor colour code chart

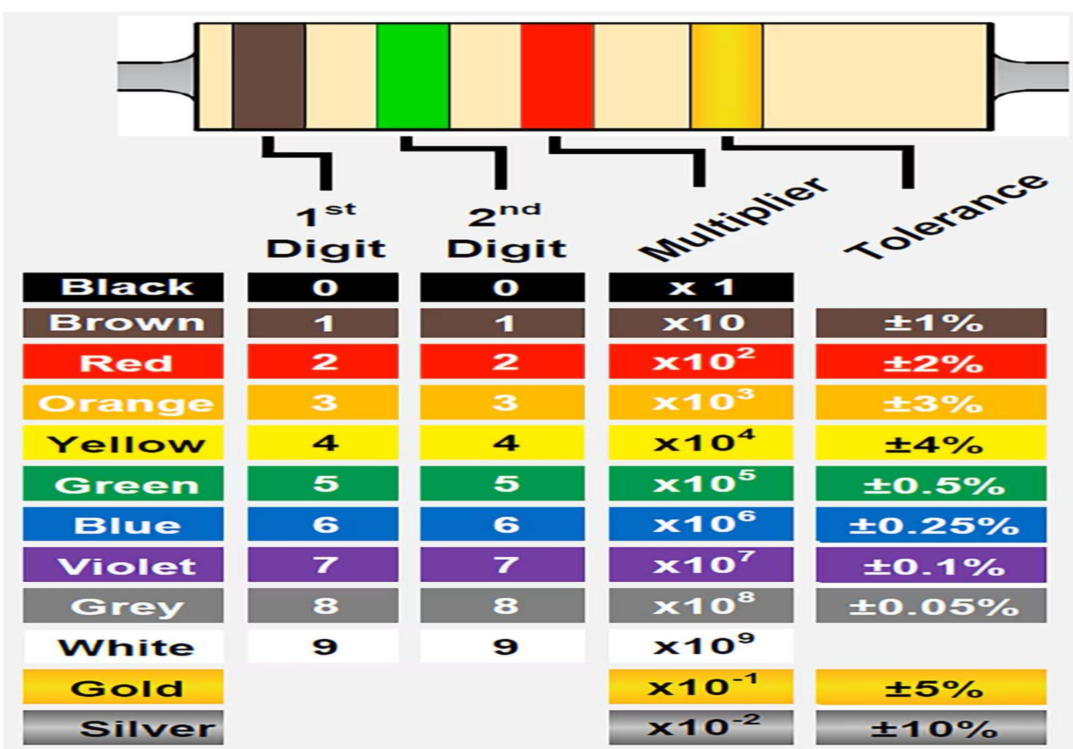
THEORY:

Carbon resistors have 4 or 5 colour bands printed on them. Each colour represents a digit, multiplier, or tolerance.

4-Band Resistor Colour Code:

Band 1 = 1st Digit, Band 2 = 2nd Digit, Band 3 = Multiplier, Band 4 = Tolerance

Formula: Resistance = (1st Digit 2nd Digit) × Multiplier ± Tolerance%



	1st Digit	2nd Digit	Multiplier	Tolerance
Black	0	0	x 1	
Brown	1	1	x10	±1%
Red	2	2	$x10^2$	±2%
Orange	3	3	$x10^3$	±3%
Yellow	4	4	$x10^4$	±4%
Green	5	5	$x10^5$	±0.5%
Blue	6	6	$x10^6$	±0.25%
Violet	7	7	$x10^7$	±0.1%
Grey	8	8	$x10^8$	±0.05%
White	9	9	$x10^9$	
Gold			$x10^{-1}$	±5%
Silver			$x10^{-2}$	±10%

PROCEDURE:

1. Take the given resistor. Check which side has Gold/Silver band. Keep that side on right.
2. Note colours of 1st, 2nd, 3rd and 4th band from left.
3. Write corresponding digits from chart.
4. Calculate value: (1st Digit 2nd Digit) × Multiplier.
5. Check tolerance from 4th band.
6. Set multimeter to Ohm range and measure actual resistance.
7. Verify if measured value is within tolerance range.

OBSERVATION TABLE:

S.No	Band 1	Band 2	Band 3	Band 4	Coded value	Multimeter Reading	Remarks
1.							
2.							
3.							

Calculation Example

For Brown-Black-Red-Gold:

1st = 1, 2nd = 0, Multiplier = 10^2 = 100, Tolerance = ±5%

Value = 10 × 100 = 1000Ω = 1KΩ ±5%

Range: 1000 - 5% = 950Ω to 1000 + 5% = 1050Ω

RESULT:

The resistance values of given resistors were identified using colour code and verified with multimeter. All measured values lie within tolerance range.

PRECAUTIONS:

1. Always keep Gold/Silver band on right side while reading.
2. Check colours in white light.
3. Tight the multimeter probe at lead.
4. Do not touch the resistor under reading.

EXPERIMENT NO:-02

AIM:

Effect of different load conditions on terminal voltage of a source.

APPARATUS REQUIRED:

1. DC Battery / Power Supply - 6V or 12V
2. Voltmeter - 0-15V DC
3. Ammeter - 0-2A DC
4. Rheostat - 0-50Ω, 2A
5. Switch,
6. Connecting wires

THEORY:

Every real voltage source has internal resistance r. When load is connected, current I flows and voltage drops inside the source due to r.

Formula:

$V = E - Ir$

Where:

V = Terminal voltage,

E = EMF / Open circuit voltage,

I = Load current,

r = Internal resistance

PROCEDURE:

1. Connect circuit as shown. Keep rheostat at maximum resistance.
2. Keep switch open and note voltmeter reading. This is EMF E. Current = 0.
3. Close switch. Note V and I. This is light load condition.
4. Decrease rheostat resistance step by step. For each step note V and I.

5. Take 5-6 readings till rheostat is at minimum. This is heavy load.
6. Calculate r = (E - V) / I for each reading.

OBSERVATION TABLE:

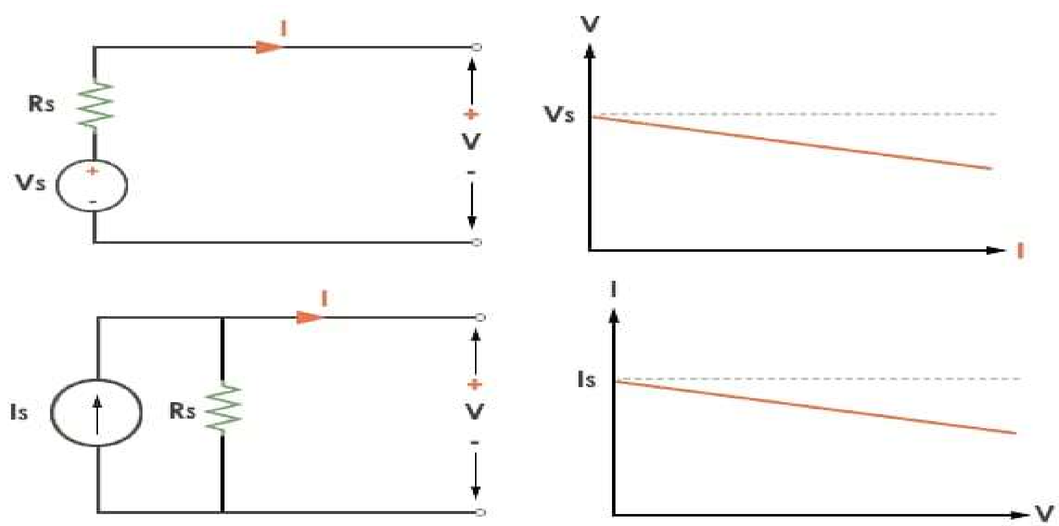
S.No	Load condition	Voltmeter (V)	Ammeter I	R=(E-v0/I
1.	Open circuit	E=12.2v	0.00A	
2.	Light load	11.9V	0.15A	2.0 Ω
3.	Medium load	11.4V	0.40A	2.0 Ω
4.	Heavy load	10.6V	0.80A	2.0 Ω
5.	Full load	10.2V	1.00A	2.0 Ω

CALCULATION:

For S.No. 4: r = (12.2 - 10.6) / 0.80 = 1.6 / 0.80 = 2.0 Ω

Mean internal resistance = 2.0 Ω

PLOT THE GRAPH



RESULT:

1. As load increases, terminal voltage decreases linearly.
2. Internal resistance of given source = 2.0 Ω.
3. Graph between V and I verifies V = E - Ir.

PRECAUTION:

1. Start with maximum load resistance to avoid high current.
2. Do not short circuit the battery.
3. Take readings quickly. Battery voltage may drop if current flows for long
4. .All connections should be tight.

EXPERIMENT NO :-03

AIM:

Measurement of current and voltage in a branch of the given electric circuit.

APPARATUS REQUIRED:

1. DC Power Supply - 0-12V
2. Resistors - 100Ω, 220Ω, 470Ω
3. Digital Multimeter - 2 Nos or 1 with Ammeter & Voltmeter mode
4. Breadboard
5. Connecting wires
6. Switch

THEORY:

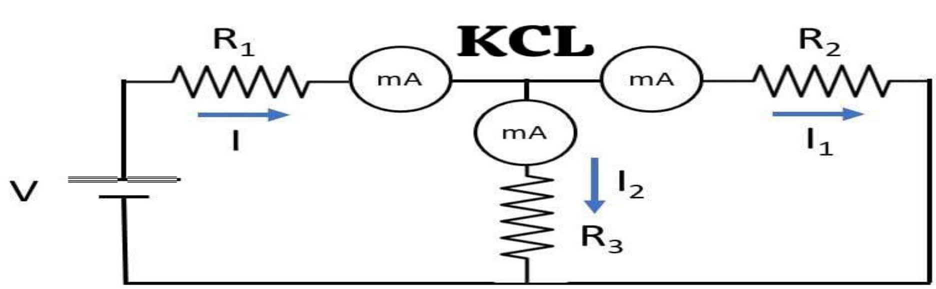
Current Measurement: Ammeter is always connected in series with the branch. Ammeter has very low resistance ≈ 0Ω so it does not affect circuit current.

Voltage Measurement: Voltmeter is always connected in parallel across the branch. Voltmeter has very high resistance ≈ 10MΩ so it does not draw current.

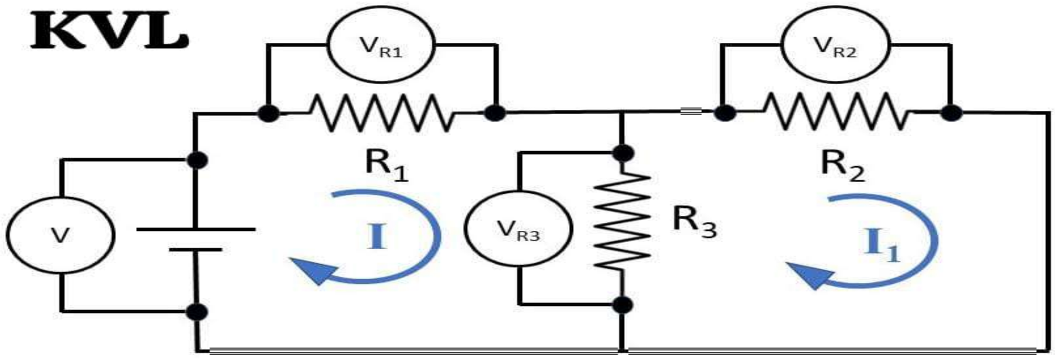
Kirchhoff's Laws:

KCL: Sum of currents entering a node = Sum of currents leaving.

KVL: Sum of voltage drops in a closed loop = Applied EMF.



KVL



PROCEDURE:

A. Current Measurement

1. Connect the circuit on breadboard as per diagram without ammeter.
2. Break the branch where current is to be measured, say R1 branch.
3. Set multimeter to DC Ampere range. Connect ammeter in series in that break.
4. Switch ON supply. Note ammeter reading = Branch current I_1.
5. Switch OFF. Repeat for other branches I_2, I_3.

