COLLEGE OF ENGINEERING, SCIENCE & TECHNOLOGY (CEST)

SCHOOL OF ELECTRICAL & ELECTRONICS ENGINEERING

CERTIFICATE IV IN ELECTRICAL ENGINEERING-STAGE 5

EEE451 ELECTRICAL MACHINES

FINAL EXAMINATION PENSTER 3, 2015

DATE/DAY: TBA　　　　**TIME**: TBA

ROOM: AS PER TIMETABLE

INSTRUCTIONS TO STUDENTS

1. You are allowed **10 minutes** extra **reading time** during which you are **NOT** to write.
2. Begin each SECTION on a fresh page and use both sides of the sheet.
3. Write your candidate number at the top of each attached sheet.
4. Insert all written foolscaps, graph paper, drawing paper, etc. in their correct sequence and secure with a string.
5. For all sheets of paper on which rough/draft work has been done, cross it through and ATTACH these to your answer scripts.
6. Write clearly the number(s) of the question(s) attempted on the top of each sheet.
7. Use of programmable calculator(s) is prohibited.
8. **ANSWER ALL QUESTIONS**
9. Show all working where necessary.
10. **ALWAYS CHECK YOUR WORK BEFORE YOU LEAVE THE EXAM ROOM**

SECTION A (35 MARKS)

1. Explain with aid of a diagram the principle operation of a transformer. (3 marks)

2. An ideal transformer with a turns ratio of 2:7 is fed from a 240 V supply. Determine its output voltage. What is an ideal transformer? (2 marks)

3. What are the three factors are required for the production of voltage in a transformer. (3 marks)

4. Specify the purpose of having tap changers on transformers? (2 marks)

5. What are the advisable colors to be used on a transformer tank and state the reason for using the indicated colors? (3 marks)

6. Explain **Regulation of the Transformer** and also write down the Percentage regulation formula. (4 marks)

7. State the three requirements for connecting three phase transformers in parallel and explain the effects of each requirement. (8 marks)

8. Name two types of instrument transformers and state the reason for their use. (3 marks)

9. The secondary circuit of a transformer must never be opened when current is flowing in the primary. Briefly explain what could happen if this occurs. (3 marks)

10. What is an auto transformer? (4 marks)

SECTION B (35 MARKS)

1. Draw and label clearly:

(i) A basic alternator circuit (4 marks)

(ii) A block diagram for an engine-driven standby alternator. (4 marks)

2. Draw the connection diagram for two-wattmeter 3 wire system for measurement of power and write down the formula to calculate total power. (4 marks)

3. What are the advantages and disadvantages three wattmeter 3wire system for measurement of power? (4 marks)

4. State the advantages and disadvantages of one wattmeter 4 wire system. (5 marks)

5. Explain the two types of alternator rotors used in synchronous machines. (4 marks)

6. Draw the circuit diagram showing the connection of instrument transformers. (3 marks)

7. Explain the two different methods of cooling transformers. (4 marks)

8. With aid for diagrams show the standard winding terminal polarity identification of a three phase transformer. (3 marks)

SECTION C (30 MARKS)

Each Question is worth five(5) marks

1. A single-phase 500 V/100 V, 50 Hz transformer has a maximum core flux density of 1.5 T and an effective core cross-sectional area of 50 cm^2. Determine the number of primary and secondary turns.

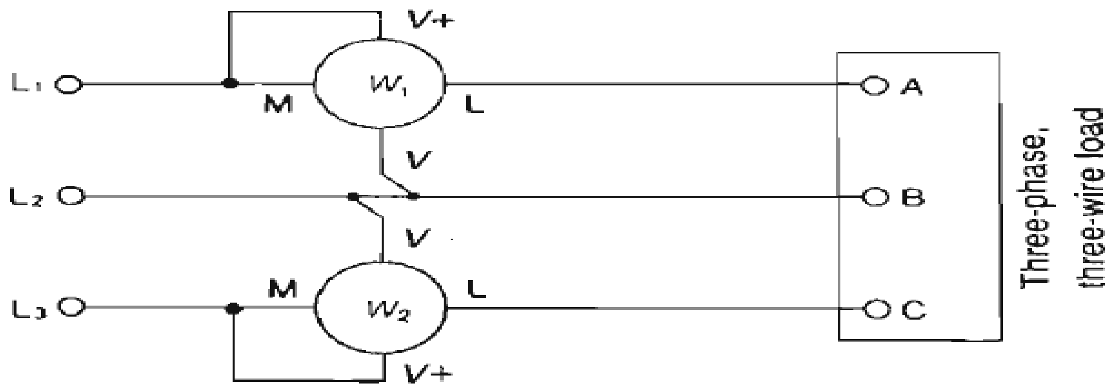
2. A single-phase transformer has 2000 turns on the primary and 800 turns on the secondary. Its no-load current is 5 A at a power factor of 0.20 lagging. Assuming the volt drop in the windings is negligible, determine the primary current and power factor when the secondary current is 100 A at a power factor of 0.85 lagging. (Use phasor diagram method)

3. A 5 kVA, 200 V/400 V, single-phase transformer has a secondary terminal voltage of 387.6 volts when loaded. Determine the regulation of the transformer.

