ELEMENTS OF ELECTRICAL ENGINEERING
Course Code : UE25EE141A/B

PES UNIVERSITY

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Variation in Wattmeter readings with power factor of the load

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Variation in wattmeter readings – Inductive load

For inductive loads,

$W_1 = V_L * I_L * \cos(30+\phi)$

&

$W_2 = V_L * I_L * \cos(30-\phi)$

As phase angle ϕ increases, load power factor decreases.

With an increase in the phase angle ϕ,

$W_1 = V_L * I_L * \cos(30+\phi)$ decreases

&

$W_2 = V_L * I_L * \cos(30-\phi)$ increases

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Variation in wattmeter readings – Inductive load (contd..)

Phase Angle, ϕ	Load Power factor, cosϕ	$W_1 = V_L I_L \cos(30+\phi)$	$W_2 = V_L I_L \cos(30-\phi)$	Comments
0°	1	$\frac{\sqrt{3}V_L I_L}{2}$	$\frac{\sqrt{3}V_L I_L}{2}$	$W_1 = W_2$
30°	0.866 Lag	$\frac{V_L I_L}{2}$	$V_L I_L$	$W_1 = \frac{W_2}{2}$
60°	0.5 Lag	0	$\frac{\sqrt{3}V_L I_L}{2}$	$W_1 = 0$; $W_2 = P_{3-phase}$
>60°	< 0.5 Lag	Negative	Positive	W_1 = -ve; W_2 = +ve

Variation in wattmeter readings – Inductive load (contd..)

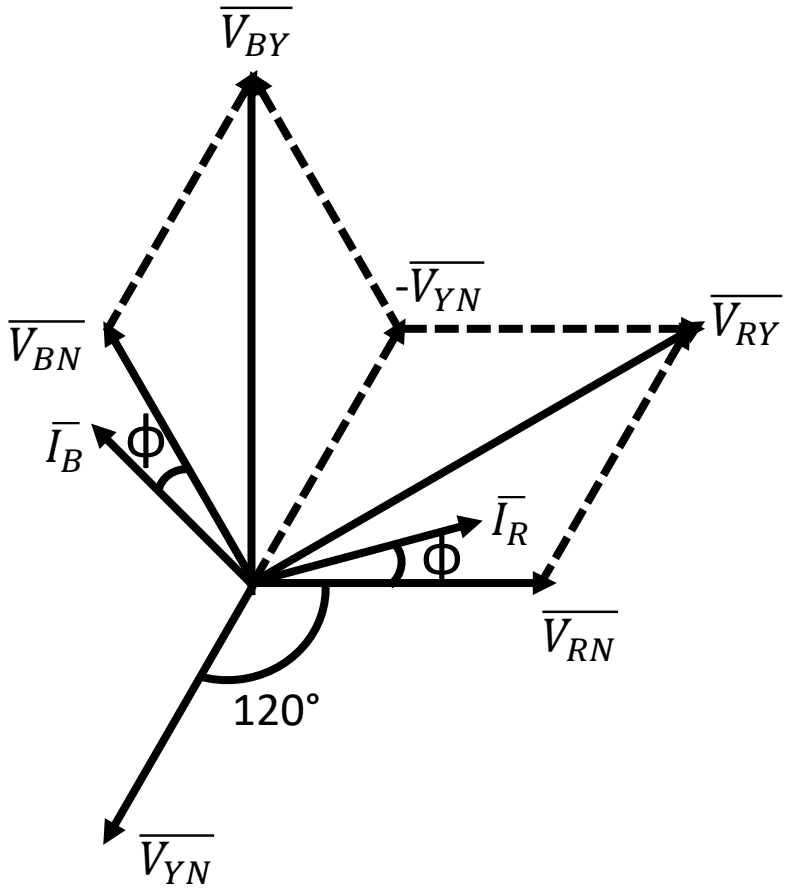
Important observations:

- When phase angle is <60° (or) power factor of the load is > 0.5 Lag, both the wattmeters read positive readings.

- When phase angle = 60° (or) power factor of the load is = 0.5 Lag, one of the wattmeters reads zero and the other reads the total three phase active power.

- When phase angle is >60° (or) power factor of the load is < 0.5 Lag, one of the wattmeters reads negative i.e., its pointer moves behind zero. To record its reading, either reverse its CC connections or PC connections (not both) & record this value with a negative sign.

Two Wattmeter Method – Phasor Diagram for capacitive Loads



Consider capacitive load. Then, phase current leads phase voltage.

$W_1 = V_{RY} * I_R * \cos(30-\phi)$ & $W_2 = V_{BY} * I_B * \cos(30+\phi)$

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Variation in wattmeter readings – Capacitive load

Phase Angle, ϕ	Load Power factor, cosϕ	$W_1 = V_L I_L \cos(30-\phi)$	$W_2 = V_L I_L \cos(30+\phi)$	Comments
0°	1	$\frac{\sqrt{3}V_L I_L}{2}$	$\frac{\sqrt{3}V_L I_L}{2}$	$W_1 = W_2$
30°	0.866 Lead	$V_L I_L$	$\frac{V_L I_L}{2}$	$W_2 = \frac{W_1}{2}$
60°	0.5 Lead	$\frac{\sqrt{3}V_L I_L}{2}$	0	$W_1 = P_{3-phase}$; $W_2 = 0$
>60°	< 0.5 Lead	Positive	Negative	W_1 = +ve; W_2 = -ve

Numerical Example

Question:

In a two wattmeter method of measuring three phase power, it is observed that the wattmeter readings are in the ratio of 3:1. Determine the power factor of the Load.

Solution:

Given Data:

$W_1 : W_2 = 3:1$

Power factor = cosϕ = $\cos\left(Tan^{-1}\left(\sqrt{3}*\frac{(W_1 - W_2)}{(W_1 + W_2)}\right)\right)$

Therefore, Power factor = 0.756

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Text Book & References

Text Book:

1. "Basic Electrical Engineering" S.K Bhattacharya, 1st Edition Pearson India Education Services Pvt. Ltd., 2017
2. "Basic Electrical Engineering", D. C. Kulshreshta, 2nd Edition, McGraw-Hill. 2019
3. "Special Electrical Machines" E G Janardanan, PHI Learning Pvt. Ltd., 2014

Reference Books:

1. "Engineering Circuit Analysis" William Hayt, Jack Kemmerly, Jamie Phillips and Steven Durbin, 10th Edition McGraw Hill, 2023
2. "Electrical and Electronic Technology" E. Hughes (Revised by J. Hiley, K. Brown & I.M Smith), 12th Edition, Pearson Education, 2016.

THANK YOU

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