B. Voltage Measurement

1. Set multimeter to DC Volt range.
2. Connect voltmeter probes directly across the resistor R1. Do not break circuit.
3. Switch ON supply. Note voltage V_1.

OBSEVATION TABLE:

Branch	V/R	Measured I	% Error

Branch	V/R	Measured V	% Error

CALCULATIONS:

RESULTS:

1. Current in R1 branch = 48.0 mA, Voltage across R1 = 4.80V.
2. Kirchhoff's Current Law and Voltage Law are verified for the given circuit.
3. Measured values are close to theoretical values.

PRECAUTION:

1. **Ammeter**: Always connect in series. Never connect across supply directly. Meter will burn.
2. **Voltmeter:** Always connect in parallel. Never connect in series.
3. Start with higher range on multimeter, then decrease for accuracy.
4. Check polarity: Red probe to +ve, Black to -ve.
5. Switch OFF supply while changing connections.

EXPERIMENT NO :-04

AIM:

Measurement of resistances in series and combination in an electric circuit.

APPARATUS REQUIRED:

- Carbon resistors - 100Ω, 220Ω, 330Ω, 470Ω
- Digital multimeter
- Breadboard
- Connecting wires

THEORY:

Series Combination: Resistors connected end to end. Same current flows through all.

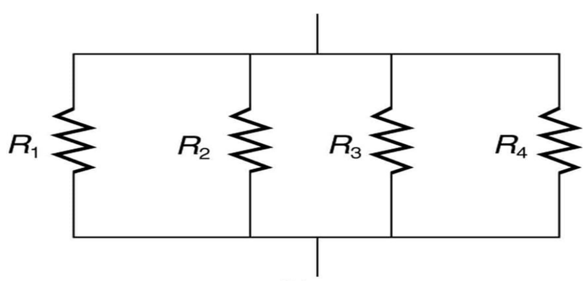
Result: R_s is always greater than the largest individual resistor.

Parallel Combination: Resistors connected between same two points. Same voltage across all.

Result: R_p is always less than the smallest individual resistor.

CIRCUIT DIAGRAM:

(a)



(b)

Resistors in Series

$$R_{total} = R_1 + R_2 + \ldots + R_n$$

Resistors in Parallel

$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}$$

PROCEDURE:

Step 1: Individual Measurement

- Set multimeter to Ohm Ω range.
- Measure each resistor separately: R_1, R_2, R_3. Note down values.

Step 2: Series Measurement

- Connect R_1, R_2, R_3 in series on breadboard as shown.
- Connect multimeter probes at point A and B.
- Note the reading. This is measured R_s.
- Calculate theoretical $R_s = R_1 + R_2 + R_3$. Compare both.

Step 3: Parallel Measurement

- Connect R_1, R_2, R_3 in parallel between same two nodes A and B.
- Connect multimeter probes at point A and B.
- Note the reading. This is measured R_p.
- Calculate theoretical R_p using formula. Compare both.

PRECAUTION:

- Resistors must not be connected to any power source while measuring resistance.
- Do not touch both metal parts of multimeter probes with hands. Body resistance will cause error.
- Use proper range on multimeter for better accuracy.
- Check multimeter zero error by shorting probes. If not zero, subtract that value from reading.

RESULT:

EXPERIMENT NO :-05

AIM:

Value of color-coded resistor.

APPARATUS REQUIRED:

1. Different colour-coded carbon resistors - 4 band and 5 band
2. Digital multimeter
3. Resistor colour code chart

THEORY:

Carbon resistors have coloured bands that represent their resistance value in ohms and tolerance.

A. 4-Band Resistor:

Band 1 = 1st Significant Digit

Band 2 = 2nd Significant Digit

Band 3 = Multiplier = 10^n

Band 4 = Tolerance

Formula: R = (Digit1 Digit2) × Multiplier ± Tolerance%

B. 5-Band Resistor - For precision resistors:

Band 1 = 1st Digit

Band 2 = 2nd Digit

Band 3 = 3rd Digit

Band 4 = Multiplier,

Band 5 = Tolerance

Formula: R = (Digit1 Digit2 Digit3) × Multiplier ± Tolerance%

STANDARD COLOR CODE TABLE:

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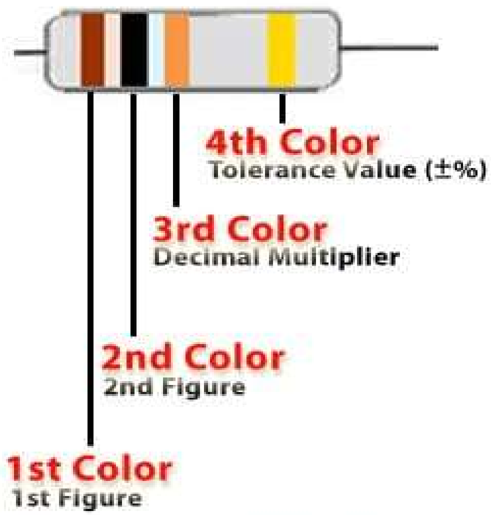
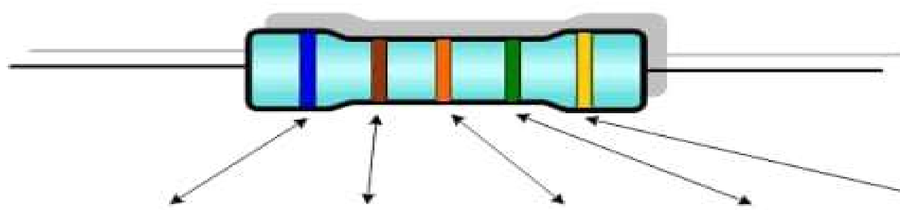


Above shown resistor's colors are Brown, Black, Orange and Golden so its value is **10 X 1000** = 10000Ω or 10KΩ with a tolerance of ±5%

Color Name	Value As Figure	As Decimal Multiplier	Tolerance ±
Black	0	x 1	±20%
Brown	1	x 10^1	±1%
Red	2	x 10^2	±2%
Orange	3	x 10^3	-
Yellow	4	x 10^4	±5%
Green	5	x 10^5	±0.5%
Blue	6	x 10^6	±0.25%
Violet	7	x 10^7	±0.1%
Grey	8	x 10^8	±0.05%
White	9	x 10^9	±10%
Golden	-	x 10^{-1}	±5%
Silver	-	x 10^{-2}	±10%

5-band Resistor



Color	1st band value	2nd band value	3rd band value	Multiplier	Tolerances
Black	0	0	0	× 1	
Brown	1	1	1	× 10	± 1%
Red	2	2	2	× 100	± 2%
Orange	3	3	3	× 1000	± 3%
Yellow	4	4	4	× 10,000	± 4%
Green	5	5	5	× 100,000	± 0.5%
Blue	6	6	6	× 1,000,000	± 0.25%
Violet	7	7	7	× 10,000,000	± 0.10%
Grey	8	8	8	× 100,000,000	± 0.05%
White	9	9	9	× 1,000,000,000	
Gold				× 0.1	± 5%
Silver				× 0.01	± 10%
No band					± 20%

PROCEDURE:

1. Take the given resistor. Identify tolerance band Gold/Silver/Brown. Keep it on right side.
2. Note colours of bands from left to right.
3. For 4-band: Write 1st digit, 2nd digit, multiplier. Calculate value.
4. For 5-band: Write 1st, 2nd, 3rd digit, multiplier. Calculate value.
5. Note tolerance from last band and find range.
6. Set multimeter to Ohm range. Measure actual resistance.
7. Check if measured value lies within tolerance range. If yes, resistor is OK

CALCULATION TABLE:

S.No	Colors	No. Of Bands	Calculation	Coded value	Tolerance range	Measured value	remarks

RESULT:

The values of given colour-coded resistors were determined using colour code. The measured values using multimeter were found within tolerance range. Hence colour code is verified.

PRECAUTION:

1. Always keep the tolerance band Gold/Silver/Brown on the right side while reading the colour code.
2. Identify colours in proper white light. Avoid confusion between similar colours like Red and Orange, Blue and Violet, Brown and Black.
3. Set the multimeter to the appropriate Ohm range before measurement. Start with a higher range and then decrease for better accuracy.

EXPERIMENT NO :-06

AIM:

Measurement of the value of Inductor in series and parallel combination in a circuit.

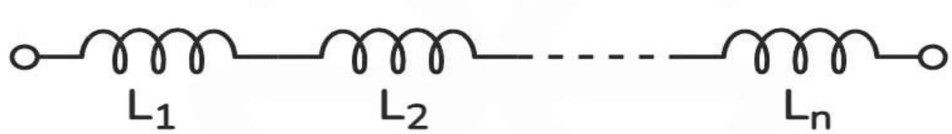
APPARATUS REQUIRED:

1. Inductors - 1mH, 2.2mH, 4.7mH, 10mH
2. LCR Meter / Digital Inductance Meter
3. Breadboard
4. Connecting wires

THEORY:

Inductors store energy in magnetic field. Their combination rules are similar to resistors.

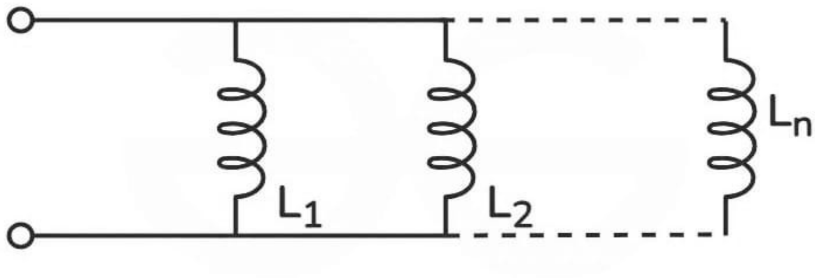
Series combination:



Series Inductances

$$L_{total} = L_1 + L_2 + \dots L_n$$

Parallel Combintion**:**



Parallel Inductances

$$L_{total} = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \dots \frac{1}{L_n}}$$

PROCEDURE:

Step 1: Individual Measurement

Set LCR meter to Inductance L mode and 1kHz frequency.

Measure each inductor separately: L_1, L_2, L_3. Note values.

Step 2: Series Measurement

Connect L_1, L_2 in series on breadboard. Keep them 10cm apart to avoid mutual coupling.

Connect LCR meter probes at ends A and B.

Note reading. This is measured L_s.

Calculate theoretical L_s = L_1 + L_2. Compare

Step 3: Parallel Measurement

Connect L_1, L_2 in parallel between same two nodes A and B.

Keep inductors far apart with axes perpendicular to minimize M.

Measure with LCR meter. This is measured L_p.

Calculate theoretical L_p using formula. Compare.

OBSERVATION:

RESULT:

PRECAUTION:

- Keep inductors far apart or with axes perpendicular to avoid mutual inductance M. If M is present, formula will not match.
- Use LCR meter at fixed frequency, usually 1 kHz, for all measurements. Inductance changes with frequency.
- Ensure zero correction on LCR meter before starting. Short the probes and press REL/Zero button.
- Do not measure inductance in a live circuit. Inductors must be isolated.
- Avoid long connecting wires. Wire inductance will add error in mH range measurements.
- Keep inductors away from metal surfaces and magnetic materials during measurement.