4. A 200 kVA rated transformer has a full-load copper loss of 1.5 kW and an iron loss of 1 kW. Determine the transformer efficiency y at full load and 0.85 power factor.

5. Calculate the line voltage of a 50 Hz star-connected alternator given the following details:
   ϕ = 0.67 Wb/pole, k_d = 0.85, k_p = 0.98, N = 36 turns/phase.

6. Two watt meter 3wire system when connected to a three-phase motor, two watt meters gave readings of 5 kW and -1 kW. Find:
   (a) The total power being consumed
   (b) The power factor of the motor.



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MARKING SCHEME

School: Electrical & Electronic Engineering
Course: Certificate IV in Electrical Engineering
Title:/Code: **ELECTRICAL MACHINES / EEE451**
Stage/Penster/Year: C4EL 5 / Penster 3 / Year 2015
Date: **TBA**
Examiner: Niraj Chand

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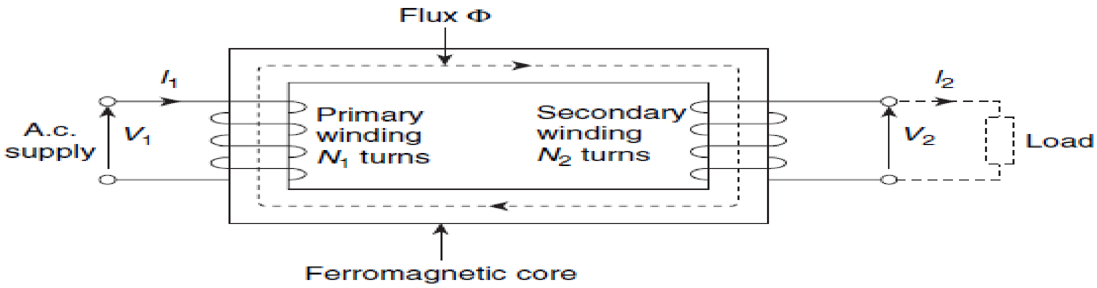
Model Answers and Marking Scheme
NOTE: Give a clear indication of answers expected and marks allocated for each part of a question.

SECTION A **(40 marks)**

1.



When the secondary is an open-circuit and an alternating voltage V1 is applied to the primary winding, a small current — called the no-load current I_0 — flows, which sets up a magnetic flux in the core. This alternating flux links with both primary and secondary coils and induces in them e.m.f.'s of E1 and E2 respectively by **mutual induction**. (3 Marks)

2.

$$V_2 = \frac{(240)(7)}{2} = 840 \text{ V}$$

(2Marks)

An ideal transformer is a transformer is one in which no losses occur and its core is infinitely permeable. (2 Marks)

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3. - conductors (1 mark)
- flux (1 mark)
- And relative movement (1 mark)

4. Tap changers are installed in situations where they can compensate for variations in voltage. A rising or falling voltage at the load end of the line can be corrected by the action of a tap changer at the supply end. (4 marks)

5. Polished metallic surfaces inhibit the removal of heat from transformer oil and casings. Colors such as low sheen variations of black, green and grey enable the oil to run at lower temperatures. (4 marks)

6. When the secondary of a transformer is loaded, the secondary terminal voltage, V2, falls. As the power factor decreases, this voltage drop increases. This is called the regulation of the transformer and it is usually expressed as a percentage of the secondary no-load voltage, E2. For full-load conditions:

$$\text{Regulation} = \left(\frac{E_2 - V_2}{E_2}\right) \text{ x } 100\%$$

(4 marks)

7. *Equal voltage*
A circulating current is set up between the transformers due to unequal voltage sources; therefore, the transformers become a burden on each other and are unable to supply power to an external load. (3 marks)

Same phase sequence
The east that can occur when two transformers which are connected in parallel and have different phase sequence, is a short circuit occurring between the lines and heavy circulating current flows which can cause damage to all sections of the instillations. (3 marks)

Phase voltage to be in step
Transformers must be compatible owing to possible phase shifts. When transformers in parallel are connected to different source supplies, phase shift occurring in one and not the other can damage both transformers and impose a heavy drain on the supply. (3 marks)

8. Voltage Transformer/ Potential Transformer (1 marks)
Current transformer (1 marks)
These transformers are used to step down the values of current and voltage to proportionate values that can be read by the metering equipment. (2 marks)

