3 Measurement of Power & Energy

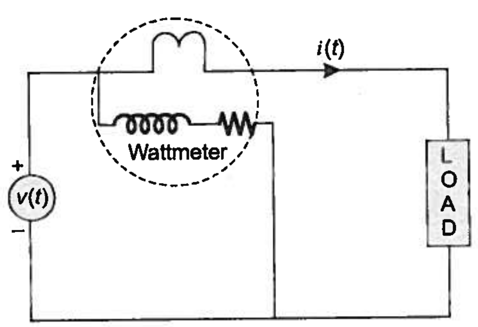
Multiple Choice Questions

1. For the circuit shown in the figure, the voltage and current expressions are

$$v(t) = E_1\sin(\omega t) + E_3\sin(3\omega t)$$

and $$i(t) = I_1\sin(\omega t - \phi_1) + I_3\sin(3\omega t - \phi_3) + I_5\sin(5\omega t)$$

The average power measured by the wattmeter is



(a) $\frac{1}{2}E_1 I_1\cos\phi_1$

(b) $\frac{1}{2}[E_1 I_1\cos\phi_1 + E_1 I_3\cos\phi_3 + E_1 I_5]$

(c) $\frac{1}{2}[E_1 I_1\cos\phi_1 + E_3 I_3\cos\phi_3]$

(d) $\frac{1}{2}[E_1 I_1\cos\phi_1 + E_3 I_1\cos\phi_1]$

[GATE-2012]

2. The pressure coil of a dynamometer type wattmeter is
(a) highly inductive (b) highly resistive
(c) purely resistive (d) purely inductive

[GATE-2009]

3. Two wattmeters, which are connected to measure the total power on a three-phase system supplying a balanced load, read 10.5 kW and –2.5 kW, respectively. The total power and the power factor, respectively, are
(a) 13.0 kW, 0.334 (b) 13.0 kW, 0.684
(c) 8.0 kW, 0.52 (d) 8.0 kW, 0.334

[GATE-2005]

4. In the measurement of power on balanced load by two-wattmeter method in a 3-phase circuit, the readings of the Watt meters are 3 kW and 1 kW respectively, the latter being obtained after reversing the connections to the current coil. The power factor of the load is
(a) 0.554 (b) 0.377
(c) 0.277 (d) 0.866

[ESE-2002]

5. Consider the following statements regarding measurement of 3-phase power by two-wattmeter method; one of the wattmeter reads negative implying:
1. Power factor is less than 0.5.
2. Power flow is in the reverse direction.
3. Load power factor angle is greater than 60°.
4. Load is unbalanced.

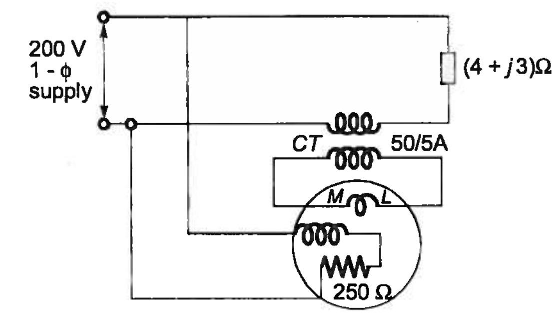
Which of the above statements are correct?
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2, 3 and 4

[ESE-2010]

6. The current and potential coils of a dynamometer type wattmeter were accidentally interchanged while connecting. After energizing the circuit, it was observed that the wattmeter did not show the reading. This could be due to the
(a) Damage to potential coil
(b) Damage to current coil
(c) Damage to both the potential and current coil
(d) Loose contacts

[ESE-2011]

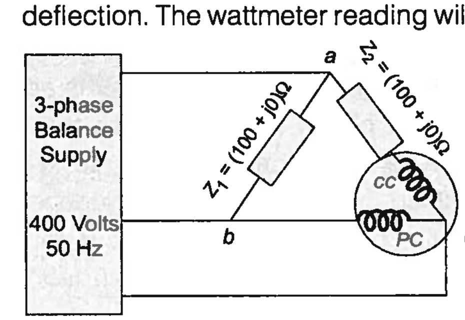
7. In the circuit shown in the given figure, the wattmeter reading will be



(a) 480 W (b) 640 W
(c) 800 W (d) 1000 W

[ESE-1999]

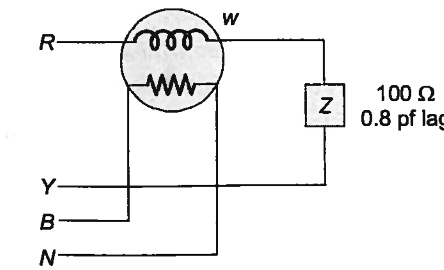
8. The figure shows a three-phase delta connected load supplied from a 400V, 50 Hz, 3-phase balanced source. The pressure coil (PC) and current coil (CC) of a wattmeter are connected to the load as shown, with the coil polarities suitably selected to ensure a positive deflection. The wattmeter reading will be



(a) 0 (b) 1600 Watt
(c) 800 Watt (d) 400 Watt

[GATE-2009]

