



جامعة المنصورة

كلية الهندسة

برنامج هندسة القوى والآلات الكهربائية

دليل معمل

القياسات الكهربائية

٢٠٢١ / ٢٠٢٠

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١- بيانات المعمل الأساسية

القياسات الكهربائية	اسم المعمل
قسم الهندسة الكهربائية	القسم العلمي
د/ بيشوي القس سيدهم بشاي ابراهيم	المشرف
م/ سماء فوزي عثمان - م/ أسماء محمد ابوالعز	مهندس المعمل
أ/ ايمن ابراهيم	أمين المعمل
١٣٠٨	التليفون
مبنى المعامل البحرية - الدور الثاني	الموقع بالنسبة للكلية
٢م ١٢٥	مساحة المعمل
١٩٩٠ م	تاريخ انشاء المعمل

٢- رسالة معمل القياسات الكهربائية

Mission	الرسالة
<p>The mission of the electrical measurement laboratory is to prepare distinguished graduates who are able to compete locally and regionally in the scientific and research fields of electrical measurements and to participate in community services within a framework of ethical commitment.</p>	<p>تتمثل رسالة معمل القياسات الكهربائية في إعداد خريجين متميزين وقادرين على المنافسة محليا وإقليميا في المجالات العلمية والبحثية الخاصة بالقياسات الكهربائية والمشاركة في الخدمات المجتمعية في إطار من الالتزام الأخلاقي.</p>



٣- قائمة بالأجهزة والمعدات الموجودة بمعمل القياسات الكهربائية

م	اسم الجهاز	العدد	Serial Number
1	Digital Multimeter	9	163
2	Analog multimeter	16	157-211
3	Current transformer	4	52
4	Voltage transformer	3	207
5	DC Analog voltmeter	1	63
6	AC Analog voltmeter	2	67
7	Analog Ammeter	3	6
8	Digital trainer	15	195
9	Analog trainer	2	186
10	Mini -ICE	2	188
11	Variac	3	1022-1021-148
12	Digital Application	15	185
13	DC power supply	1	213
14	Digital multimeter	4	159
15	Wattmeter	3	170
16	Avometer	1	149
17	Logic trainer	2	192
18	oscilloscope	1	1014
19	AC voltmeter	2	149



جامعة المنصورة
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برنامج هندسة القوى والآلات الكهربائية



147	5	voltmeter	20
143-25	2	Galvanometer	21
1001-1005	2	Computer	22
147	3	Voltmeter 0-300V	23
353	1	AC power supply	24
102-103-106-110-122-136-137	17	Resistor	25
127-130	17	Inductor	26
123-138	13	Capacitor	27
185	15	Micro computer	28
200-201	2	LS PLC Trainer	29





٤- الخدمات الطلابية التي يؤديها معمل القياسات الكهربائية

٧٥٠ طالب	عدد الطلاب المستفيدين من المعمل
قسم الهندسة الكهربائية	الاقسام العلمية المستفيدة من المعمل
الفرقة الاولى - الثانية - الرابعة	الفرق الدراسية المستفيدة من المعمل
مادة قياسات كهربية - اختبارات كهربية (١) - اختبارات كهربية (٤)	المقررات الدراسية التي تستفيد من المعمل
تجارب عملية - مشاريع طلابية - ابحاث علمية	الانشطة الطلابية داخل المعمل
١٠	عدد طلاب الدراسات العليا المستفيدين من المعمل
٩	عدد الرسائل العلمية التي تمت في المعمل
<ul style="list-style-type: none">▪ Made in Egypt (MIE)▪ MIT Undergraduate Research Opportunity Program	المسابقات العلمية التي شارك فيها طلاب من المستفيدين من المعمل

٥- المشاريع الطلابية التي تمت بمعمل القياسات الكهربائية

- Design of water desalination system prototype
- Grid integration of PV, wind, and energy battery storage
- Operation and control of smart grid
- Application of phasor measurement units (PMUs) in microgrid
- Energy management system in smart microgrid-based internet of things (IoT)
- Protection of HVDC transmission grids based IoT
- Protection of FREEDM system based on IoT
- Design of fault current limiter in microgrid
- Design of concentrated photovoltaic (CPV) system
- Smart home automation implementation
- DC microgrid protection
- Operation and protection of DC ship microgrid



٦- الاتجاهات البحثية لمعمل القياسات الكهربائية

- Advanced electrical circuit analysis.
- Measurement applications in power system and Microgrids.
- Advanced power system harmonic mitigation.
- Power factor correction methods.
- Advanced energy management issues in Microgrids.
- Advanced control techniques for Microgrids.



٧- التجارب المعملية لمعمل القياسات الكهربائية

Experiment	title
Introduction	Introduction to Electric Measurement Lab
Experiment No. (1)	Measurement of Power without Wattmeter (1)
Experiment No. (2)	Measurement of Power without Wattmeter (2)
Experiment No. (3)	Measurement of Power in Single Phase AC Circuits using Wattmeter
Experiment No. (4)	Measurement of Power using Wattmeter in three phase circuits
Experiment No. (5)	Calibrations of a Wattmeter
Experiment No. (6)	Calibrations of a Varmeter
Experiment No. (7)	The Wheatstone Bridge
Experiment No. (8)	AC Bridges (Maxwell's Bridge)
Experiment No. (9)	I-V Characteristics of Two Terminal Network Elements
Experiment No. (10)	Cable Testing-Fault Location
Experiment No. (11)	LC Circuit
Experiment No. (12)	3 Phase Power Measurement for Delta connected load employing Two Wattmeter Method



Introduction to Electric Measurement Lab

Purpose

- To become familiar with simple electric measurements and test equipment including the voltmeter, ammeter, and ohmmeter.
- To become familiar with electric instruments used for measuring different electrical indices including wattmeter, varmeter, power-factor-meter
- To become aware of measurement techniques including voltage across and current through electric components.
- Measuring electronic parameters as a function of time through oscilloscope measurements, understanding scope displays and how to focus them on areas of interest.
- To become familiar with electrical passive components and how to connect them in different electrical circuits.

Passive Components

The basic passive electrical components include resistors, capacitors, and inductors. The term 'passive' describes circuit elements which do not add energy to a circuit. Resistors dissipate energy (convert electrical energy to heat), while capacitors and inductors store it

You have to understand how to differentiate, read (know their values) and to connect different passive components.

Lab Equipments

- DC Power Supply
- Variac (variable AC source)
- AC and DC Ammeters



- AC and DC Voltmeters
- Wattmeters
- Watthour meters
- Varmeter
- Power-factor-meter
- Oscilloscope
- Multimeter

Questions

1. Draw a free hand graph of passive components you have seen in the lab
2. What is the main function of:
 - a. The variac
 - b. Oscilloscope
3. How can you differentiate between Dc and Ac Voltmeters?
4. How can you change the scale of a wattmeter?