EXPERIMENT NO :-07

AIM:

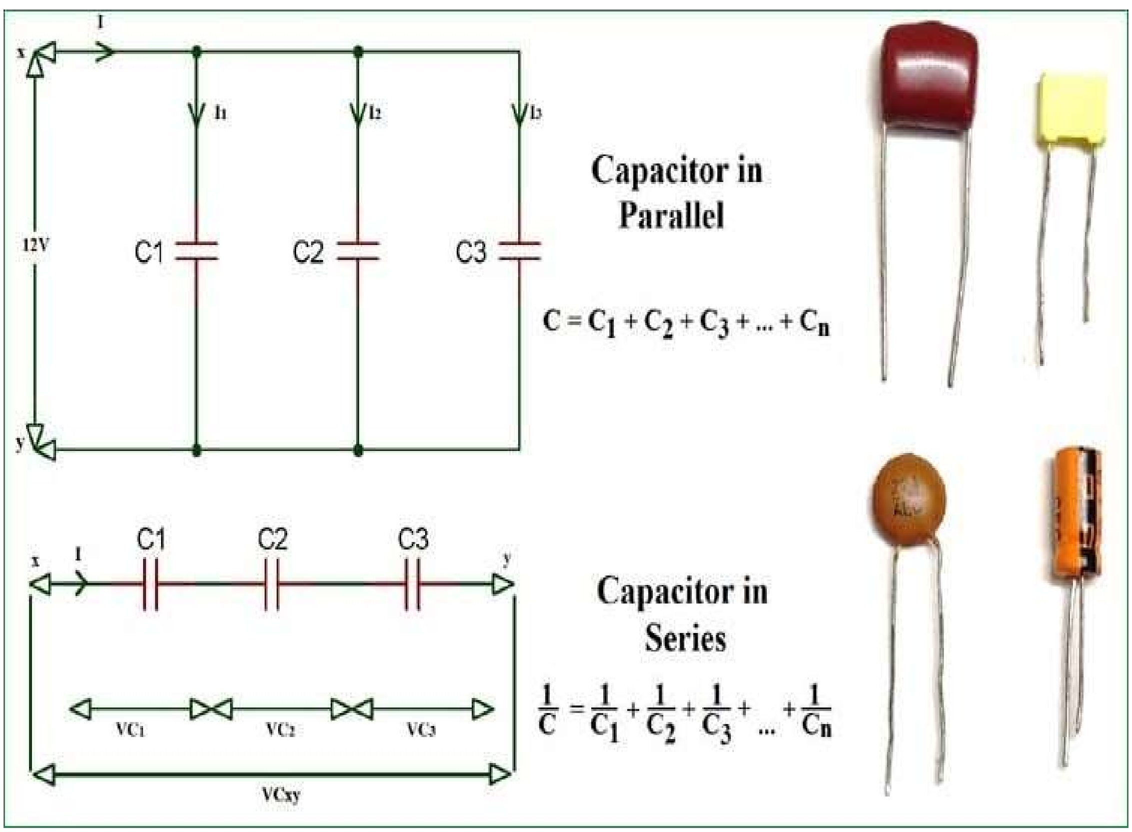
Measurement of the value of capacitor in series and parallel combination in a circuit.

APPARATUS REQUIRED:

- Capacitors - 1μF, 2.2μF, 4.7μF, 10μF, 100nF
- LCR Meter / Digital Capacitance Meter
- Breadboard
- Connecting wires

THEORY:

Capacitors store energy in electric field. Their combination rules are opposite to resistors and inductors.



PROCEDURE:

Step 1: Individual Measurement

- Discharge all capacitors by shorting their leads before measurement.
- Set LCR meter to Capacitance C mode and 1kHz frequency.
- Measure each capacitor separately: C_1, C_2, C_3. Note values.

Step 2: Series Measurement

- Connect C_1, C_2 in series on breadboard.
- Connect LCR meter probes at ends A and B.
- Note reading. This is measured C_s.
- Calculate theoretical C_s using formula. Compare.

Step 3: Parallel Measurement

- Connect C_1, C_2 in parallel between same two nodes A and B.
- Measure with LCR meter. This is measured C_p.
- Calculate theoretical $C_p = C_1 + C_2$. Compare.

OBSERVATION:

CALCULATION:

RESULT:

- For series combination, $C_s < C_{min}$. Measured 0.67 μF is less than 0.98 μF. Formula $1/C_s = 1/C_1 + 1/C_2$ is verified.
- For parallel combination, $C_p = C_1 + C_2$. Measured 3.11 μF matches theoretical 3.13 μF. Law verified.
- Capacitors in series decrease total capacitance, in parallel increase total capacitance.

PRECAUTION:

1. Always discharge capacitors before connecting to LCR meter. Charged capacitor can damage the meter.
2. For electrolytic capacitors, check polarity. Connect +ve lead of meter to +ve of capacitor.
3. Use LCR meter at fixed frequency, usually 1 kHz. Capacitance value changes slightly with frequency.
4. Keep hands away from capacitor leads during measurement. Body capacitance will cause error.
5. Do not measure capacitance in a live circuit. Capacitors must be isolated.
6. For very small capacitance in nF/pF range, use short leads and do REL/Zero correction to remove stray capacitance.

EXPERIMENT NO :-08

AIM:

Phase difference (lag) between voltage and current waveform in a given inductor.

APPARATUS REQUIRED:

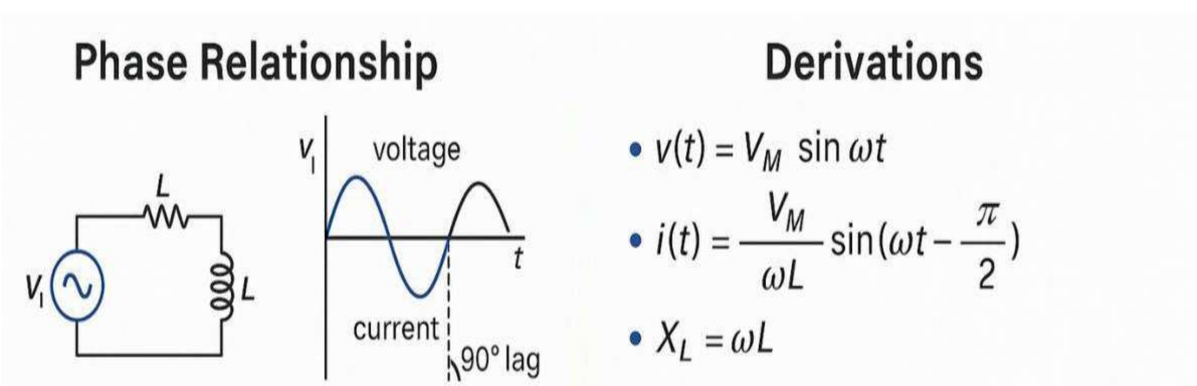
- Signal Generator - 1 kHz, 5V p-p sine wave
- Inductor - 10mH or 33mH air core
- Resistor - 100Ω, non-inductive, used as current sensing resistor
- Dual Channel Oscilloscope - CRO or DSO
- Connecting wires
- Breadboard

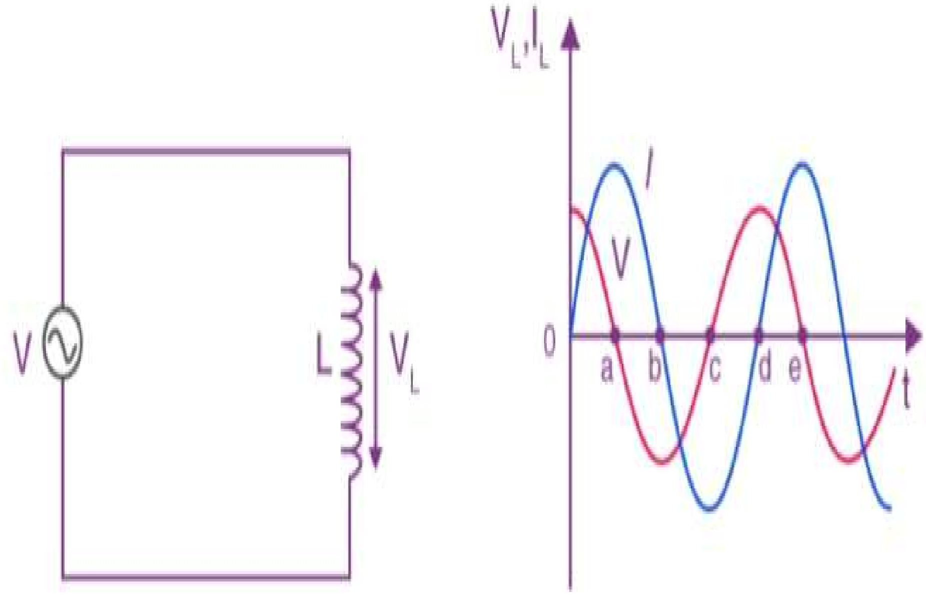
THEORY :

In a pure inductor, voltage leads current by 90°. Or current lags voltage by 90°.

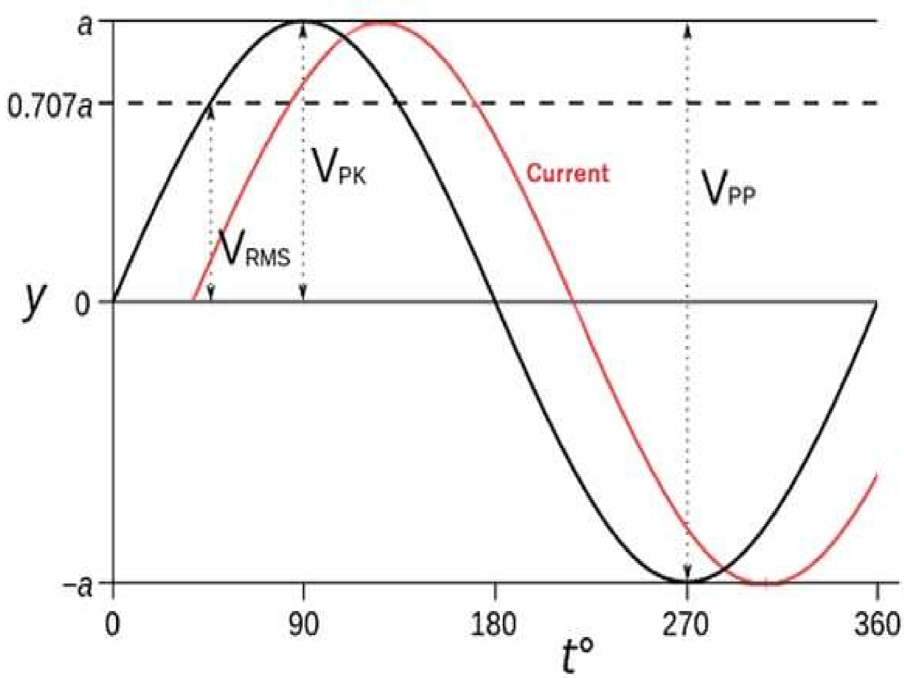
Reason: Inductor opposes change in current. From V_L = L dI/dt.

If I = I_m sin(ωt), then V_L = L d/dt[I_m sin(ωt)] = ωL I_m cos(ωt) = ωL I_m sin(ωt + 90°) So V_L leads I by 90°.





Voltage leads current. This implies an inductive circuit.



PROCEDURE:

- Connect circuit as per diagram. Inductor and resistor in series with signal generator.
- Connect CH1 of CRO across inductor L. Connect CH2 across resistor R. Keep CRO ground common at bottom point.
- Set signal generator: Sine wave, f = 1 kHz, Amplitude = 5V p-p.
- Switch ON CRO. Adjust time base to get 1-2 cycles on screen. Adjust Volts/div for both channels.
- Select Dual mode. Trigger on CH1. You will see two sine waves.
- Note that V_L waveform leads V_R waveform. V_R is same phase as current I.
- Measure time difference Δt between two peaks or zero crossings using CRO cursors.
- Measure time period T of one full cycle.
- Calculate phase difference: $\phi = (\Delta t / T) \times 360°$ degrees.
- Calculate theoretical $X_L = 2\pi fL$, $Z = \sqrt{(r^2 + X_L^2)}$, $\phi = \tan^{-1}(X_L / r)$. Compare.

OBSERVATION :

S No.	f	L	R	Δt	T	Measured $\phi = (\Delta t/T)\times 360°$	Theoretical ϕ

RESULT :

- For given inductor, current lags voltage by 79.2° at 1 kHz.
- In ideal inductor lag should be 90°. Due to winding resistance, measured lag is less than 90°.
- As frequency increases, X_L increases, phase angle approaches 90°. Hence verified.

