EE 256: POWER AND ENERGY

Experiment: Three Phase Measurements

(3 hours)

DATE: .....

CAUTION: High voltages are present in this Laboratory Experiment! Do not make any connections when the power is on. The power should be turned off after completing each set of measurements.

INTRODUCTION:

This experiment covers power measurement of three phase system. In this section, the students will get hand on experience on measuring voltage and current in a real three phase system. Also, they will get an exposure on power measurements on three phase Delta connected/ Wye connected balanced and unbalanced loads using one wattmeter and two wattmeters.

LEARNING OUTCOMES:

- LO 1: Calculate the voltages, currents and power of delta and star connected three phase systems (covering attributes of WA1 and WA2)
- LO 2: Discuss and demonstrate different methods of power and energy measurements (covering attributes of WA1 and WA2)

OBJECTIVES:

1. Verify the relationship between the phase and line quantities of a balanced and unbalanced three phase system. (LO1)
2. Discuss and demonstrate different methods of three phase power measurement using Wattmeter. (LO2)

a) Measurements on a real three phase system

APPARATUS:

- Clip-on meter

PROCEDURE:

Step 1 – Use the clip-on ammeter to measure currents in each phase and the neutral of the incoming feeder to the lab. Note down the readings.

Step 2 – Use the multi-meter to measure the voltage of each phase with respect to the neutral and voltage between phases. Note down the readings.

OBSERVATIONS:

I_A / A	
I_B / A	
I_C / A	
I_N / A	

V_{AN}/V	
V_{BN}/V	
V_{CN}/V	
V_{AB}/V	
V_{BC}/V	
V_{AC}/V	

CALCULATIONS:

Calculate the apparent power of the three-phase system.

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b) Power measurements of a three-phase delta connected balanced system using single wattmeter

APPARATUS:

- Single Phase Wattmeter: 5A, 480V (YOKOGAWA)
- AC Ammeter: 0~5A (YOKOGAWA) x 2Nos
- AC Voltmeter: 0~750V (YOKOGAWA)
- Three Phase Inductive Load: (Terco MV1101) – position 4 value = 185mH
- Water Load: Low Position value = 120Ω

PROCEDURE:

Step 1 – Connect the circuit as shown in Figure 1. Here the load is formed by parallel connection of the resistive and inductive loads.
Step 2 – Keep the water load at low position (120Ω). Set the inductor bank to position 4 (185mH).
Step 3 – Switch on the three-phase voltage supply.
Step 4 – Obtain meter readings
Step 5 – Switch off the supply.
Step 6 – Then, connect voltage coil of the wattmeter between;

i. A and C
ii. B and C

Step 7 – Then, follow the steps 2 – 5 for above two cases.

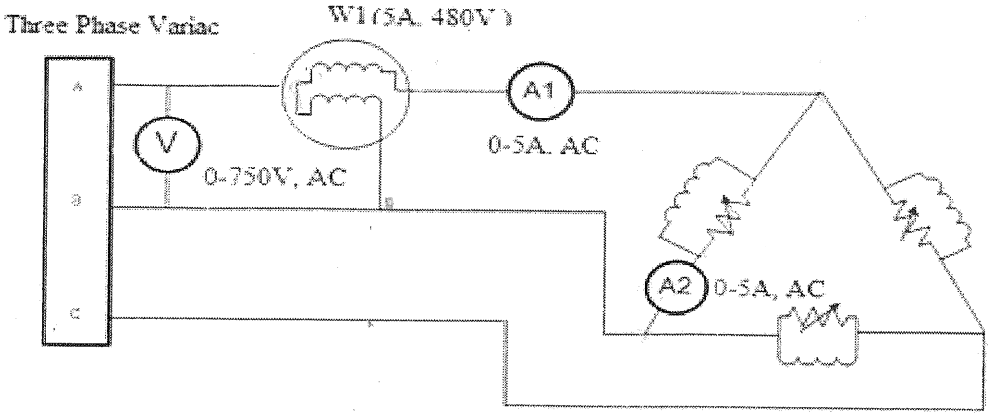

Figure 1: Circuit diagram for power measurement using single wattmeter

OBSERVATIONS:

Meter	V coil at A & B	V coil at A & C	V coil at B & C
V_1			
A_1			
A_2			
W_1			

CALCULATIONS:

Calculate the **Active power** using watt meter reading:

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Calculate the **Reactive power** using wattmeter reading:

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RESULTS:

Active Power	
Reactive Power	

c) Power measurements of a balanced three phase system using two wattmeter method

A. *Delta connected balanced system*

APPARATUS:

- Single Phase Wattmeter: 5A, 480V (YOKOGAWA) x 2Nos
- AC Ammeter: 0~5A (YOKOGAWA) x 2Nos
- AC Voltmeter: 0~750V (YOKOGAWA)
- Three Phase Inductive Load: (Terco MV1101) – position 4 value = 185mH
- Water Load: Low Position value = 120Ω

PROCEDURE:

Step 1 – Connect the circuit as shown in Figure 2. Here the load is formed by parallel connection of the resistive and inductive loads.

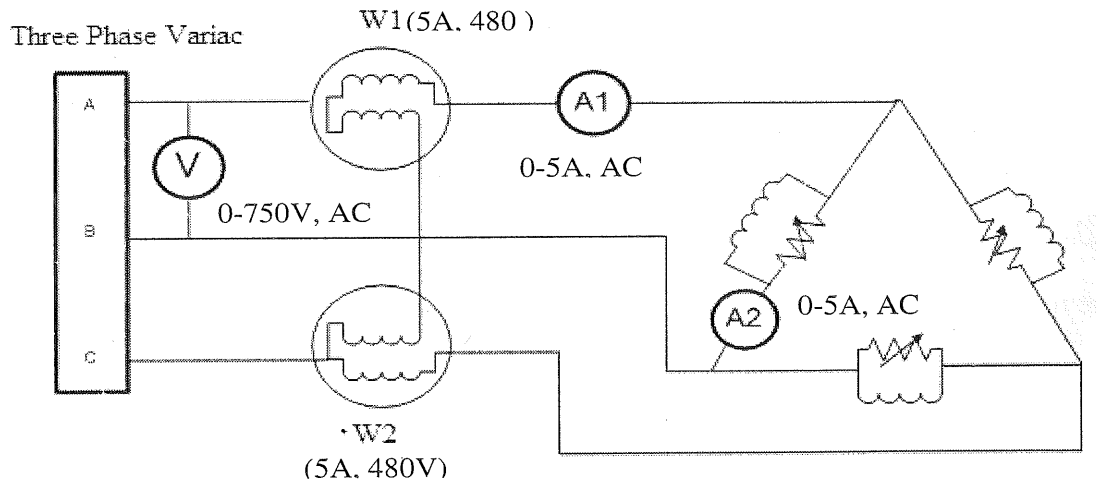

Figure 2: Circuit diagram for power measurement of a delta connected balanced system by two wattmeter method.

Step 2 – Keep the water load at low position (120Ω). Set the inductor bank to position 4 (185mH).
Step 3 – Switch on the three-phase voltage supply.
Step 4 – Obtain meter readings.
Step 5 – Switch off the supply.

OBSERVATIONS:

V_1	
A_1	
A_2	
W_1	
W_2	

CALCULATIONS:

i. Obtain the relationship between line and phase quantities:

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ii. Calculate the active power factor, reactive power and apparent power of the system using wattmeter readings:

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iii. Calculate the power factor of the system using given impedance values:

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iv. Calculate the power factor of the system using voltmeter and ammeter readings:

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iv. Calculate the power factor of the system using Wattmeter readings:

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B. Wye connected balanced system

APPARATUS:

- Single Phase Wattmeter: 5A, 480V (YOKOGAWA) x 2Nos
- AC Ammeter: 0~5A (YOKOGAWA) x 3Nos
- AC Voltmeter: 0~750V (YOKOGAWA) x 2Nos
- Three Phase Inductive Load: (Terco MV1101) – position 4 value = 185mH
- Water Load: Low Position value = 120Ω

Procedure:

Step 1 – Connect the circuit as shown in Figure 3.