Experiment No. (1) Measurement of Power without Wattmeter (1)

Objective

To measure the power in single phase circuits using 3 voltmeters

Diagram

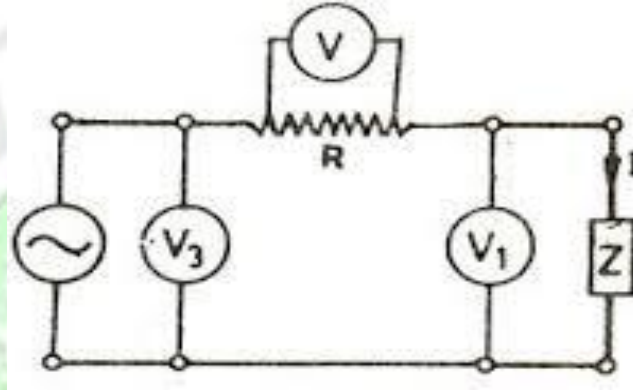


Fig. 1

Equipment

- AC Source 220 V, 50 Hz.
- V_1, V_2, V_3 Three Voltmeters.
- A AC Ammeter.
- R Variable resistance.
- L Coil with variable inductance

Procedure

- 1- Wire the circuit shown in Fig. 1.
- 2- Apply the source voltage ($V_3=220$ V)
- 3- Read and record the reading of both V_1 and V_2
- 4- Calculate the power absorbed in the circuit as

$$P = (V_3^2 - V_2^2 - V_1^2) / 2R$$

- 5- Calculate the power factor as:

$$\cos\phi = \frac{(V_3^2 - V_2^2 - V_1^2)}{2V_1V_2}$$

- 6- Changes the load value (by changing the values of R and/or L) and repeat steps 3 to 5.
- 7- Draw the relation between P & cos ϕ .

Table 1

V_3	V_2	V_1	P	Pf = cos ϕ	Notes

Comments

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Experiment No. (2) Measurement of Power without Wattmeter (2)

Objective

To measure power in single phase circuits using 3 Ammeters.

Diagram

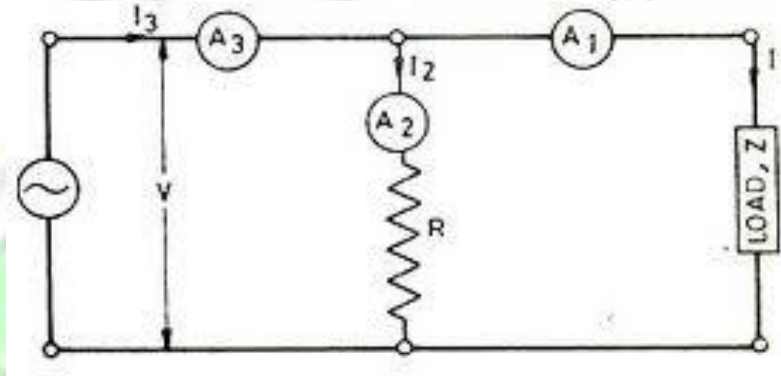


Fig. 2

Equipment

- AC Source 220 V, 50 Hz.
- A₁, A₂, A₃ Three Ammeters.
- A AC Ammeter.
- R Non-inductive resistance.
- L Coil with variable inductance

Procedure

- 1- Wire the circuit shown in Fig. 2.
- 2- Apply the source voltage.
- 3- Read and record the reading of the three ammeters I₁ and I₂, I₃
- 4- Calculate the power absorbed in the circuit as

$$P = (I_3^2 - I_2^2 - I_1^2) * \frac{R}{2}$$

5- Calculate the power factor as:

$$\cos\phi = \frac{(I_3^2 - I_2^2 - I_1^2)}{2I_1I_2}$$

6- Changes the load value (by changing the values of R and/or L) and repeat steps 3 to 5.

7- Draw the relation between P & cos ϕ .

Table 2

A ₃	A ₂	A ₁	P	PF = cos ϕ	Notes

Comments

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Experiment No. (3) Measurement of Power in Single Phase AC Circuits using Wattmeter

Objective

- To understand the operation of the wattmeter
- To measure power in a single-phase load using wattmeter.
- To detect the errors due to wattmeter connections

Diagram

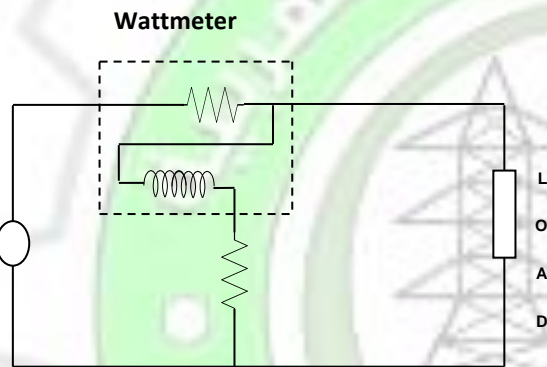


Fig. 3-1

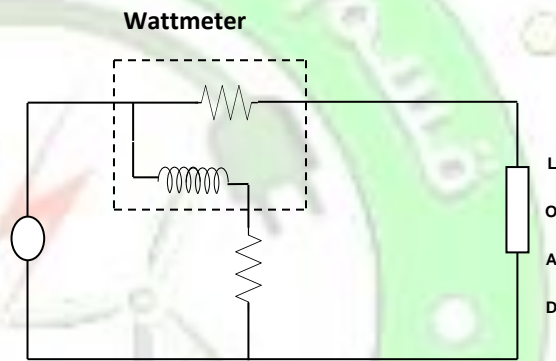


Fig. 3-2

Equipment

- S AC Source 220 V, 50 Hz.
- W Wattmeter.
- R Variable resistance.
- L Coil with variable inductance

Procedure

- 1- Wire the circuit shown in Fig.3-1
- 2- Set the power supply unit for a zero O/P voltage.
- 3- Turn the power supply unit on.



- 4- Record the reading of W_1 in Table 3
- 5- Change the load and record the readings.
- 6- Wire the circuit shown in Fig. 3-2
- 7- Repeat the steps 2 to 4 and Record the reading of W_2 in Table 3
- 8- Compare the results and write your comments.

Table 3

Case	W_1 (W)	W_2 (W)

Comments

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Experiment No. (4) Measurement of Power using Wattmeter in three phase circuits

Objective

To measure power in a three-phase load using two Wattmeters.

Diagram

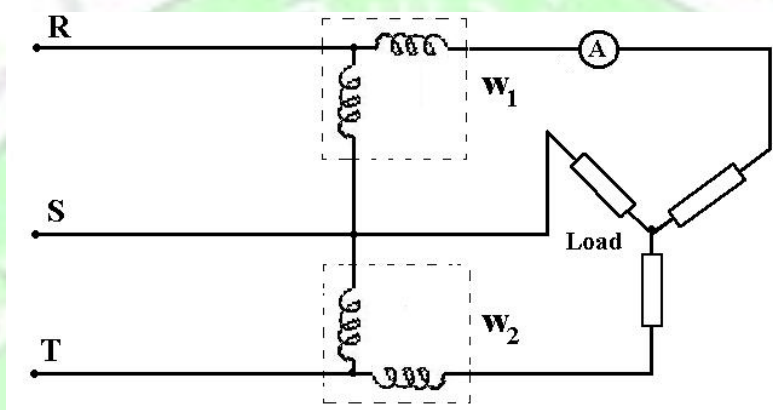


Fig. 4

Equipment

- L Three phase load.
- W1, W2 Two Wattmeters.
- A A.C Ammeter
- RST Three phase supply (380 V, 50 Hz).