9. A single-phase load is connected between R and Y terminals of a 415 V, symmetrical, 3-phase, 4 wire system with phase sequence RYB. A wattmeter is connected in the system as shown in figure. The power factor of the load is 0.8 lagging. The wattmeter will read



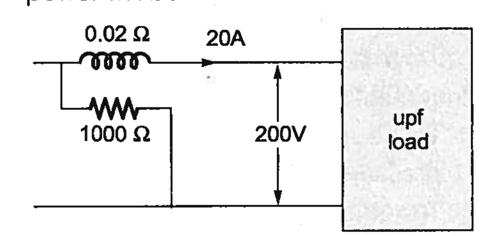
(a) –795 W (b) –597 W
(c) +597 W (d) +795 W

[GATE-2004]

10. A wattmeter reads 400 W when its current coil is connected in the R phase and its pressure coil is connected between this phase and the neutral of a symmetrical 3-phase system supplying a balanced star connected 0.8 p.f. inductive load. Ths phase sequence is RYB. What will be the reading of this wattmeter if its pressure coil alone is reconnected between the B and Y phases, all other connections remaining as before?
(a) 400.0 (b) 519.6
(c) 300.0 (d) 692.8

[GATE-2003]

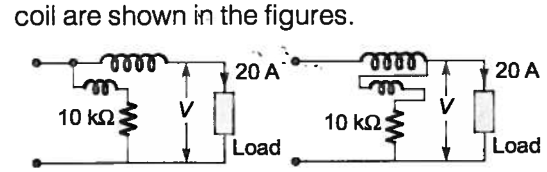
11. The circuit in figure is used to measure the power consumed by the load. The current coil and the voltage coil of the wattmeter have 0.02 Ω and 1000 Ω resistances respectively. The measured power compared to the load power will be



(a) 0.4% less (b) 0.2% less
(c) 0.2% more (d) 0.4% more

[GATE-2004]

12. Two types of connections of Wattmeter pressure coil are shown in the figures.



The value of the Wattmeter current coil resistance r, which makes the connection errors the same in the two cases is

(a) 0.05 Ω (b) 0.1 Ω
(c) 0.01 Ω (d) 0.125 Ω

[ESE-2002]

13. **Assertion (A):** General purpose dynamometer type Wattmeter cannot indicate the correct value of power at low power factors.
Reason (R): The presence of self-inductance in the pressure coil circuit introduces an error in the indicated value which increases appreciably with decrease in power factor.
(a) Both A and R are true but R is the correct explanation of A.
(b) Both A and R are true and R is NOT the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

[ESE-2006]

14. Due to the effect of inductance in the pressure coil, a dynamometer type wattmeter
(a) Reads low on lagging power factor and high on leading power factor
(b) Reads high on lagging power factor and low on leading power factor
(c) Reading is independent of the power factor
(d) Always reads lower than actual value

[ESE-2011]

15. In a low power factor wattmeter, why is a compensating coil employed?
(a) To neutralize the capacitive effect of pressure coil
(b) To compensate for inductance of pressure coil
(c) To compensate for the error caused by power loss in the pressure coil
(d) To compensate for the error caused by eddy currents

[ESE-2007]

16. The magnetic field responsible for the production of the deflecting torque in an accurate dynamometer type wattmeter, being very weak, the accuracy of the measurement can be increased by providing a
(a) Magnetic shield around the instrument
(b) Compensating winding along with the pressure coil
(c) Astatic arrangement to the moving system of the instrument
(d) Capacitance shunt across a portion of the pressure coil

[ESE-2011]

Energy Meter

17. The pressure coil of energy meter is
(a) highly capacitive (b) highly Resistive
(c) highly Inductive (d) purely Inductive

18. Consider the following statements associated with an energy meter:
1. It is an integrating type instrument.
2. It is an induction type instrument.
3. It uses a permanent magnet for rotation of aluminium disc.
4. It employs a high control torque.

Which of these statements are correct?
(a) 1, 2, 3 and 4 (b) 1 and 2 only
(c) 2 and 3 only (d) 3 and 4 only

[ESE-2011]

19. The voltage-flux adjustment of a certain 1-phase 220 V induction watt-hour meter is altered so that the phase angle between the applied voltage and the flux due to it is 85° (instead of 90°). The errors introduced in the reading of this meter when the current is 5 A at power factors of unity and 0.5 lagging are respectively
(a) 3.8 mW, 77.4 mW
(b) –3.8 mW, –77.4 mW
(c) –4.2 W, –85.1 W
(d) 4.2 W, 85.1 W

[GATE-2003]

20. A 230 V, 10 A single-phase energy meter makes 90 revolutions in 3 minutes at half load rated voltage and unity pf. If the meter constant is 1800 revolutions/k Wh, then is error at half load will be
(a) 13.04% slow (b) 13.04% fast
(c) 15% slow (d) 15% fast

[ESE-1997]

21. Which one of the following is the main cause of creeping in the induction type energy meters?
(a) Friction compensation
(b) Lag/Lead compensation
(c) Overload compensation
(d) Braking torque producing system

[ESE-2007]