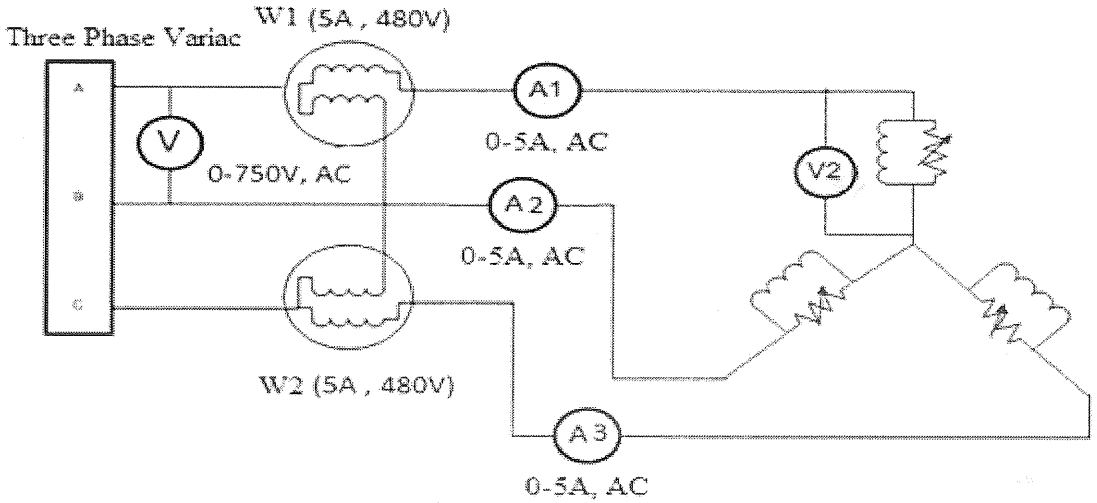

Figure 3: Circuit diagram for power measurement of a delta connected balanced system by two wattmeter method.

Step 2 – Keep the water load at low position. Set the inductor bank to position 4.
Step 3 – Switch on the three-phase voltage supply.
Step 4 – Obtain meter readings.
Step 5 – Switch off the supply.

OBSERVATIONS:

V_1	
V_2	
A_1	
A_2	
A_3	
W_1	
W_2	

CALCULATIONS:

i. Obtain the relationship between line and phase quantities:

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ii. Calculate the total power dissipated in the loads using Wattmeter readings:

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iii. Calculate the power factor of the system using Voltmeter and Ammeter readings:

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iv. Calculate the power factor of the system using Wattmeter readings:

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RESULTS:

	Delta connected System	Wye connected system
Active power		
Reactive power		
Apparent power		
Power factor		

d) Power measurement of unbalanced wye connected system

PROCEDURE:

Step 1 – Use the circuit in Figure 3
Step 2 – Keep the inductor bank at position 4.
Step 3 – Change the water load connected to phase A, to medium position while keeping other water loads at low position.
Step 4 – Switch on the three-phase voltage supply.
Step 5 – Obtain meter readings.
Step 6 – Use the multi-meter to measure the voltage of the load neutral point (N') with respect to supply neutral (N) and phase voltage of each load.
Step 7 – Switch off the supply.

OBSERVATIONS:

Meter readings

V_1	
A_1	
A_2	
A_3	
W_1	
W_2	

Voltage of the load neutral point (N') with respect to supply neutral (N)

$V_{NN'}$	
$V_{AN'}$	
$V_{BN'}$	
$V_{CN'}$	

CALCULATIONS:

i. Calculate the total power dissipated in the loads using Wattmeter readings:

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ii. Calculate the power factor of the system using Wattmeter readings:

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iii. Draw the phasor diagram to illustrate the neutral shift.

TABULATION:

	1 wattmeter method, Δ, balanced	2 Wattmeter method		
		Balanced		Unbalanced
		Δ	Y	Y
Active Power				
Reactive power				
Apparent power				
Power factor				

DISCUSSION:

1. Compare the values obtained for the power factor in steps 1, 2 and 3 in your calculations.
2. What happens if the neutral connection in the lab supply is disconnected?