PRECAUTION:

- Use air-core or high-quality inductor to minimize resistance and get phase close to 90°.
- Sensing resistor R value should be small compared to X_L so it does not affect phase much. But not too small else V_R will be noisy. 100Ω is good for mH range at 1kHz.
- CRO ground is common for both channels. Connect it at one point only to avoid ground loop and short circuit.
- Use non-inductive resistor for current sensing. Carbon composition or MFR type.
- Keep signal generator amplitude moderate. High current can saturate inductor core.
- For accurate Δt, use CRO cursor measurement or X-Y mode to get Lissajous figure. For 90° lag, ellipse with major axis at 45° is seen.

EXPERIMENT NO :-09

AIM:

Voltage across each element in a given linear circuit.

OBJECTIVES:

To measure voltage across each element in a given RLC series circuit using AC supply and verify Kirchhoff's Voltage Law KVL.

APPRATUS REQUIRED:

1. Signal Generator - 1 kHz, 5V p-p sine wave
2. Resistor - 1kΩ
3. Inductor - 10Mh
4. Capacitor - 0.1μF
5. Digital Multimeter / AC Voltmeter / Oscilloscope
6. Breadboard,
7. connecting wires

THEORY:

Kirchhoff's Voltage Law:

In any closed loop, sum of all voltages is zero. For AC:

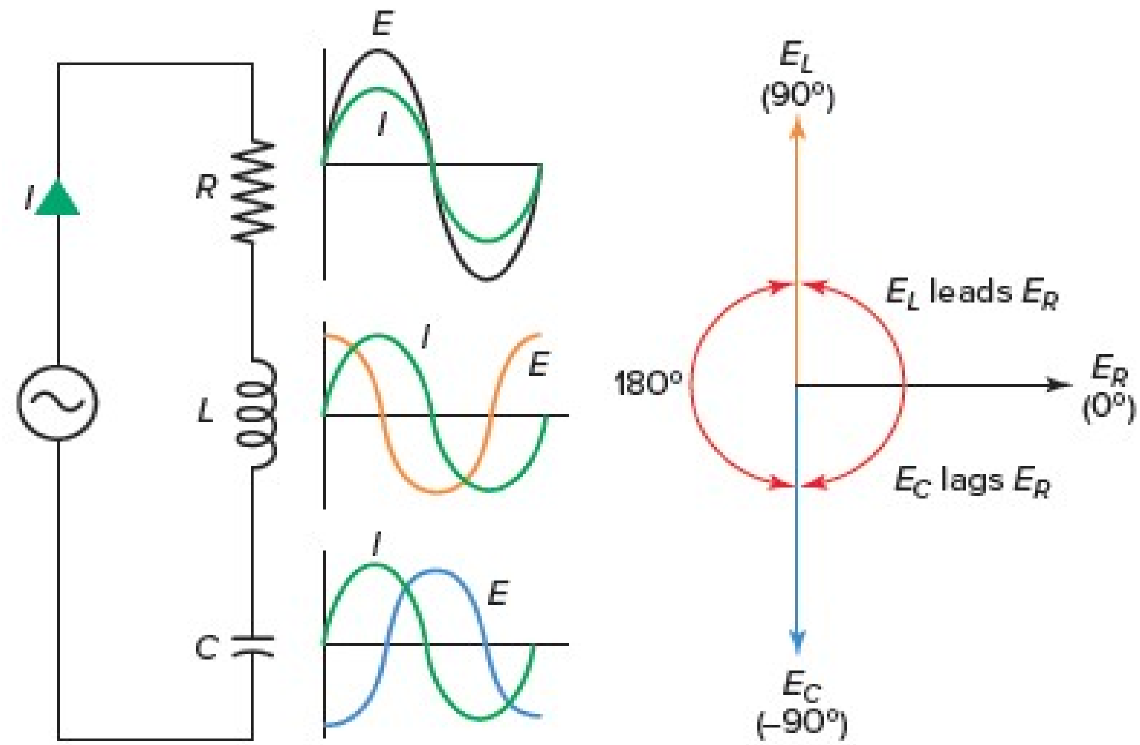
$V_s = V_R + V_L + V_C$ in phasor form, not scalar sum.

In AC circuits, voltages across R, L, C have different phases:

- V_R is in phase with current I.
- V_L leads I by 90° .
- V_C lags I by 90° .

So total supply voltage $V_s = \sqrt{(V_R^2 + (V_L - V_C)^2)}$ for series RLC.

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connect R, L, C in series with signal generator as per diagram.
2. Set signal generator: Sine wave, f = 1 kHz, V_s = 3V RMS or 5V p-p.
3. Set multimeter to AC Voltage mode, suitable range 0-20V.
4. Measure supply voltage V_s across signal generator terminals. Note it.
5. Measure voltage across resistor V_R by connecting multimeter probes across R only.
6. Measure voltage across inductor V_L across L only.
7. Measure voltage across capacitor V_C across C only.
8. Note: Do not measure all at once with single meter. Change probes for each element.
9. For phase, use Dual Channel CRO: CH1 for V_s, CH2 for V_R or V_L or V_C to see phase shifts.

OBSERVATION TABLE:

S.No	Parameter	Theoretical value	Measured value	Remarks

RESULT:

PRECAUTIONS:

1. Use AC voltmeter or DMM in AC mode. DC mode will give wrong reading.
2. For inductor and capacitor, use signal frequency where X_L and X_C are comparable to R for better observation. At very low/high f, one element dominates.
3. Do not touch circuit when supply is ON. Use low voltage <10V for safety.
4. Ensure multimeter leads have no loose contact. Error will occur.
5. For accurate phase relation, use CRO instead of DMM. DMM gives only magnitude.
6. Discharge capacitor before connecting/removing from circuit.
7. Check frequency of signal generator with CRO. Wrong frequency changes X_L, X_C.

EXPERIMENT NO :-10

AIM:

Measurement of current in the given electric circuit.

(We consider current measure through KCL)

APPARATUS REQUIRED:

S No.	Name of the Apparatus	Range	Quantity
01.	RPS	0-15V	1
02.	Resistor	1KiloOhms	3
03.	Ammeter	0-10 mA	3
04.	Bread Board	……	1
05.	Connecting Wire	……	As required

THEORY:

Kirchoff's current law:

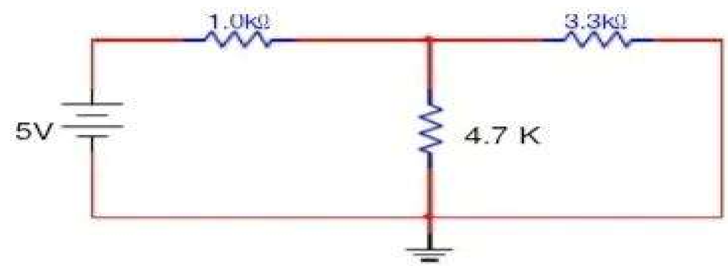
The algebraic sum of the currents entering in any node is Zero.

The law represents the mathematical statement of the fact change cannot accumulate at a node. A node is not a circuit element and it certainly cannot store destroy (or) generate charge. Hence the current must sum to zero. A hydraulic analog sum is zero. For example consider three water pipes joined pn the shape of Y. we defined free currents as following into each of 3 pipes. If we insists that what is always

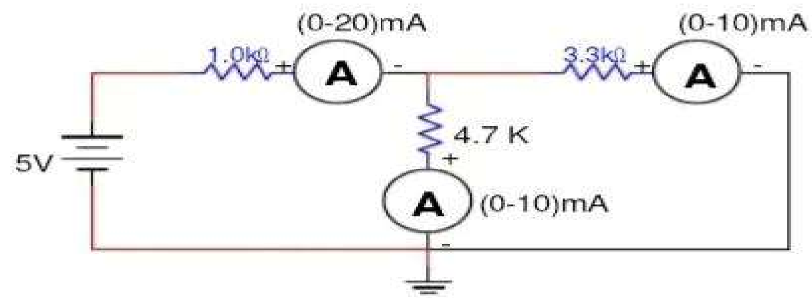
PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Check your connections before switch on the supply.
3. Vary the regulated supply.
4. Measure the current using ammeter.
5. Note the readings in the tabulation.
6. Compare the observation reading to theoretical value.

Kirchoff`s current law



Practical measurement:



Tabulation:

Voltage	Total current I(mA)	I_1(mA)	I_2(mA)

RESULT:

EXPERIMENT NO :-11

AIM:

Measurement of voltage in a given electric circuit.

(Measure the voltage by help of KVL)

APPARATUS REQUIRED:

S No.	Name of the Apparatus	Range	Quantity
01.	RPS	0-15V	1
02.	Resistor	(1,2.2,3.3)KiloOhms	3
03.	Voltmeter	0-20V	3
04.	Bread Board	……	1
05.	Connecting Wire	……	As required

THEORY:

kirchoff's voltage law

The algebraic sum of the voltage around any closed path is zero.

PROCEDURE:

1. Connections are made as per the circuit diagram.

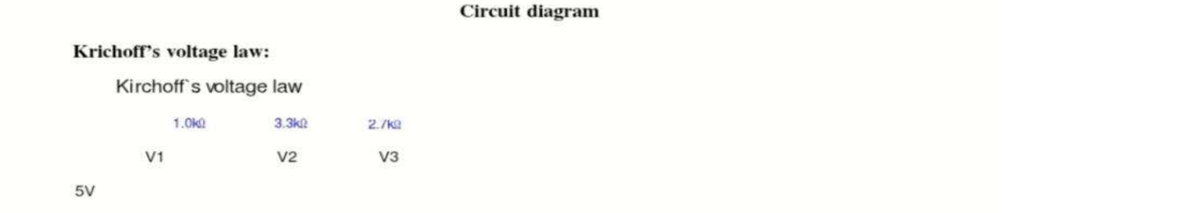
2. Check your connections before switch on the supply. 3. Vary the regulated supply.

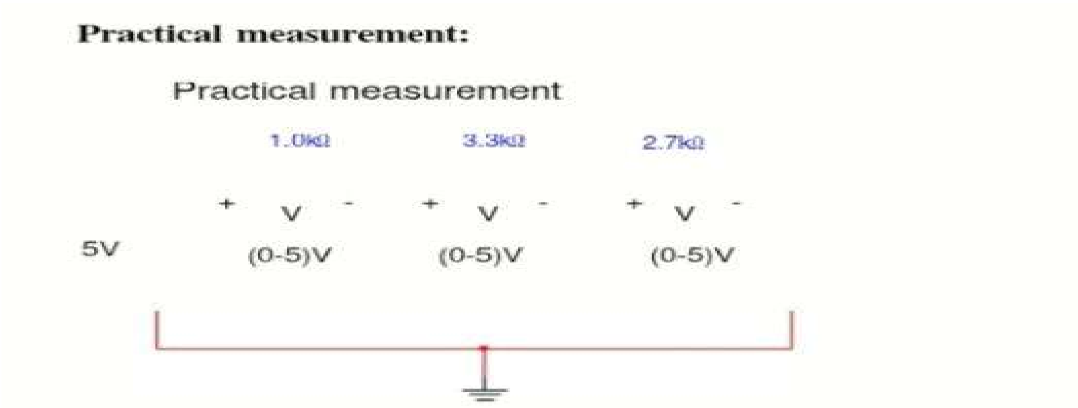
4. Measure the voltage using voltmeter.

5. Note the readings in the tabulation.

6. Compare the observation reading to theoretical value.

Circuit diagram





TABULATION:

Voltage (V)	V1 (Volts)	V2 (Volts)	V3(Volts)

CALCULATIONS:

RESULTS:

Thus the voltage in branch is measured by KVL.

EXPERIMENT NO :-12

AIM:

Phase difference (lead) between voltage and current waveform in a given capacitor.

