LABORATORY
EXPERIMENT
NO. 44

THREE - PHASE CIRCUITS

OBJECT

1. To study the relationship between voltage and current in three-phase circuits.
2. To learn how to make delta and wye connections.
3. To calculate the power in three-phase circuits.

DISCUSSION

Students tend to approach three-phase circuits with a certain apprehension which is not at all justified. Three-phase circuits, in the majority of cases, are symmetrical. They consist of three identical branches, each of which has the same impedance. Each of these branches can be treated exactly like a single-phase circuit. Consequently, three-phase circuits are not necessarily harder to work with than single-phase circuits.

Unbalanced three-phase circuits represent an unnatural condition. Circuit analysis becomes somewhat difficult and will not be covered in this manual.

Three-phase systems are usually connected in either a *delta* or a *wye* configuration. Each of these connections has definite electrical characteristics and the designations *delta* and *wye* are derived from the method of connection.

INSTRUMENTS AND COMPONENTS

Power Supply Module *(0-220/380V/3ϕ)*	*EMS 8829*
AC Metering Module *(250/250/250V)* *(500/500/500V)*	*EMS 8429*
AC Metering Module *(0.25/0.25/0.25A)* *(1.5/1.5/1.5A)*	*EMS 8428*
Resistance Module	*EMS 8319*
Connection Leads	*EMS 8941*

PROCEDURE

Caution: High voltages are present in this Laboratory Experiment! Do not make any connections with the power on! The power should be turned off after completing each individual measurement!

☐ 1. a) Using your **EMS Power Supply and AC Metering Module** connect the circuit shown in *Fig. 44-1*.

☐ b) Turn on the power supply and adjust the line-to-neutral voltage (as indicated by the power supply voltmeter) to exactly *220 Vac*.

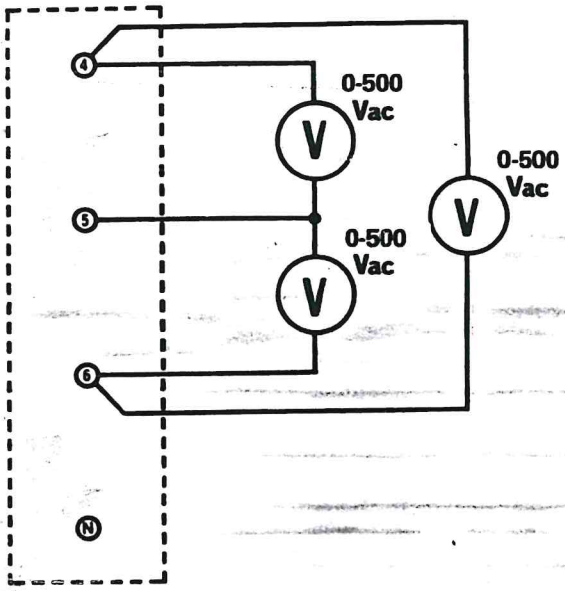

Fig. 44-1

☐ c) Measure and record each line-to-line voltage.

$E_{4\ to\ 5}$ = _____ *Vac*

$E_{5\ to\ 6}$ = _____ *Vac*

$E_{4\ to\ 6}$ = _____ *Vac*

☐ d) Return the voltage to zero and turn off the power supply.

☐ e) Calculate the average value of the line-to-line voltage.

_____

_____

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_____ $E_{line\text{-}to\text{-}line}$ = _____ V

☐ **2. a)** Reconnect your three voltmeters in order to measure the voltage from each line-to-neutral.

☐ **b)** Turn on the power supply and adjust the line-to-neutral voltage (as indicated by the power supply voltmeter) to exactly *220Vac.*

☐ **c)** Measure and record each line-to-neutral voltage.

$E_{4\ to\ N}$ = _____ *Vac*

$E_{5\ to\ N}$ = _____ *Vac*

$E_{6\ to\ N}$ = _____ *Vac*

☐ **d)** Return the voltage to zero and turn off the power supply.

☐ **e)** Calculate the average value of the line-to-neutral voltage.

_____

_____

_____

_____

_____ $E_{line\text{-}to\text{-}neutral}$ = _____ *Vac*

☐ **3. a)** Calculate the ratio of the average line-to-line voltage to the average line-to-neutral voltage.