Procedure

- 1- Wire the circuit shown in Fig. 4
- 2- Set the power supply unit for a zero O/P voltage.
- 3- Turn the power supply unit on.
- 4- Record the reading of W_1 & W_2 in Table 4
- 5- Change the load and record the readings.

6- Repeat the two steps (4 & 5).

7- Calculate the active, reactive and power factor using the following formulas.

$$P = W_1 + W_2$$

$$Q = \sqrt{3}(W_1 - W_2)$$

$$\tan \phi = \frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2} = \frac{Q}{P}$$

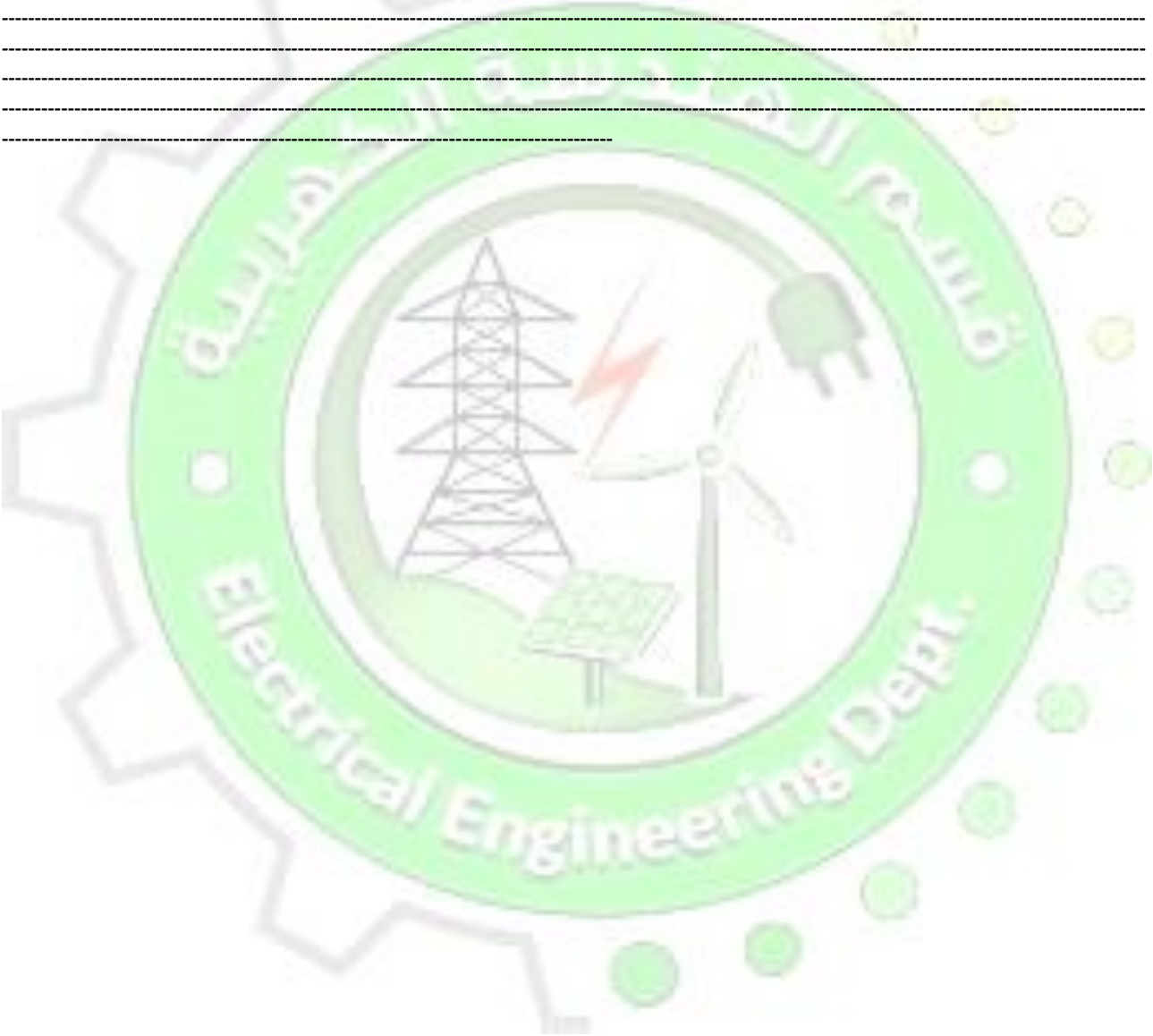
8- Draw the relation between P, Q & cos ϕ and the current I.

Table 4

I (A)	W ₁ (W)	W ₂ (W)	P=W ₁ +W ₂ (W)	Q (VAr)	tan ϕ



Comments



Experiment No. (5) Calibrations of a Wattmeter

Objective

To calibrate a wattmeter in case of Z load.

Diagram

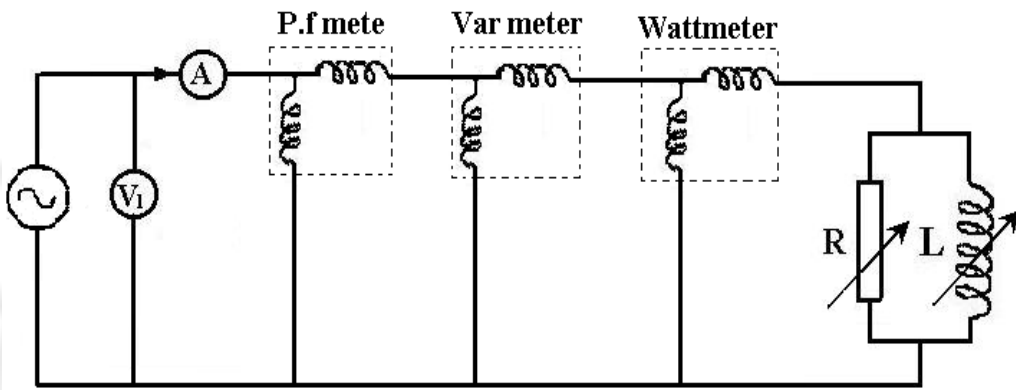


Fig. 5

Equipment

- AC. Source 220v, 50 Hz.
- A AC. Ammeter
- V AC Voltmeter.
- R Variable resistance
- L Coil with Variable inductance.
- W Wattmeter,
- Pf Power factor meter.

Procedure

- 1- Wire the circuit as shown in Fig. 5.
- 2- Feed it with suitable voltage and record the values of the Ammeter, I, the Voltmeter, V, the Power-factor-meter $\cos \phi$ and the Wattmeter, W.