APPARATUS:

1. Signal Generator - 1 kHz, 5V p-p sine wave
2. Capacitor - 0.1µF or 0.22µF non-polar ceramic/polyester
3. Resistor - 1kΩ, non-inductive, used as current sensing resistor
4. Dual Channel Oscilloscope - CRO or DSO
5. Connecting wires,
6. Breadboard

THEORY:

In a pure capacitor, current leads voltage by 90°. Or voltage lags current by 90°.

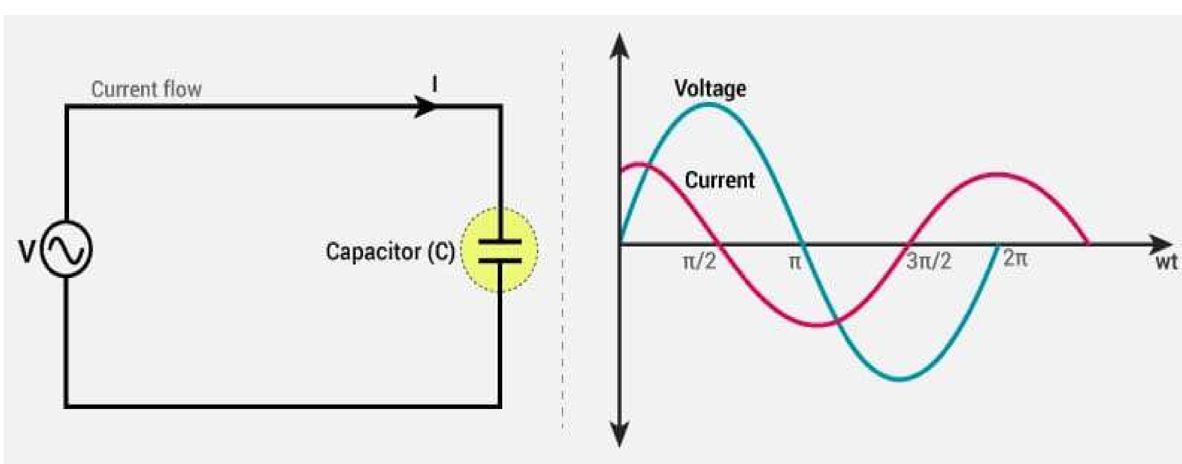
Reason: Capacitor opposes change in voltage.

From I_C = C dV/dt.

If V = V_m sin(ωt), then

I_C = C d/dt[V_m sin(ωt)] = ωC V_m cos(ωt) = ωC V_m sin(ωt + 90°) So

I_C leads V_C by 90°.



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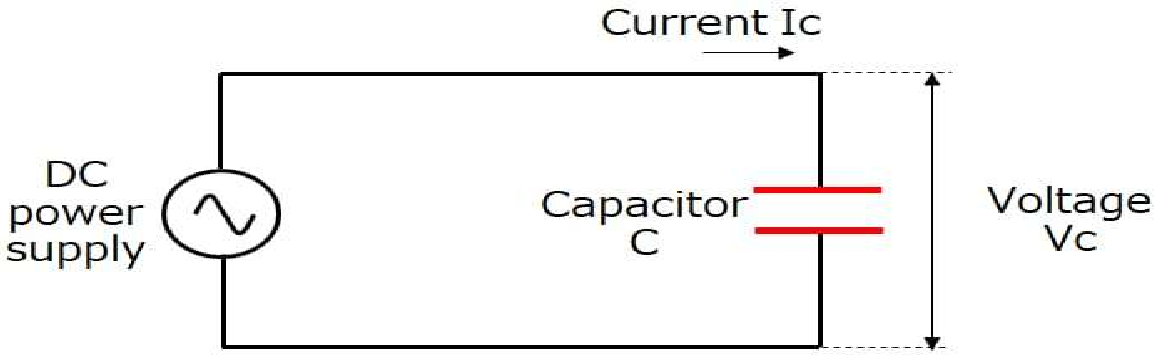
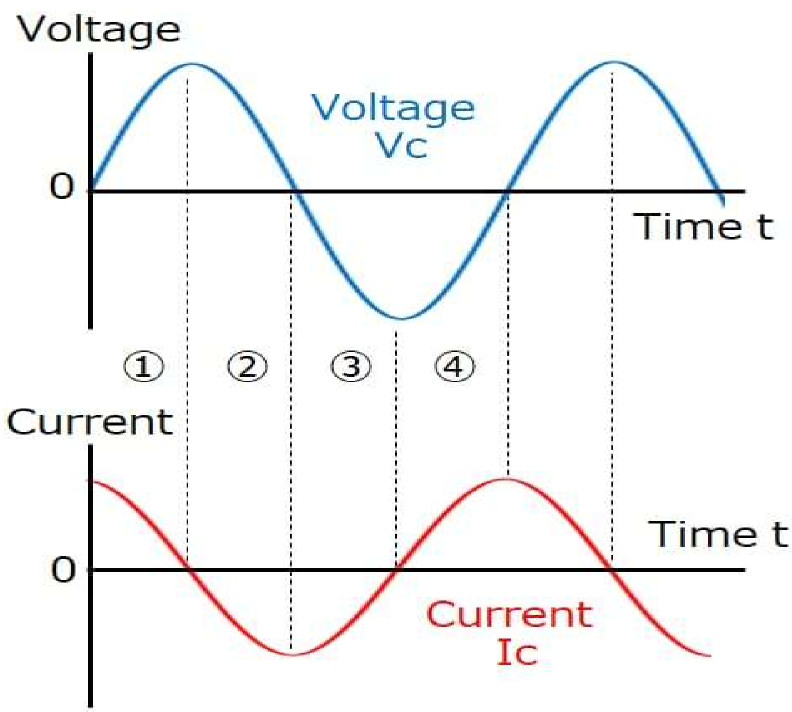
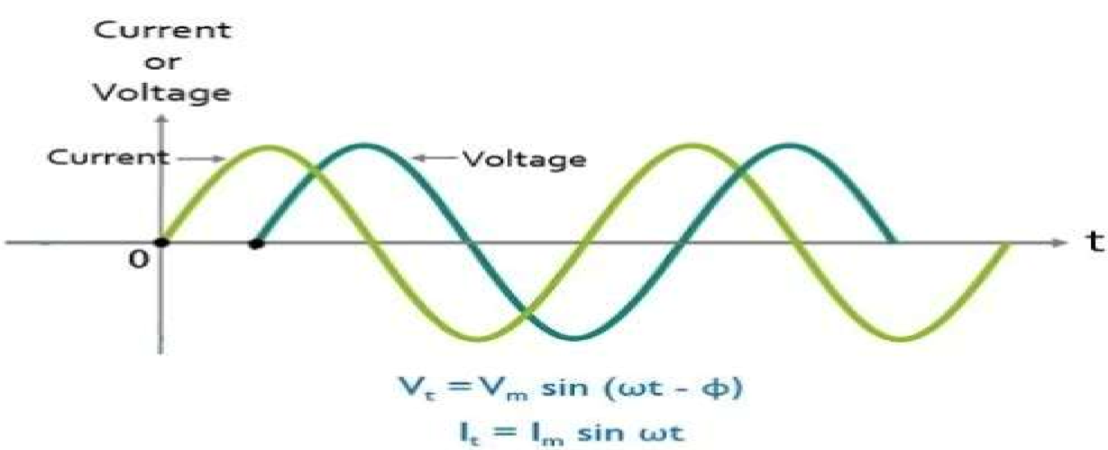






PROCEDURE:

1. Connect capacitor and resistor in series with signal generator as per diagram.
2. Connect CH1 of CRO across capacitor C to observe V_C. Connect CH2 across resistor R to observe V_R which is in phase with current I.
3. Set signal generator: Sine wave, f = 1 kHz, Amplitude = 5V p-p.
4. Switch ON CRO. Use Dual mode. Trigger on CH2. Adjust time/div to display 1-2 cycles clearly.
5. Observe waveforms. V_R or I waveform should appear before V_C waveform. Current leads voltage.
6. Measure time difference Δt between zero crossing or peak of CH2 V_R and CH1 V_C. CH2 peak occurs first.
7. Measure time period T of one full cycle.
8. Calculate phase difference: $\phi = (\Delta t / T) \times 360°$ degrees. This is phase lead of current.
9. Calculate theoretical $X\_C = 1/(2\pi fC)$, $\phi = \tan^{-1}(X\_C / ESR)$. For ideal C, $ESR \approx 0$, so $\phi \approx 90°$. Compare.

RESULT:

1. For given capacitor, current leads voltage by 82.8° at 1 kHz.
2. In ideal capacitor lead should be 90°. Due to ESR and dielectric loss, measured lead is less than 90°.
3. As frequency increases, X_C decreases, but phase angle stays close to 90° for good capacitors. Hence verified.

PRECAUTION:

1. Use good quality non-polar capacitor. Electrolytic capacitors have high ESR and leakage, giving large error in phase.
2. Sensing resistor R value: Choose R << X_C so that most voltage drops across C and phase measurement is accurate. But not too small else

V_R is too small to measure. At 1kHz, 0.1μF: X_C=1.59kΩ, so R=1kΩ is ok

3. .CRO ground is common. Connect it at bottom point only to avoid shorting capacitor or resistor.
4. Use sine wave only. For other waveforms, phase concept is different and DMM will not work.
5. Do not apply DC to circuit for long. Capacitor will block DC and charge up.
6. For accurate Δt, use CRO cursor or Lissajous X-Y mode. For 90° lead, ellipse with major axis at 135° is seen.
7. Discharge capacitor before disconnecting to avoid shock.

OBSERVATION:

EXPERIMENT NO :-13

AIM:

Demonstration of self and mutual inductance.

APPARATUS REQUIRED:

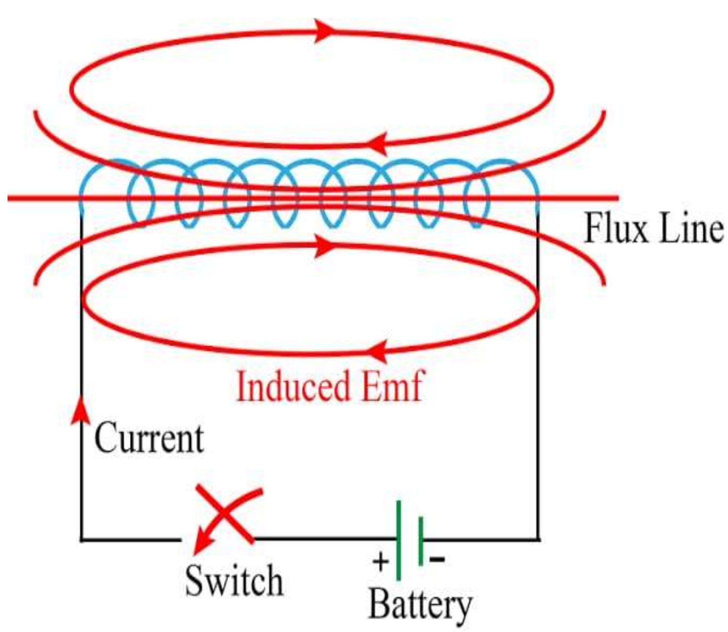
1. Two identical air-core coils - 300 turns each, with ferrite rod for core.
2. Signal Generator - 1 kHz, 5V p-p sine wave.
3. AC Voltmeter / DMM in AC mode, AC Milliammeter / DMM in mA AC.
4. Resistor - 100Ω for current limiting.
5. Iron/ferrite core rod
6. Connecting wires,
7. Breadboard

THEORY:

A. Self Inductance(L):

Property of a coil by which it opposes change in current flowing through it due to induced EMF in the same coil.