_____

_____

_____

_____

_____

_____

_____

$E_{line\text{-}to\text{-}line}/E_{line\text{-}to\text{-}neutral}$ = _____

☐ **b)** Is this ratio approximately equal to the $\sqrt{3}$ *(1.73)*? _____

☐ **4. a)** Repeat **Procedures 1 and 2** but this time measure the voltages from the fixed output terminals of your power supply.

$E_{1\ to\ 2}$ = _____ *Vac* $E_{1\ to\ N}$ = _____ *Vac*

$E_{2\ to\ 3}$ = _____ *Vac* $E_{2\ to\ N}$ = _____ *Vac*

$E_{1\ to\ 3}$ = _____ *Vac* $E_{3\ to\ N}$ = _____ *Vac*

☐ **b)** Are the fixed line-to-line and the line-to-neutral voltages reasonably equal? _____

☐ **c)** Is the voltage between any two terminals a single-phase voltage or a three-phase voltage?

_____

☐ **5. a)** Using your **EMS Resistance and AC Metering Modules** connect the **WYE** circuit shown in *Fig. 44-2.* Use a separate resistance section for each of the loads R_1, R_2 and R_3. **Do not connect the neutral of the resistance module to the neutral of the power supply.**

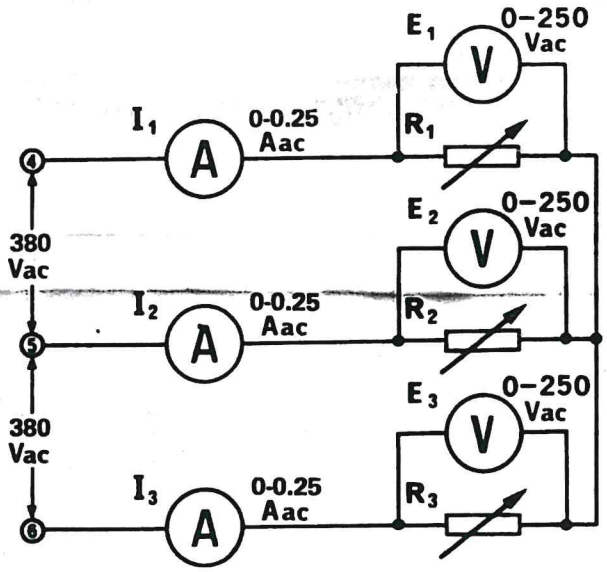

Fig. 44-2

☐ b) Set each resistance section to *1100Ω.*

☐ c) Turn on the power supply and adjust for *380Vac.*

☐ d) Measure and record the voltages across, and the currents through, the three load resistances R_1, R_2 and R_3.

E_1 = _____ *Vac* I_1 = _____ *Aac*

E_2 = _____ *Vac* I_2 = _____ *Aac*

E_3 = _____ *Vac* I_3 = _____ *Aac*

☐ e) Return the voltage to zero and turn off the power supply.

☐ f) Are the currents and voltages reasonably well balanced? _____

☐ g) Calculate the average value of load voltage.

_____

_____

_____

_____ E_{load} = _____ *Vac*

☐ h) What is the average value of the line-to-line voltage? **(from Procedure 1 (e):**

$E_{line\text{-}to\text{-}line}$ = _____ *Vac*

☐ i) Calculate the ratio of the average line-to-line voltage to the average load voltage.

$E_{line\text{-}to\text{-}line}/E_{load}$ = _____

☐ j) Is this ratio approximately equal to the $\sqrt{3}$ *(1.73)?* _____

☐ k) Calculate the power dissipated by each load resistance.

P_1 = _____ *W*

P_2 = _____ *W*

P_3 = _____ *W*

☐ l) Calculate the total three-phase power P_T.