- 3- Compare between the reading of the wattmeter (W) and the calculated value of the power ($I V \cos \phi$).
- 4- Calculate the error ε_w between the calculated and the measured values as:
$$\varepsilon_w = W - I V \cos \phi$$
- 5- Change the load and repeat the previous steps.
- 6- Tabulate the obtained values in Table 5
- 7- Draw the graph between error (ε) and power.
- 8- Comment on the results.

Table 5

I	V	Cos ϕ	IV cos ϕ	W	ε_w

Experiment No. (6) Calibrations of a Varmeter

Objective

To calibrate a Varmeter in case of Z load.

Diagram

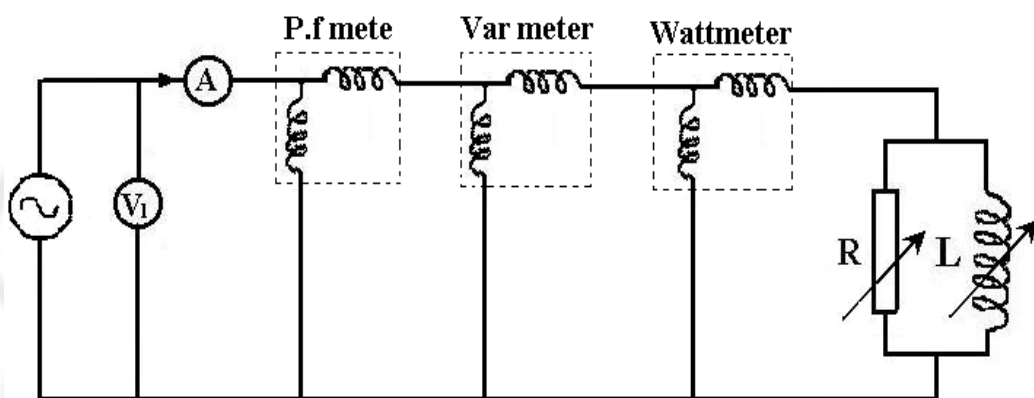


Fig. 6

Equipment

- AC. Source 220 V, 50 Hz.
- A AC. Ammeter
- V AC Voltmeter.
- R Variable resistance
- L Coil with variable inductance.
- Var Varmeter
- Pf Power-factor-meter.

Procedure

- 1- Wire the circuit as shown in Fig. 6.
- 2- Apply a suitable voltage and record the values of the Ammeter, I, the Voltmeter, V, and the Varmeter, Var.

- 3- Read the record of the Power-factor-meter ($\cos \phi$) and hence calculate $\sin \phi$
- 4- Compare between the reading of the Varmeter (Var) and the calculated value of the reactive power ($I V \sin \phi$).
- 5- Calculate the error ϵ_{Var} between the calculated and the measured values as:

$$\epsilon_{Var} = \text{Var} - I V \sin \phi$$
- 6- Change the load and repeat the previous steps.
- 7- Tabulate the obtained values in Table 6.
- 8- Draw the graph between error and reactive power.
- 9- Comment on the results.

Table 6

I	V	Cos ϕ	Sin ϕ	$I V \sin \phi$	Var	ϵ_{Var}

Experiment No. (7) The Wheatstone Bridge

Objective

- To verify Wheatstone bridge operation.
- To measure unknown resistances

Theory

The bridge comprises three pairs of accurately adjusted non-inductive ratio arms and a four-decade variable resistance for balancing purposes.

A sensitive galvanometer is incorporated which is protected by diodes against accidental overloads and a variable sensitivity switch in series with the galvanometer is also fitted.

A DC supply of 2 Volts in series with a protective resistor of 10.8 ohms is required for the bridge. A null balance is obtained by adjustment of the four-decade variable R_3 and observing the movement of the detector. The detector only works when the press switch is depressed and turning the sensitivity control clockwise may increase the sensitivity of the galvanometer.

Diagram

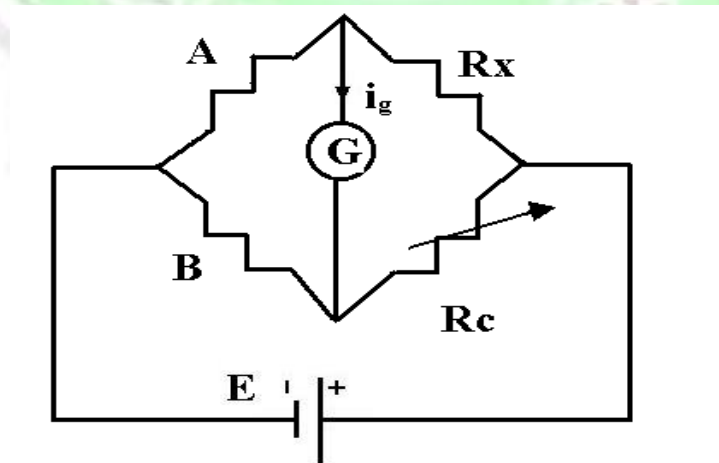


Fig. 7

Equipment

- Wheatstone bridge.
- Unknown resistance.
- DC. source.

Procedure

- 1- Wire the circuit as shown in Fig 7.
- 2- Change the resistance R_c to obtain the balance condition (i.e. $i_g=0$)
- 3- Calculate the unknown resistance R_x from the following relations at the balance condition:

$$A / B = R_x / R_c$$

$$R_x = R_c * A / B$$

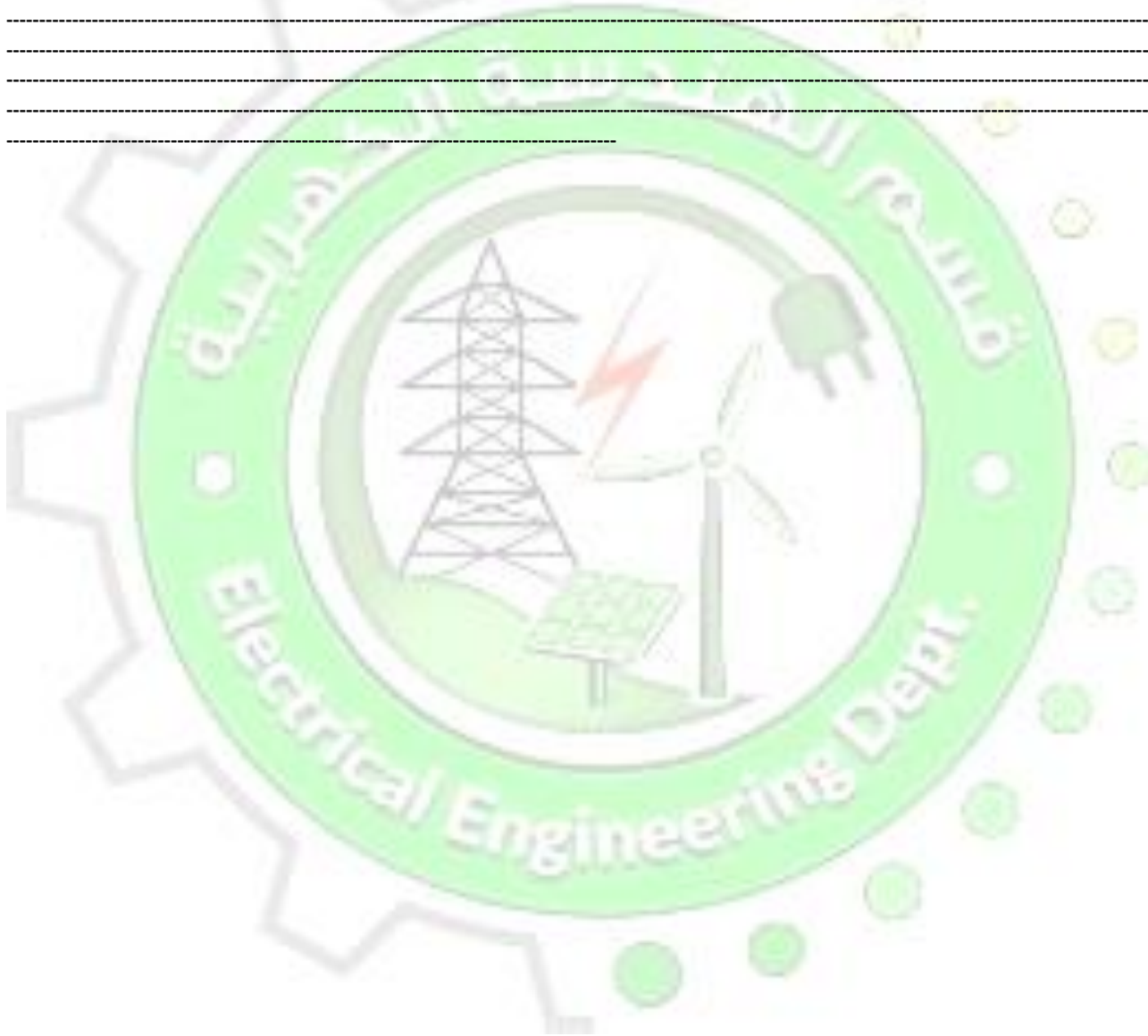
- 4- Change the output voltage of D.C. source and calculate R_x .
- 5- Draw the relation between R_x and R_c .

Table 7

A	B	R_c	$R_x = R_c * A / B$



Comments



Experiment No. (8) AC Bridges (Maxwell's Bridge)

Objective

- To verify the AC bridges operation.
- To measure the inductance and resistances of a coil using Maxwell's bridge

Diagram

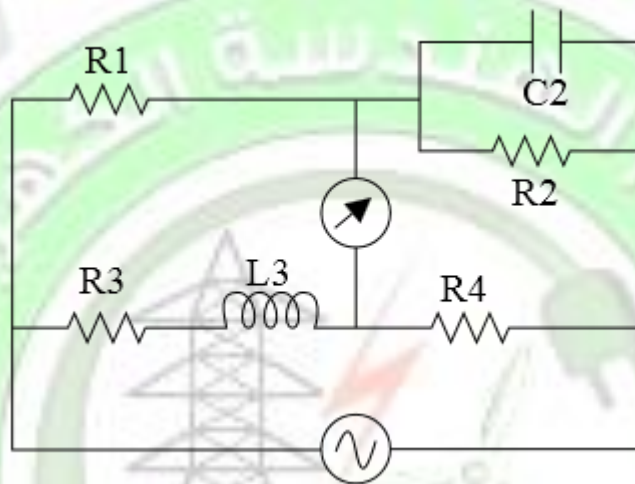


Fig. 8

Equipment

- S AC Source 220 V, 50 Hz.
- D Detector (Milliammeter)
- R1 Unknown resistance.
- R2, R4 Variable resistances
- L3, R3 Coil with variable inductance

Procedure

- 1- Wire the circuit as shown in Fig 8.
- 2- The bridge is balanced by varying L_3 , and one of the resistances R_2 or R_4 . The balance condition is obtained when the current flowing through the detector is zero

- 3- The value of the unknown self-inductance L_1 can be determined using the following relations at the balance condition:

$$L_1 = \frac{R_2}{R_4} * L_3$$

- 4- The resistance value of the unknown coil R_1 can be determined using the following relations at the balance condition:

$$R_1 = \frac{R_2}{R_4} * R_3$$

- 5- Repeat the previous steps for different unknown inductances and tabulate the results in Table 8

Table 8

R_2	R_4	R_3	L_3	L_1	R_1

Experiment No. (9) I-V Characteristics of Two Terminal Network

Elements

Objective

To study the I-V characteristics of both linear and non-linear resistive two-terminal network elements.

Introduction

According to Ohm's law A linear resistor is characterized by a straight line on an I-V plane passing through the origin.

On the other hand, a non-linear two-terminal element such as the solid-state diode is represented, on the I-V plane, by a characteristic which is not a straight line and may not pass through the origin.

In order to analyze a circuit containing two-terminal network elements it is necessary to know the I-V characteristics of all the elements in the network.

The I-V characteristics may be either in the form of a mathematical expression relating voltage across the element to the current flowing through it or in form of a graph on the I-V plane. It may be easier to use the graphical representation of the I-V characteristics when dealing with nonlinear elements.

Diagram

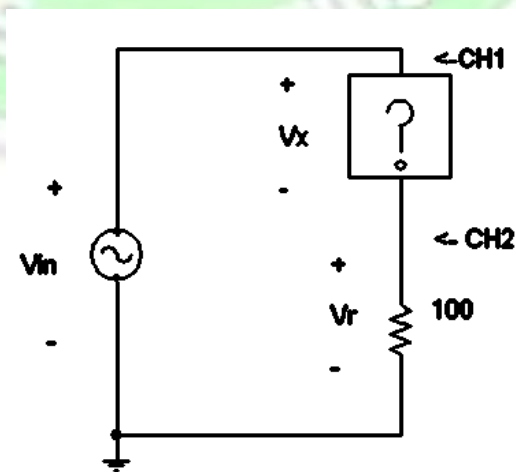


Fig. 9-1



Equipment

- Function generator
- Multimeter
- Tektronix Oscilloscope
- Standard Resistances

Procedure

- 1- Wire the circuit as shown in Fig. 9-1
- 2- Set function generator to display a 1 KHz triangular output with an amplitude of approximately 10 volts peak-to-peak. Do not change the amplitude or frequency of the function generator throughout the experiment.

a) Linear Resistor

1. Connect a standard resistor then using the color code find and record the provided resistors nominal value.
2. Measure the resistance of the resistors using multimeter.
3. Insert the 680 resistor in position X. Draw (accurately) the resulting curve. Calculate the conductance from I-V curve and then obtain the resistance from the conductance and compare it with the measured resistance value.
4. Repeat the last step using a 2.2K resistor in position X.

b) Diode

1. Using the multimeter diode-test check for the forward and reverse bias. Forward biased means that the plus side of the diode is connected to the red multimeter post when the diode has the lowest resistance. A forward biased diode behaves like a closed switch.
2. Insert the diode (forward biased), in position X. Draw the resulting curve. Explain any discrepancy.

c) Series Diode and Resistor Combination

1. Insert the diode, the diode is to be forward biased, and a series 680 resistor in position X. Draw the resulting curve.
2. Compare the results obtained with their individual characteristics.

d) Parallel Diode and Resistor combination

1. Insert the diode (forward biased), and a parallel 680 resistor in position X. Draw the resulting curve.
2. Compare the results obtained with their individual characteristics.