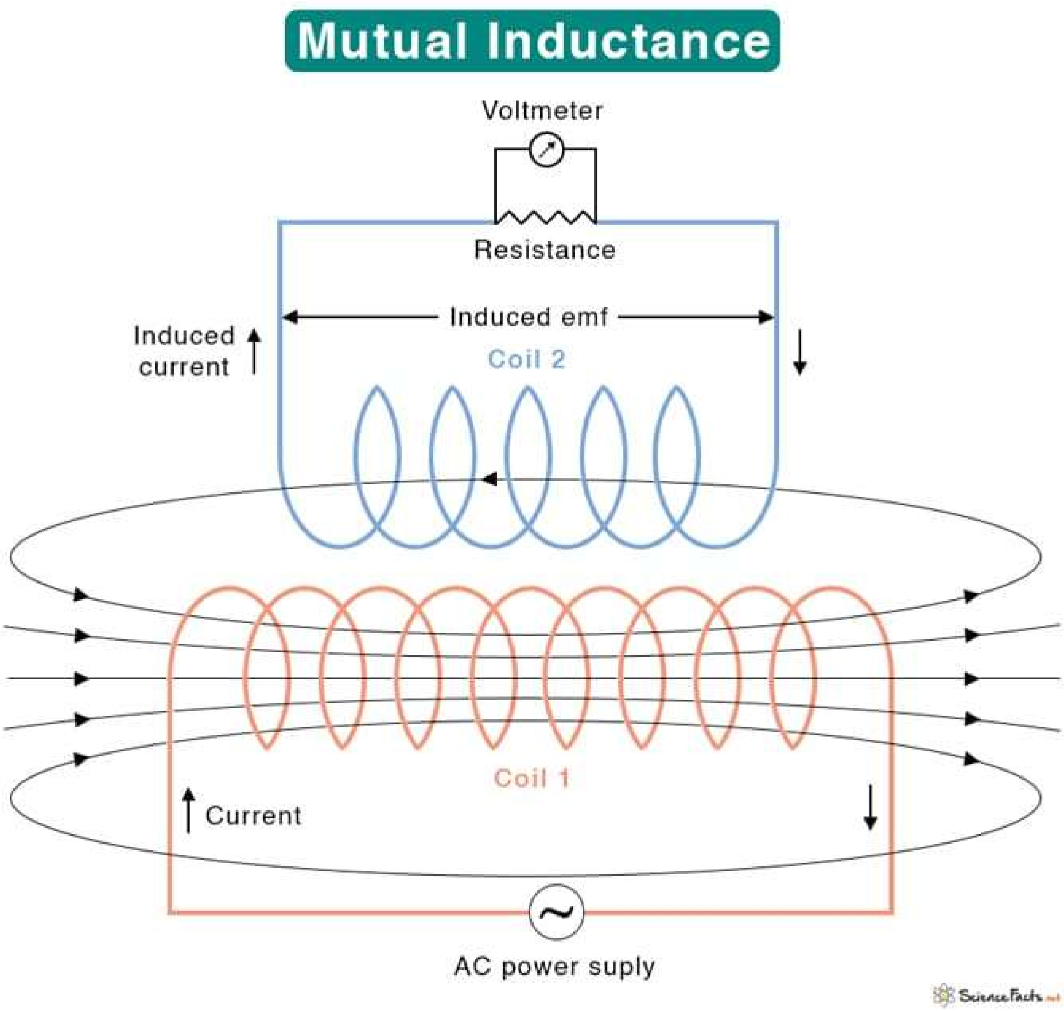
e = -L dI/dt. Unit: Henry H.



B. Mutual Inductance (M):

When two coils are placed close, change in current in primary coil induces EMF in secondary coil.

$e_2 = -M\, dI_1/dt$. Unit: Henry H.



PROCEDURE:

Part A: Self Inductance L

- Connect coil L1 in series with 100Ω resistor and signal generator. Insert AC milliammeter to measure I.

- Set f = 1 kHz, adjust amplitude so I ≈ 10-20 mA. Do not saturate core.
- Measure voltage V_L across coil L1 using AC voltmeter.
- Calculate X_L = V_L / I, then L = X_L / (2πf).
- Insert ferrite core inside L1. Note V_L increases. Calculate new L. Core increases L.

Part B: Mutual Inductance M

- Place coil L2 coaxially close to L1. Keep distance 1-2 cm. Secondary open, no load.
- Apply AC to primary L1. Measure primary current I_1.
- Measure open-circuit voltage V_2 induced in L2.
- Calculate $M = V_2 / (2\pi f I_1)$.
- Now insert common ferrite core through both coils. V_2 will increase drastically. Calculate new M. Note k increases.
- Increase distance between coils. V_2 decreases, M decreases, k decreases.

RESULT:

PRECAUTION:

1. Use low frequency 1-5 kHz. At high f, skin effect and self-capacitance of coil cause error.
2. Keep current low <50mA to avoid heating and core saturation. Saturation makes L non-linear.
3. For mutual inductance, secondary must be open circuit. If loaded, V_2 will drop due to secondary current.
4. Coils should be rigid. Moving coils changes M during reading.
5. Use AC meters. DC cannot measure inductance. DMM must be in AC mode.
6. Ensure ferrite core does not touch windings. It may crack and change μ.
7. Keep coils away from metal bench and other magnetic material to avoid stray coupling.

EXPERIMENT NO :-14

AIM:

BH curve of magnetic material.

APPARATUS REQUIRED:

1. Ring type specimen with primary winding N_1 and secondary winding N_2
2. Step-down transformer 6V-0-6V, 2A
3. Rheostat 50Ω, 3A
4. Non-inductive resistor 1Ω for H measurement
5. RC integrator: R = 47kΩ, C = 8μF non-polar
6. Dual channel CRO with X-Y mode
7. AC Ammeter 0-2A, connecting wires

THEORY:

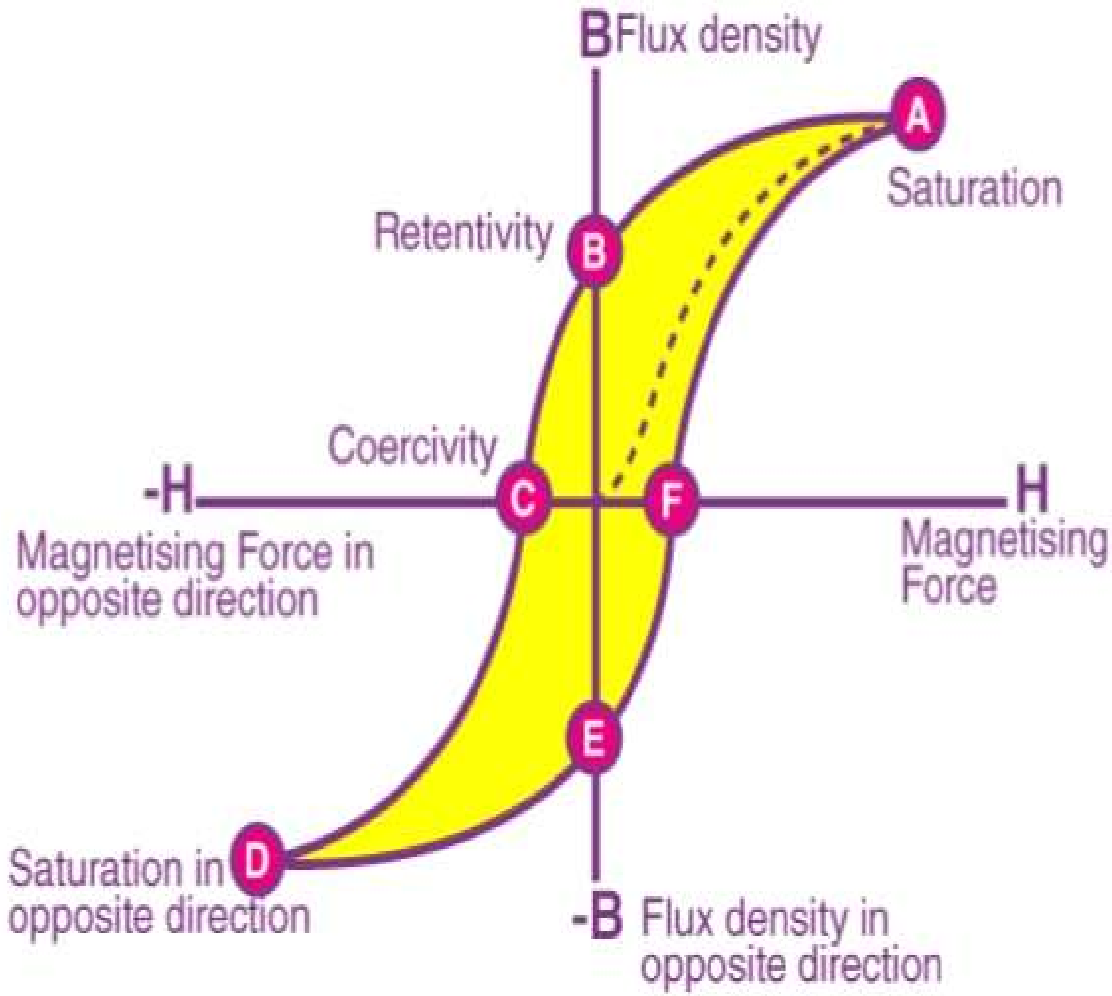
Hysteresis:

In ferromagnetic materials, B lags behind H due to domain wall motion. Plotting B vs H for one complete AC cycle gives a closed loop called hysteresis loop.

Key Parameters:

1. H - Magnetizing Force: $H = N_1 I / l$ A/m, where l = mean length of magnetic path.
2. B - Flux Density: $B = \Phi / A$ Tesla, where A = area of cross-section.
3. Saturation B_s: Max value of B. All domains aligned.
4. Retentivity B_r: Value of B when H = 0. Residual magnetism.
5. Coercivity H_c: Value of -H required to make B = 0. Measure of magnetic hardness.
6. Hysteresis Loss: Area enclosed by B-H loop = energy loss/m^3/cycle = $\oint H\, dB$ J/m^3.

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connect circuit as shown. Ensure CRO is in X-Y mode, DC coupling for both channels.
2. Keep rheostat at max resistance. Bring CRO spot to center with GND inputs.
3. Switch ON 6V AC. Gradually decrease rheostat to increase primary current.
4. A loop appears on CRO. Adjust X and Y gains to get 6-8 div loop size. Adjust rheostat till core saturates, loop tips become pointed.
5. Trace the loop on butter paper from screen. Note CRO sensitivity: V/div for X and Y.
6. To demagnetize at end, slowly reduce current to zero using rheostat.
7. From traced curve, find intercepts on X and Y axes for H_c and B_r. Note max H and B for saturation.

OBSERVATION:

CALCULATION:

RESULT:

1. B-H curve of given specimen is obtained. Nature of loop confirms ferromagnetic behavior.
2. Saturation flux density $B_s = 1.17$ T
3. Retentivity $B_r = 0.79$ T
4. Coercivity $H_c = 240$ A/m. Material is semi-hard magnetic.
5. Hysteresis loss = 1338 J/m³ per cycle.
6. Small coercivity and narrow loop indicate material is suitable for transformer cores where low loss is needed.

PRECAUTION:

1. Specimen must be demagnetized before experiment by gradually reducing AC from max to zero. Old magnetization gives asymmetric loop.
2. RC time constant must satisfy $RC \gg T = 1/f$. For 50Hz, T=20ms. Here RC=376ms, so condition ok. Else output of integrator will not be $\propto$ B.
3. Use non-polar capacitor. Polar electrolytic causes distortion.
4. 1Ω resistor must be non-inductive. Any inductance adds phase shift between V_x and H.
5. Keep leads twisted and short to avoid picking up stray EMF.
6. Do not increase current beyond saturation. Excessive heating changes material properties.

EXPERIMENT NO :-15

AIM:

Demonstration of statically and dynamically induced emf.