9. When the secondary circuit is open circuited high current in the primary side causes flux in the core to reach peaks higher then normal which causes the core to be totally saturated. During this period very high voltage is induced across the open circuited secondary, an unsuspecting operator can easily receive a bad shock. (3 marks)

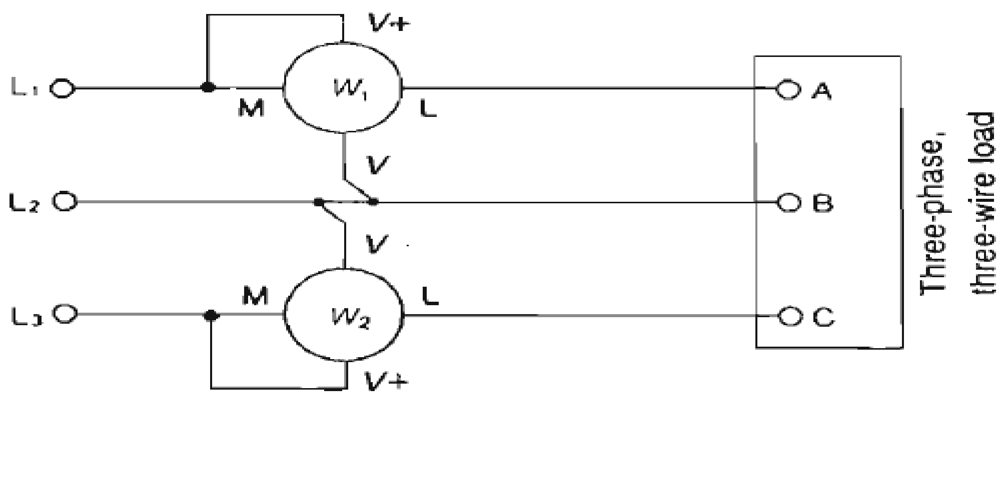
10. An autotransformer is one in which part of the winding is common to both the primary and the secondary circuits. The induced e.m.f. across any given number of turns in a transformer depends on the turns-per-volt ratio of the winding. If the winding is tapped at a convenient point, a nominal voltage is available across the terminals. (3 marks)

SECTION B (30 marks)

1. (i) Basic alternator circuit
(ii) A block diagram for an engine-driven standby alternator. (5 marks each)

Fig 11.2 and 11.5 from Electrical Principles for Trades page252 & 253

2.



3. **Advantages**

    1. Suitable for balanced and unbalanced loads.
    2. Convenient for obtaining total power.
    3. More accurate than one wattmeter for fluctuating loads.

    Disadvantage

    Three wattmeters are needed.

4. **Advantages**

    1. One wattmeter only is required.
    2. Suitable for balanced and unbalanced loads.

    Disadvantages

    1. Neutral connection required for the wattmeter.
    2. Not accurate for unbalanced fluctuating loads.
    3. The wattmeter has to be connected or switched into each phase in turn for unbalanced loads.

5. The alternator rotor can be of two types-low speed and high speed.

    Low speed (salient pole) - This type usually consists of a 'spider' similar to that used in d.c. machines, on which are bolted the field poles and the field coils (see Fig. l1.2(a)) . Physical constraints limit the use of this type of rotor to low-speed machines.

    High speed (cylindrical) - The cylindrical rotor was developed to meet the needs of higher-speed prime movers. To counteract centrifugal forces its diameter must be small compared to its length.

6.

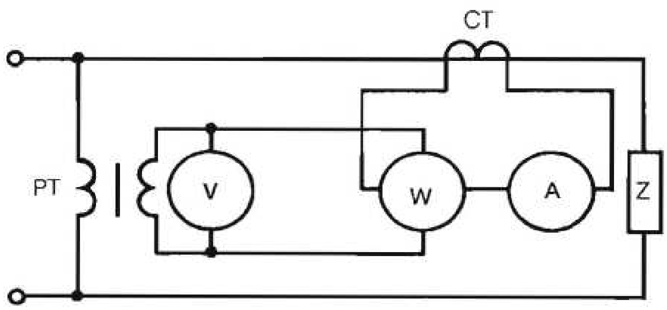


Figure 14.33 • Instrument transformer connections

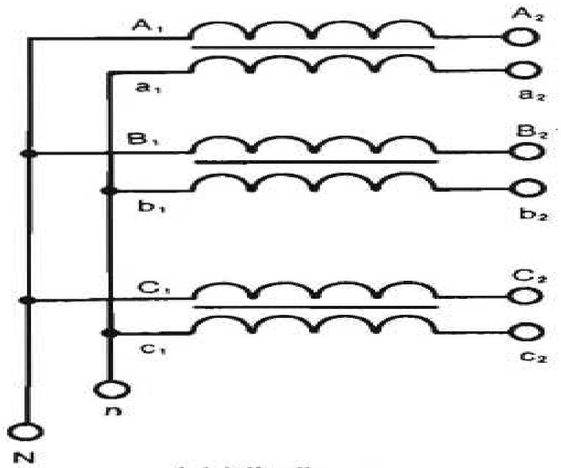
7. ***Air cooling***

    The air blast type of cooling is used on transformers where economy of space weight is required, or where oil cooling may be a fire hazard.