Application

1. Connect the circuit of Fig. 9-2. Measure both current flowing through and voltage across the diode using $R1 = 2.2 \text{ K}\Omega$.
2. Find $R1$ for the network if $V_s = 10 \text{ V}$ and if it is desired to have $I_D = 5 \text{ mA}$ and the diode voltage drop previously measured.
3. Reconnect the circuit of Fig. 19-2 using your calculated $R1$ and $V_s = 10 \text{ V}$. Measure I_D and V_D .
4. Compare them with the desired values and explain any discrepancy.

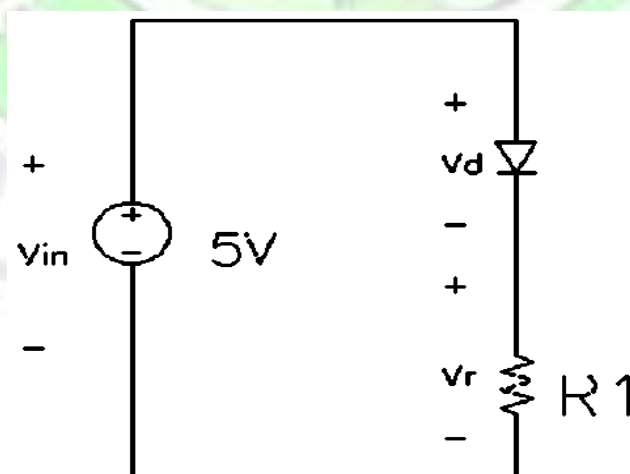


Fig. 9-2

Experiment No. (10) Cable Testing-Fault Location

Objective

To determine the type & position of various faults on a model 3-core distribution cable

Introduction

When fault finding, an engineer would have access to the terminals at the sending and receiving ends of a cable. He may also have access to a joint box where two sections of each phase could be separated. A measuring bridge could therefore be connected at any set of 3 phase terminals but could not be connected at intermediate points between the terminal sites and the joint box.

Diagram

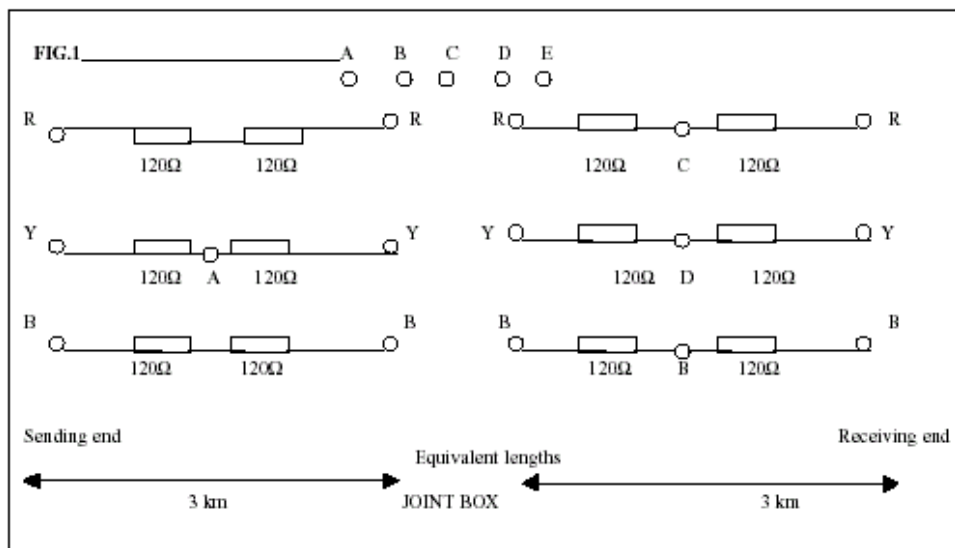


Fig. 10-1

Equipment

- DC Power Supply, 20 V
- A Wheatstone bridge

- An Ohmmeter
- Ohm rheostat
- 6-km cable located in laboratory bench (The circuit for this is shown in Fig. 10-1. It contains four 120-ohm resistors for each phase as shown in the Figure. Each 120-ohm resistor represents 1.5 km of the cable length)

Procedure

1. Use the ohmmeter to check the continuity and phase connections.
2. Prepare a table to receive your results and your comments on the type of fault for each test.

TEST 1

Use the Wheatstone bridge to find the resistance of each conductor and thus the resistance per meter run of the cable. Fig. 20-2.

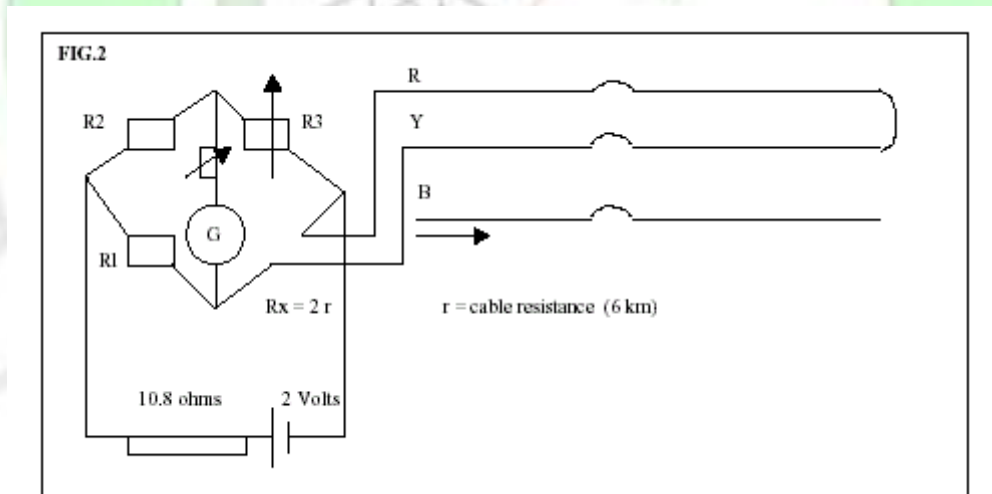


Fig. 10-2

TEST 2 Single-line to ground fault

1. Join terminal A to E. Check each phase for ground and between phase for a short.
2. Which phase has a fault? What is the type of fault?

- Find the resistance from the sending end to the fault. (Fig. 10-3) Use the resistance per meter, r to find the distance to the fault.
- Connect B to E with the fault resistance and check the type of fault.

$$R2/R3 = R1/Rx$$

$$(R2 + R3)/R3 = (R1 + Rx)/Rx = 2r/Rx$$

$$Rx = 2r R3/(R2 + R3)$$

- Join C to D with the fault resistor. Identify the faulty phases and establish the type of fault. Find the distance to the fault. Fig. 20-4.