22. In a single phase induction type energy meter, the lag adjustment is done to ensure that
(a) Current coil flux lags the applied voltage by 90°
(b) Pressure coil flux lags the applied voltage by 90°
(c) Pressure coil flux in phase with applied voltage
(d) Current coil flux lags the pressure coil flux by 90° [IES -2000]

23. If an induction type energy meter runs fast, it can be slowed down by
(a) lag adjustment
(b) light load adjustment
(c) adjusting the position of braking magnet and moving it closer to the centre of the disc
(d) adjusting the position of braking magnet and moving it away from the centre of the disc

[ESE-2001]

24. The disc of a house service energy meter of 230 V, 1-ϕ, 50 Hz, 5 A, 2400 rev. per kWh creeps at 1 rev. per min. The creep error (in per cent) of full load unity pf is

(a) $+\frac{60}{2400} \times 100$

(b) $-\frac{60}{2400} \times 100$

(c) $+\frac{60}{1.15 \times 2400} \times 100$

(d) $-\frac{60}{1.15 \times 2400} \times 100$

[ESE-1999]

25. For testing of energy meter, phantom loading arrangement is used because
(a) the arrangement gives accurate results
(b) the power consumed in calibration work is minimum
(c) the method gives quick results
(d) the onsite calibration is possible

[ESE-2002]

26. The energy meter connected to an immersion heater (resistive) operating on an 230V, 50 Hz, AC single phase source reads 2.3 units (kWh) in 1 hour. The heater is removed from the supply and now connected to a 400 V peak to peak square wave source of 150 Hz. The power in kW dissipated by the heater will be
(a) 3.478 (b) 1.739
(c) 1.54 (d) 0.87

[GATE-2006]

27. For controlling the vibration of the disc of ac energy meter, damping torque produced by
(a) Eddy current
(b) Chemical effect
(c) Electrostatic effect
(d) magnetic effect

[ESE-2014]

Numerical Data Type Questions

28. An LPF wattmeter of power factor 0.2 is having three voltage settings 300 V, 150 V and 75 V, and two current settings 5 A and 10 A. The full scale reading is 150. If the wattmeter is used with 150 V voltage setting and 10 A current setting, the multiplying factor of the wattmeter is ______.

[GATE-2014]

29. An electrodynamic wattmeter is employed to measure power in a single phase circuit the load voltage is 220 V and the load current is 4 A, at a lagging power factor of 0.1. The wattmeter potential coil has a resistance of 10,000 Ω and an inductive reactance negligible compared to

resistance. ______ percentage error will be in the wattmeter reading. When inductance of coil is 100 mH and pressure coil is connected on load side.

30. An energy meter, having meter constant of 1200 revolutions/kWh, makes 20 revolutions in 30 sec for a constant load. The load, in kW, is______.

31. The voltage (V) and current (A) across a load are as follows.
$V(t) = 100 \sin(\omega t)$
$i(t) = 10 \sin(\omega t - 60°) + 2\sin(3\omega t) + 5 \sin(5\omega t)$
The average power consumed by the load, in W, is______.

Conventional Questions

32. The inductive reactance of the pressure coil circuit of a dynamometer wattmeter is 0.4 % of its resistance at normal frequency (50 Hz) and the capacitance is negligible. Calculate the percentage error and correction factor due to the reactance for load at 0.707 p.f lagging.

[ESE-2010]

33. Prove that for electrodynamometer type of wattmeters:

$$\text{True power} = \frac{\cos\phi}{\cos\beta\cos(\phi-\beta)} \times \text{actual wattmeter reading}$$

Where ϕ = Power factor of the circuit

$$\beta = \tan^{-1}\frac{\omega L}{R}$$

where L and R are the inductance and resistance of the pressure coil.
Explain why errors are large when power factor is low. **[ESE-2007]**

34. Derive the expression for reading of a wattmeter having pressure coil inductance.

35. Explain, how a dynamometer-type wattmeter can be used to measure power in a circuit having low power factor?

[ESE-2004]

36. Sketch the circuit diagram for power measurement in a 3-phase circuit using two wattmeters and show that total power is given by the algebraic sum of the wattmeters readings using vector diagrams.

[ESE-2003]

Try Yourself

Linked Questions (T1 and T2):
The power flowing in a 3-ϕ, 3 wire balanced load system is measured by the two wattmeter method. The reading of wattmeter A is 500 watts and wattmeter B is –100 watts.

T1. The power factor of the system is
(a) 0.86 (b) 0.707
(c) 0.56 (d) 0.359

[Ans. (d)]

T2. If the voltage of the circuit is 440 volts. The value of capacitive reactance which must be introduced into each phase to cause the whole of the power measured to appear on wattmeter A is
(a) 44.13 Ω (b) 48.13 Ω
(c) 54.13 Ω (d) 60.13 Ω

[Ans. (c)]

T3. In a circuit of a single phase induction energy meter, the pressure coil lags the voltage by 88°, the errors while measuring power in two circuits having power factors of unity and 0.5 lagging are respectively.
(a) –0.061%, +6.1% (b) +0.061%, –6.1%
(c) –0.061%, –6.1% (d) –6.1%, –6.1%

[Ans. (c)]