P_T = _____ *W*

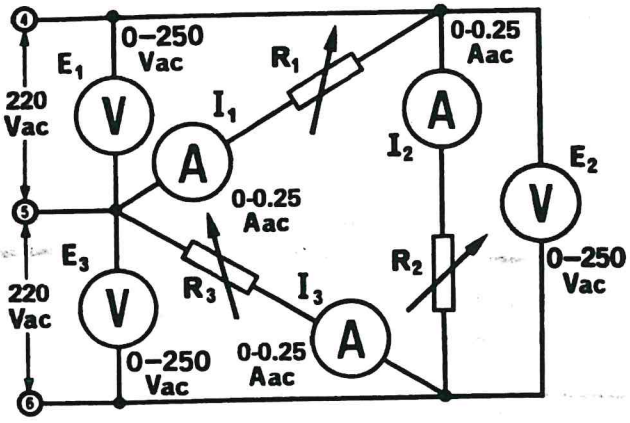

Fig. 44-3

☐ 6. a) Connect the **DELTA** circuit shown in *Fig. 44-3.*

☐ b) Set each resistance section to *1100Ω.*

☐ c) Turn on the power supply and adjust for *220Vac* line-to-line.

☐ d) Measure and record the voltages across, and the currents through, the three load resistances R_1, R_2 and R_3.

E_1 = _____ *Vac* I_1 = _____ *Aac*

E_2 = _____ *Vac* I_2 = _____ *Aac*

E_3 = _____ *Vac* I_3 = _____ *Aac*

☐ e) Return the voltage to zero and turn off the power supply.

☐ f) Are the currents and voltages reasonably well balanced? _____

☐ g) Calculate the average value of load current.

_____

_____

_____

_____

_____

_____ I_{load} = _____ *Aac*

3. In a *wye* connected circuit, the current is *10 amperes* in each resistance load. What is the line current?

4. Three loads each having a resistance of *10 ohms* are connected in *wye*. The total three-phase power is *3000 watts*. What is the line-to-line voltage of the power supply?

5. Three resistors each having a resistance of *11 ohms* are connected in *delta* across a *3ϕ 440 volt* line.

a) What is the line current?

b) What is the total three-phase power?

☐ h) Disconnect the three current meters and insert them in series with power supply terminals *4*, *5* and *6*. Replace the removed current meters with connection leads as shown in *Fig. 44-5*.

☐ i) Turn on the power supply and adjust for *220 Vac* line-to-line.

☐ j) Measure and record the three line currents.

I_4 = _____ *Aac*

I_5 = _____ *Aac*

I_6 = _____ *Aac*

☐ k) Return the voltage to zero and turn off the power supply.

☐ l) Calculate the average value of line current.

_____

_____

_____

_____ I_{line} = _____ *Aac*

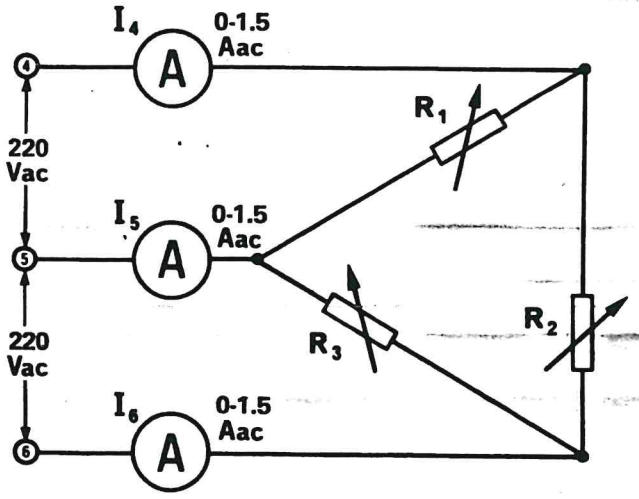

Fig. 44-4

☐ m) Calculate the ratio of the average line current to the average load current.

I_{line} / I_{load} = _____

☐ n) Is this ratio approximately equal to $\sqrt{3}$ *(1.73)*? _____

☐ o) Calculate the power dissipated by each load resistance.

P_1 = _____ *W*

P_2 = _____ *W*

P_3 = _____ *W*

☐ p) Calculate the total three-phase power P_T.

P_T = _____ *W*

TEST YOUR KNOWLEDGE

1. In a *wye* connected circuit, if the line-to-line voltage is *346 volts*, what is the line-to-neutral voltage?

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_____

_____

_____

_____

_____

2. In a *delta* connected circuit, the current is *20 amperes* in each resistance load. What is the line current?

_____

_____

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_____

_____