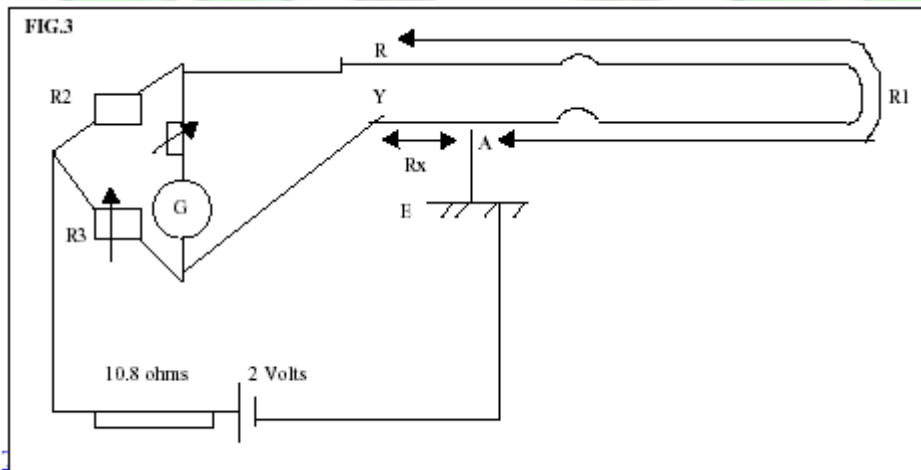


Fig. 10-3

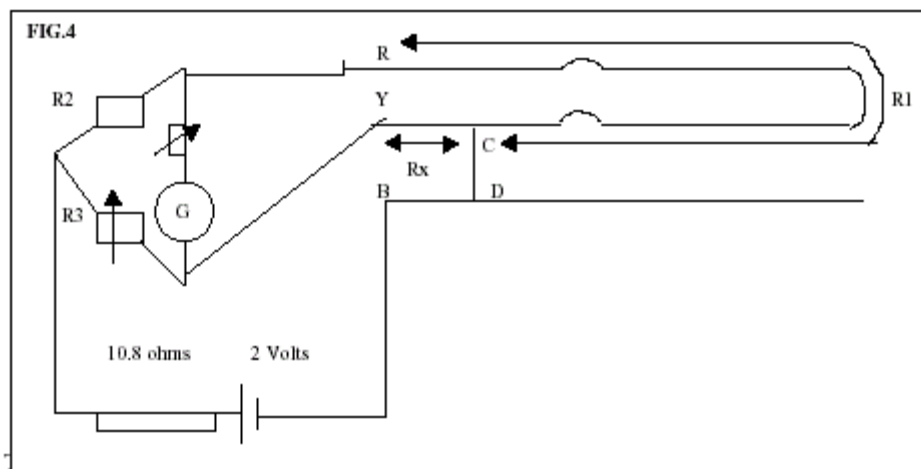


Fig. 10-4

TEST 3 Line- to- Line fault

- For a line to line fault in phases Y & B,

$$R_x = 2r.R3/(R2 + R3).$$

- For a line to line fault in phases R & Y, the circuit of Fig. 20-4 should be appropriately changed, and then

$$R_x = 2.r.R2/(R2 + R3)$$

TEST 4 Three-phase fault

- Link C, D and B. Identify the faulty phases and establish the type of fault. Find the location of the fault. Fig. 10-5.