APPRATUS REQUIRED:

- Two air-core coils - Primary 300 turns, Secondary 600 turns.
- Bar magnet – strong
- Galvanometer / Center-zero microammeter 30-0-30 μA
- Battery 6V DC, Key,
- Rheostat 100Ω
- Soft iron core rod
- Connecting wires

THEORY:

Faraday's Laws of Electromagnetic Induction:

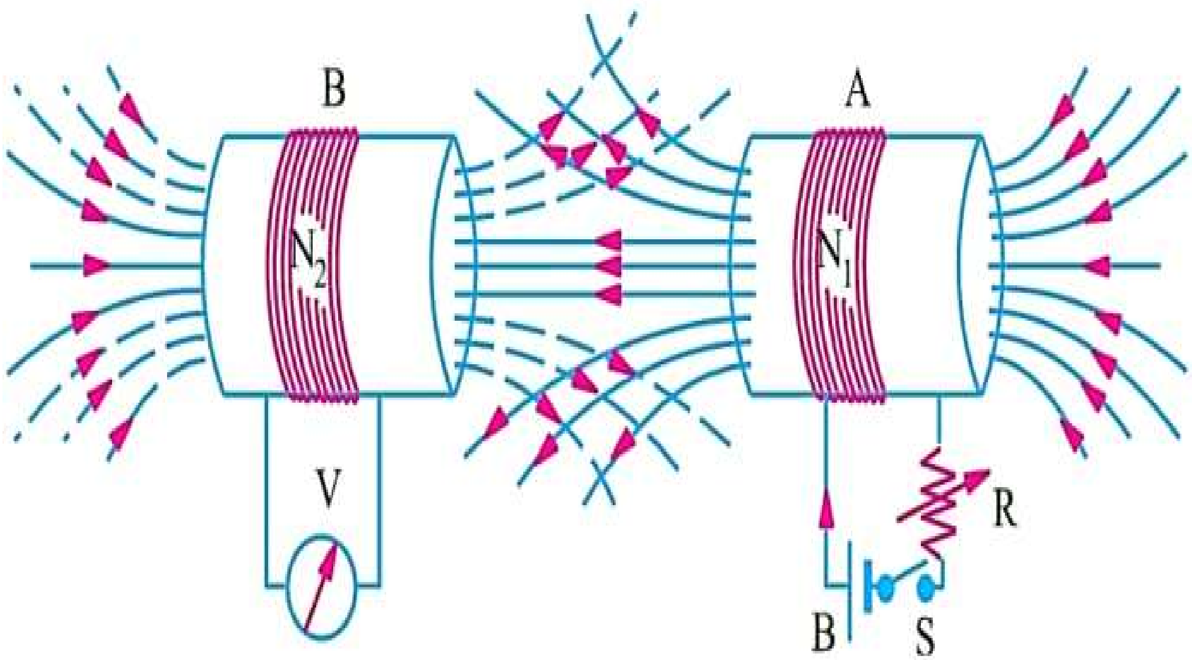
- Whenever magnetic flux linked with a coil changes, an EMF is induced in it.
- Magnitude of induced EMF $e = -N\, d\Phi/dt$, where N = turns, Φ = flux.

Types of Induced EMF:

1.Statically Induced EMF: Coil is stationary. Flux linked with it changes due to change in current in another coil or magnet. No motion.

- Mutually induced EMF: Change of current in primary induces EMF in secondary. $e_2 = -M\, dI_1/dt$

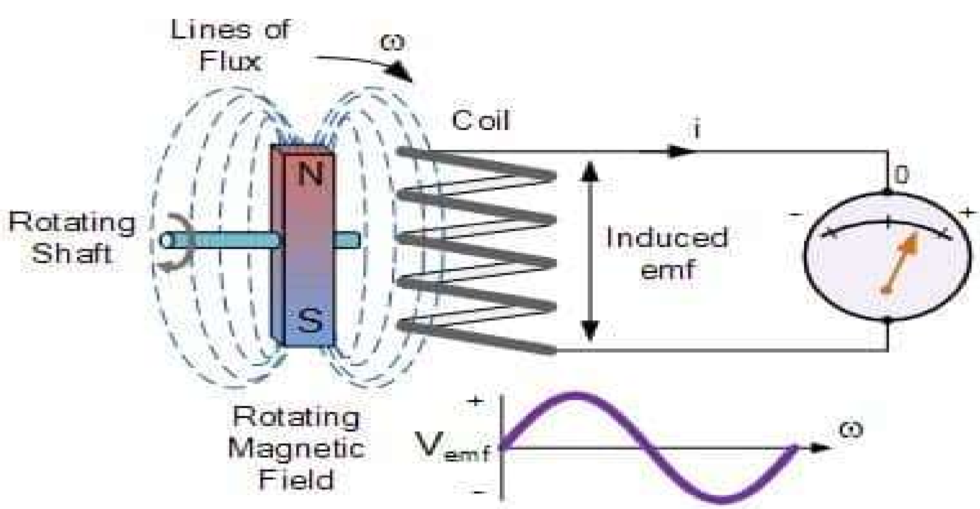
- Self induced EMF: Change of current in coil induces EMF in same coil. $e = -L\, dI/dt$



2.Dynamically Induced EMF:

Conductor moves in a stationary magnetic field, or field moves and conductor is stationary. Flux linkage changes due to relative motion.

e = Blv for straight conductor, where B = flux density, l = length, v = velocity. Direction by Fleming's Right Hand Rule.



PROCEDURE:

Part A: Statically Induced EMF - Mutual Induction

- Connect primary coil to 6V battery through key and rheostat. Connect secondary coil to galvanometer.
- Keep coils coaxial and 5cm apart with air gap. Keep key OFF.
- Close key suddenly. Observe galvanometer. It shows momentary deflection, say to right, then returns to zero. Current in primary rises from 0 to steady value, flux increases, EMF induced in secondary.
- Keep key closed. Galvanometer reads zero. Steady current → no flux change → no EMF.
- Open key suddenly. Galvanometer deflects momentarily to left, opposite direction, then zero. Current falls to zero, flux decreases, EMF reverses polarity.
- Now insert soft iron core through both coils. Repeat steps 3-5. Deflection increases. Core increases flux linkage, M increases.
- Vary rheostat quickly while key is closed. Changing I_1 gives deflection. Faster change → larger deflection → verifies $e \propto dI/dt$

Part B: Statically Induced EMF - Self Induction

- Connect 300 turn coil in series with battery, key, rheostat, galvanometer.
- Close key. Momentary deflection opposite to battery current direction. This is back EMF due to self L.
- Open key. Large deflection in same direction as battery current. L tries to maintain current.

Part C: Dynamically Induced EMF

- Connect 600 turn coil to galvanometer. Keep circuit open, no battery.

- Take bar magnet. Move N-pole quickly into coil. Galvanometer deflects one side. Hold magnet stationary inside - deflection becomes zero. Flux constant.
- Pull magnet out quickly. Galvanometer deflects to opposite side. Flux decreases.
- Move magnet faster - deflection increases. $e \propto d\Phi/dt$.
- Reverse magnet to S-pole first. Deflection direction reverses. Verify Lenz's law: induced current creates N-pole at coil face when N-pole approaches, to oppose motion.
- Instead of moving magnet, keep magnet fixed and move coil. Same effect. Relative motion matters.

OBSERVATION:

RESULT:

1.Statically Induced EMF:

Demonstrated using two coils. EMF is induced in secondary only when primary current changes. Steady DC gives no EMF. Magnitude increases with iron core and rate of change of current. Verifies $e = -M\, dI/dt$.

2.Self Induced EMF:

Observed in single coil when circuit is made/break. Coil opposes change in its own current.

3.Dynamically Induced EMF:

Demonstrated using magnet and coil. EMF induced only when there is relative motion. Direction follows Lenz's law and Fleming's Right Hand Rule. Magnitude increases with speed of motion. Verifies $e = -N\, d\Phi/dt$.

4.Hence Faraday's laws verified for both static and dynamic cases.

EXPERIMENT NO :-16

AIM:

Demonstrartion of faraday's laws of electromagnetism.

APPRATUS REQUIRED:

1. Solenoid coil - 600 turns, air-core
2. Strong bar magnet
3. Galvanometer - center zero type, 30-0-30 μA
4. Primary coil 300 turns, Secondary coil 600 turns
5. Battery 6V DC, Tap key, Rheostat 100Ω
6. Soft iron rod
7. Connecting wires
8.

THEORY:

Faraday's First Law:

Whenever magnetic flux linked with a closed circuit changes, an EMF is induced in it. The EMF lasts only as long as flux is changing.

Faraday's Second Law:

Magnitude of induced EMF is directly proportional to the rate of change of flux linkage.

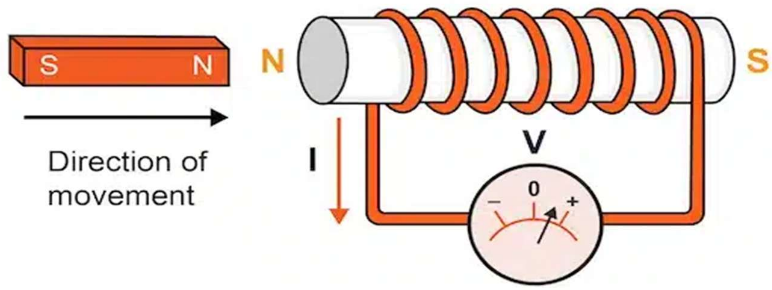
$e = -N\, d\Phi/dt$

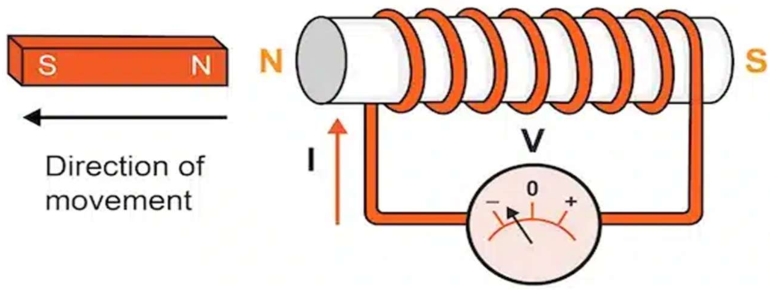
Where N = number of turns, Φ = flux, negative sign = Lenz's law.

Lenz's Law:

The direction of induced EMF/current is such that it opposes the change in flux that produced it. This is why we get the negative sign.

CIRCUIT DIAGRAM:


S
N
N
S
Direction of movement
I
V
0
−
+


S
N
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Direction of movement
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V
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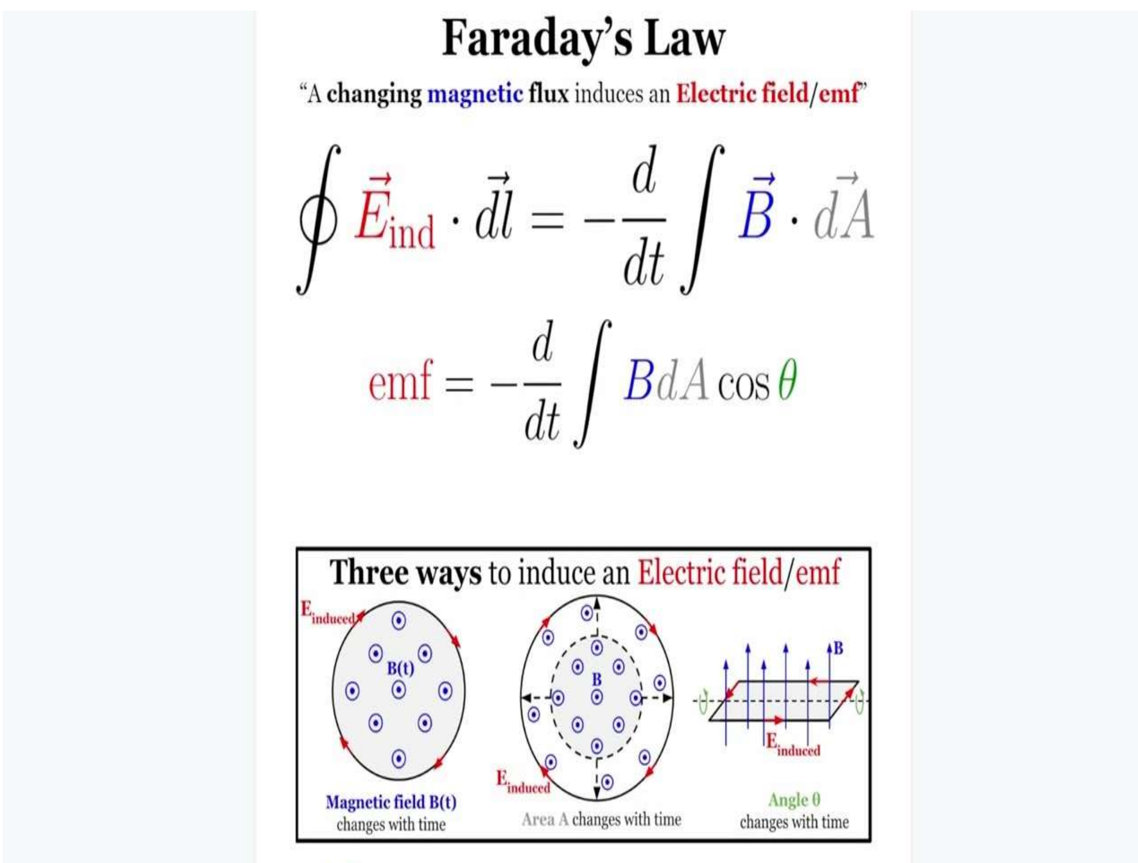
Faraday's Law
"A changing magnetic flux induces an Electric field/emf"
$\oint \vec{E}_{\text{ind}} \cdot d\vec{l} = -\frac{d}{dt}\int \vec{B} \cdot d\vec{A}$
$\text{emf} = -\frac{d}{dt}\int B\,dA\cos\theta$
Three ways to induce an Electric field/emf
E_{induced}
B(t)
B
Magnetic field B(t) changes with time
Area A changes with time
Angle θ changes with time