    Oil cooling

    The transformer tank is immersed in a tank of special transformer oil, providing as large a cooling surface area of the tank as possible. (3 marks)

8.



(a) Windings

SECTION C **(30 MARKS)**

Each Question is five marks each

1.

The e.m.f. equation for a transformer is $E = 4.44 f \Phi_m N$ and maximum flux $\Phi_m = B \times A = (1.5)(50 \times 10^{-4}) = 75 \times 10^{-4}$ Wb

Since $E_1 = 4.44 f \Phi_m N_1$ then primary turns,

$$N_1 = \frac{E_1}{4.44 f \Phi_m} = \frac{500}{(4.44)(50)(75 \times 10^{-4})}$$
$$= \mathbf{300\ turns}$$

Since $E_2 = 4.4 f \Phi_m N_2$ then secondary turns,

$$N_2 = \frac{E_2}{4.44 f \Phi_m} = \frac{100}{(4.44)(50)(75 \times 10^{-4})}$$
$$= \mathbf{60\ turns}$$

2.

Let I_1' be the component of the primary current which provides the restoring m.m.f. Then

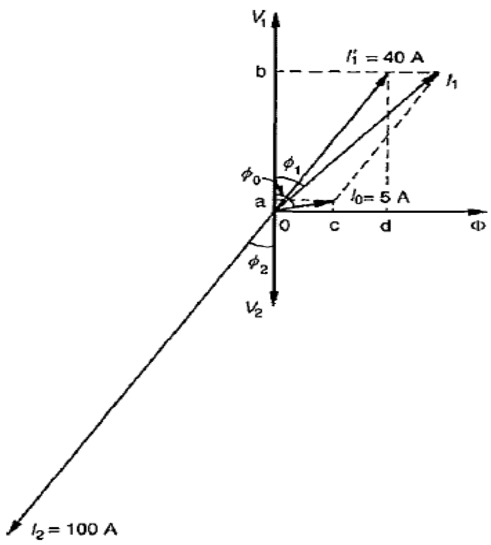
$$I_1' N_1 = I_2 N_2$$

i.e. $I_1'(2000) = (100)(800)$

from which, $I_1' = \frac{(100)(800)}{2000}$

$= 40$ A

If the power factor of the secondary is 0.85, then $\cos\phi_2 = 0.85$, from which, $\phi_2 = \cos^{-1} 0.85 = 31.8°$.



3.

$$\text{regulation} = \left(\frac{\text{No load secondary voltage} - \text{terminal voltage on load}}{\text{no load secondary voltage}}\right) \times 100\%$$

$$= \left(\frac{400 - 387.6}{400}\right) \times 100\%$$

$$= \left(\frac{12.4}{400}\right) \times 100\%$$

$$= \mathbf{3.1\%}$$

4.

$$\text{Efficien y}, \eta = \frac{\text{output power}}{\text{input power}}$$

$$= \frac{\text{input power} - \text{losses}}{\text{input power}}$$

$$= 1 - \frac{\text{losses}}{\text{input power}}$$

$$\text{Full-load output power} = VI \cos\phi = (200)(0.85) = 170\ \text{kW}.$$

$$\text{Total losses} = 1.5 + 1.0 = 2.5\ \text{kW}$$

$$\text{Input power} = \text{output power} + \text{losses} = 170 + 2.5 = 172.5\ \text{kW}.$$

$$\text{Hence efficien y} = \left(1 - \frac{2.5}{172.5}\right) = 1 - 0.01449$$

$$= 0.9855 \text{ or } \mathbf{98.55\%}$$

5. $Vg = 4.44\ \phi\ f\ N\ k_d\ k_p$

$= 4.44 \times 0.67 \times 50 \times 36 \times 0.85 \times 0.98$

$= 4460$ V

6. (a) $$P_{total} = W_1 + W_2 = -1 + 5 = 4\ \text{kW}$$

(b) $$\tan\phi = \sqrt{3}.\left[\frac{W_2 - W_1}{W_2 + W_1}\right]$$

$$= \sqrt{3}.\left[\frac{5 - (-1)}{5 + (-1)}\right]$$

$$= \sqrt{3}.\left[\frac{5 + 1}{5 - 1}\right]$$

$$= \sqrt{3} \times \frac{6}{4} = \sqrt{3} \times 1.5$$

$$= 2.598$$

$$\therefore \phi = 68.9^\circ$$

$$\lambda = \cos\phi = 0.3592 = 0.36$$