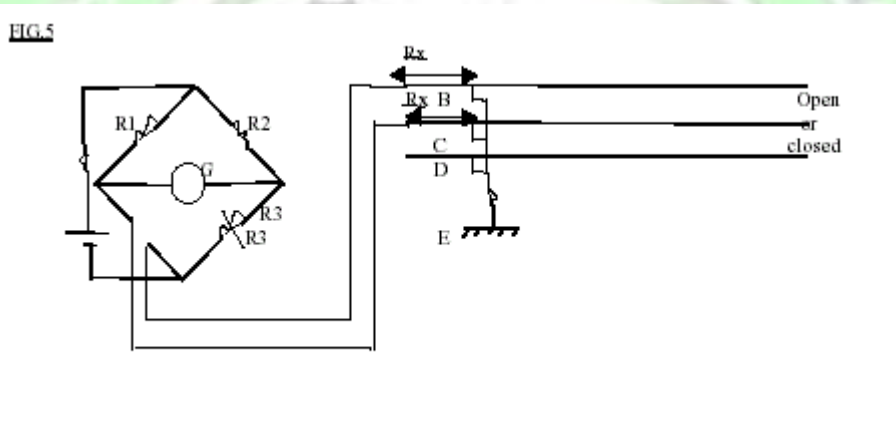


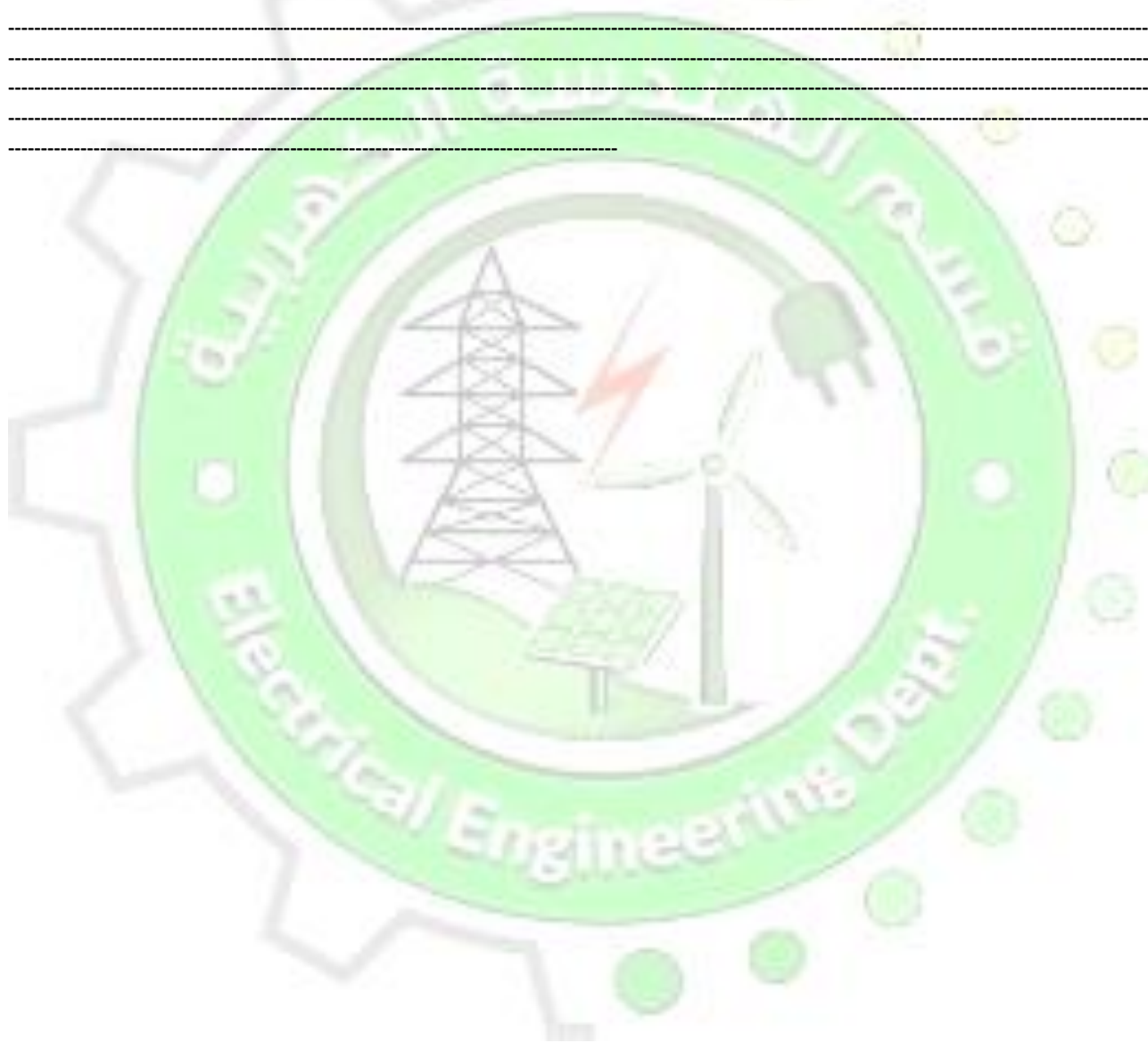
Fig. 10-5

ANALYSIS

Show details of the calculation for each test and a Table of results. Show the position of all the faults A, B, C and D on Fig.10-1



Comments



Experiment No. (11) LC Circuit

Objective

Analysis of LC Circuit

Introduction

The value of the resistance in a parallel RLC circuit becomes infinite or that in a series RLC circuit becomes zero, we have a simple LC loop in which an oscillatory response can be maintained forever at least theoretically. Besides we may get a constant output voltage loop for a fairly long period of time. Thus, it becomes a design of a lossless circuit.

- Total Response = Forced Response + Natural Response
- Forced Response = Forcing Function (Sinusoidal in this Case)
- Natural Response = Content voltage waveform.

Diagram

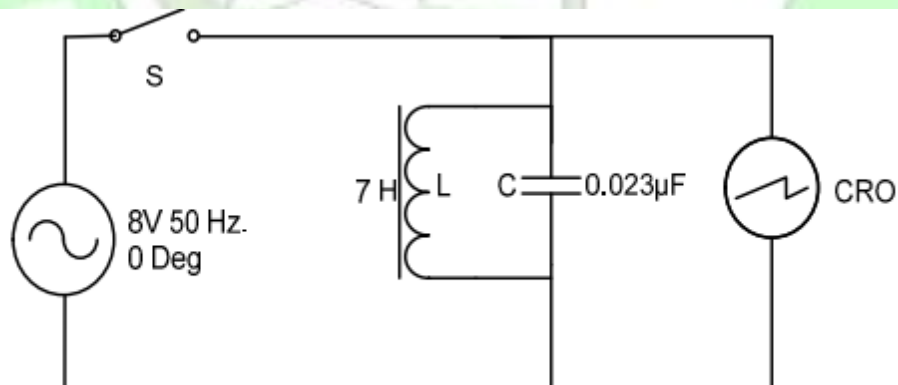


Fig. 11-1

Equipment

- Power Supply,
- Capacitor,

- Inductor,
- SPDT switch,
- Breadboard,
- Connecting wires, and
- Oscilloscope

Procedure

1. Connect the circuit according to the circuit diagram.
2. ON Power switch and set the oscilloscope according to requirement.
3. Place the channel A of Oscilloscope at the input and channel B at output.
4. Initially switch is open observe waveform.
5. Observe waveforms when switch is closed.
6. Again, open the switch and observer output waveform.
7. Draw observed waveforms in the observation table.

Observation

Position of switch	Output Waveform
Switch at pos B	
Switch at pos A	



Experiment No. (12) 3 Phase Power Measurement for Delta connected load employing Two Wattmeter Method

Objective

To measure the Three Phase Power of Delta connected load using Two Wattmeter methods

Introduction

In two watt-meter method, two wattmeters are used & their potential coils are connected between phase to phase and current coil in series with the line. Two wattmeters can be used to measure power of star and delta connected load, but here we are performing experiment on delta connected load only, same method can be applied for star connected load. Following formulas are used for calculating P, Q and p.f.

TWO WATTMETER CALCULATIONS

1) Real power

$$P = W_1 + W_2$$

2) Reactive power

$$Q = \sqrt{3} (W_2 - W_1)$$

3) Power Factor

$$\cos \theta = \frac{P}{\sqrt{P^2 + Q^2}}$$

$$\cos \theta = \sqrt{\frac{P^2}{P^2 + Q^2}}$$

$$\cos \theta = \sqrt{\frac{(W_1 + W_2)^2}{(W_1 + W_2)^2 + 3(W_2 - W_1)^2}}$$

Diagram

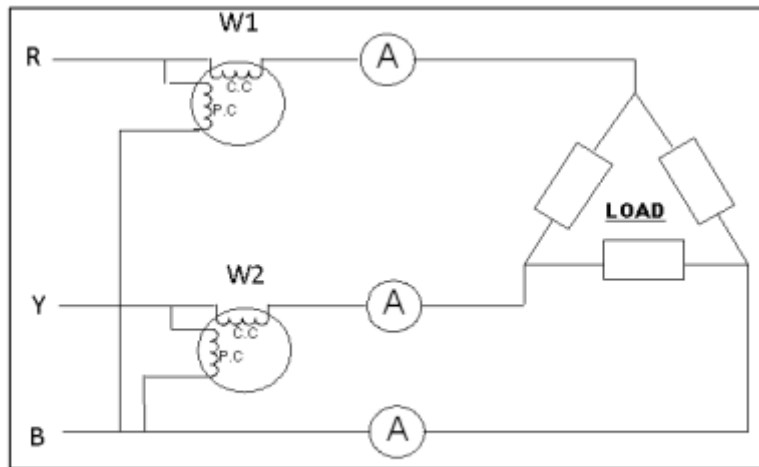


Figure: Two Wattmeter Method

Equipment

1. Three Watt-meters
2. Ammeter
3. Voltmeter
4. Star Connected Load

Procedure

Arrange the watt-meters according to the load (single phase or three-phase) and whether neutral available or not (as shown in the above figures).

Observation

- 1- Power of Delta Connected Load: -----
- 2- Bulbs in series of ----- W
- 3- Line to line Voltage: ----- V



Result

S. No	Type of Load	Wattmeter Reading (W1)	Wattmeter Reading (W2)	W1+W2	p.f.	Current (IL)
1	Three Phase Delta Connected Load					

Comments

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