RESULT:

1. EMF is induced only when magnetic flux linked with coil changes. This verifies Faraday's 1st law.
2. Magnitude of induced EMF increases with faster motion of magnet, more turns, and iron core. This verifies 2nd law $e = -N\, d\Phi/dt$.
3. Direction of induced current always opposes the change causing it. This verifies Lenz's law.
4. Both dynamically induced EMF magnet-coil and statically induced EMF coil-coil obey Faraday's laws.

PRECAUTION:

1. Galvanometer must be sensitive center-zero type. Dead-beat type will not show momentary kick clearly.
2. Move magnet along axis of coil for max flux linkage. Do not move sideways.
3. Make and break primary circuit sharply. Slow operation gives negligible dI/dt.
4. Keep magnet, coils away from other magnetic materials and meters to avoid stray deflection.
5. Do not pass high current in primary for long. Coil may heat and change resistance.
6. Use non-inductive rheostat for primary if possible, to get clean step change.
7. While demonstrating Lenz's law, feel the opposition force manually when you push magnet fast into shorted coil. Coil will repel.
8. Demagnetize core after use so residual magnetism doesn't affect next reading.

EXPERIMENT NO :-17

AIM:

Demonstrartion of Flemings right hand and left hand rules.

APPARATUS REQUIRED:

1. Strong U-shaped permanent magnet or 2 bar magnets
2. Rectangular copper coil - 50 turns, mounted on axle with commutator
3. Battery 6V DC, Rheostat 10Ω, Key
4. Galvanometer - center zero 30-0-30 μA
5. Connecting wires, Stand
6. Straight copper wire - 10cm
7. Soft iron rod for core

THEORY:

A. Fleming's Left Hand Rule - Motor Rule:

Used to find direction of force on a current carrying conductor in magnetic field.

- **Thumb:** Direction of Force/Motion
- **Forefinger:** Direction of Magnetic Field N→S
- **Middle finger**: Direction of Current + to –

If conductor carries current in magnetic field, it experiences force $F = BIL \sin\theta$. Motor works on this.

B. Fleming's Right Hand Rule - Generator Rule:

Used to find direction of induced current when conductor moves in magnetic field.

- Thumb: Direction of Motion of conductor
- Forefinger: Direction of Magnetic Field N→S
- Middle finger: Direction of Induced Current

Generator works on this: $e = Blv$. Direction given by right hand rule.Remember: Left for Motor, Right for Generator. LMRG - Left Motor, Right Generator.

REPRESENTATION:

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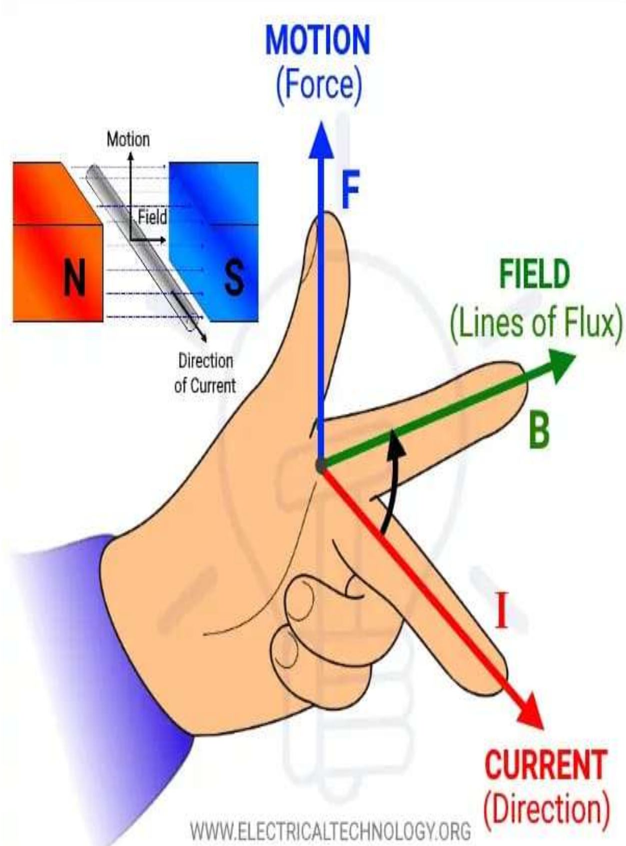
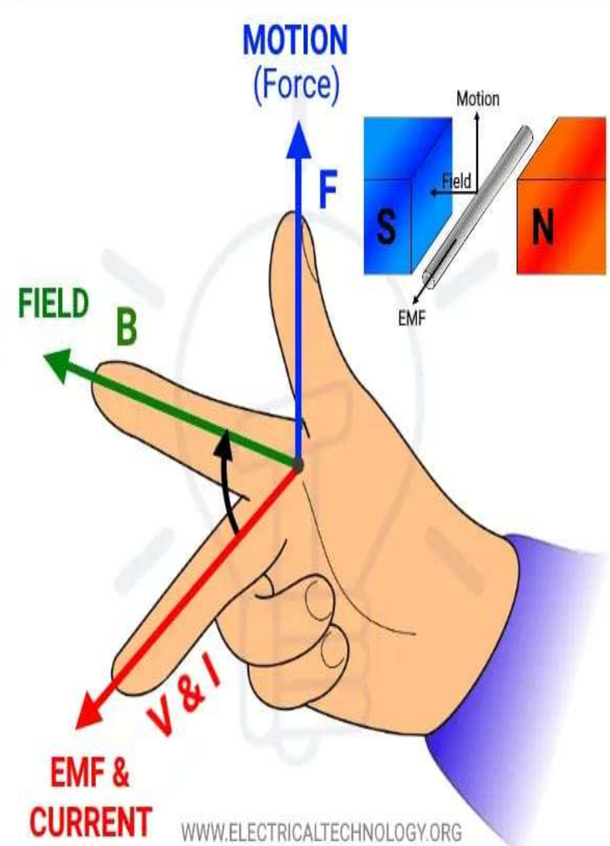
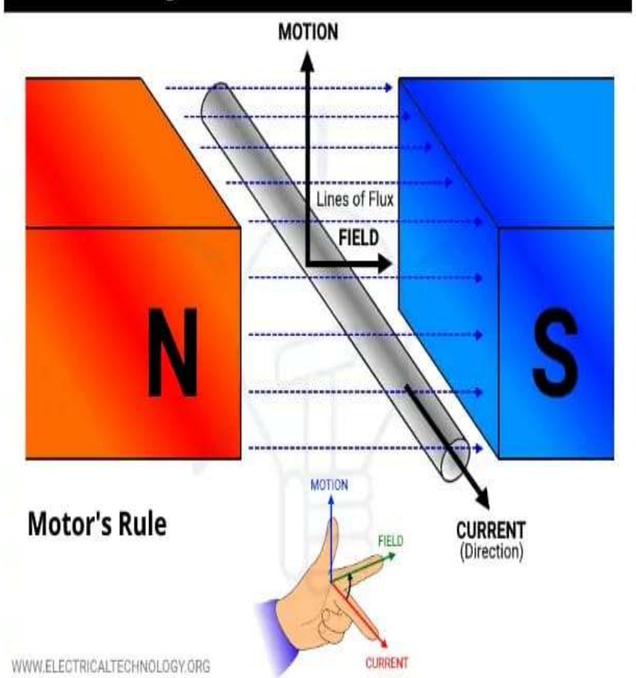
FLEMING'S LEFT HAND RULE



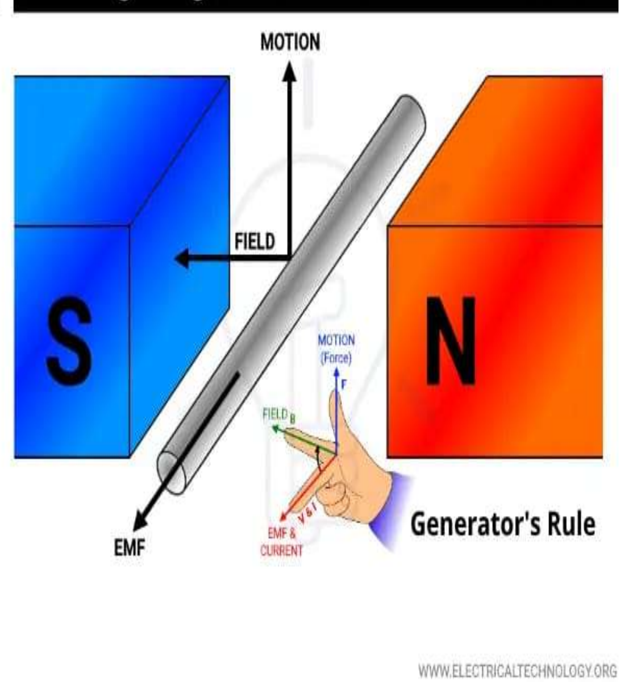
FLEMING'S RIGHT HAND RULE



Fleming's Left Hand Rule for Motors



Fleming's Right Hand Rule for Generators



OBSERVATION:

RESULT:

1. When current flows through conductor in magnetic field, it experiences mechanical force. Direction of force is given by Fleming's Left Hand Rule. Demonstrated with wire kick. This is principle of DC motor.
2. When conductor is moved in magnetic field, EMF is induced in it. Direction of induced current is given by Fleming's Right Hand Rule. Demonstrated with rotating coil and galvanometer. This is principle of DC generator.
3. Both rules verified practically. Left hand for motor, right hand for generator.

PRECAUTION:

1. Use strong magnet to get appreciable force and EMF. Weak field gives negligible deflection.
2. For motor effect, pass current only for 1-2 sec. Continuous current heats wire and discharges battery.
3. Wire should be free to move but not touch magnet poles. Use flexible leads.
4. In generator demo, rotate coil at moderate speed. Too fast may damage galvanometer due to high EMF.
5. Keep galvanometer away from magnet. Stray field affects needle.
6. While applying hand rules, keep three fingers mutually perpendicular. Many students make error in orientation
7. Ensure good contact at commutator brushes if using motor model. Poor contact gives no deflection.
8. Disconnect battery before touching wire. It may be hot.

CUT SECTION OF MACHINE:

3 Phase induction motor:

DEPARTMENT OF ELECTRICAL ENGINEERING