<u>**Third Question (12 Marks)**</u>

Choose the correct answer: انقل رقم السؤال ورقم اجابته الصحيحة فقط فى كراسة الاجابة

1. For a single-phase transformer with 6 kVA rating, a secondary terminal voltage of 487.5 V, and a voltage ratio of 100V/500 V, the transformer regulation is:
   a. 2.50% **b. 2.56%** **c. 3.5%**

2. A generator rated 1000 VA and 200 V has internal impedance of j10 Ω. Its per-unit reactance is:
   a. j0.025 **b. j0.25** **c. j 2.5**

3. A 200 km long 3-Φ transmission line having sending end voltage of 44 kV and current of 178 A. If the line supplies load of 20 MW at 0.9 p.f., the transmission efficiency is:
   a. 92 %. **b. 94 %.** **c. 95 %.** **d. 96 %.**

4. A generating station has a connected load of 43MW, a maximum demand of 20 MW; and the units generated being $61 \cdot 5 \times 10^6$ kWh/year. The demand factor is:
   a. 2.15 **b. 0·351** **c. 0·465**

<u>**Fourth Question (5 Marks)**</u>

Choose the correct answer: انقل رقم السؤال ورقم اجابته الصحيحة فقط فى كراسة الاجابة

1. Per unit conversion affects:

a) Angles only
b) Magnitudes only
c) Both the magnitudes and values

2. A short transmission line is represented without any shunt capacitors because

a) There is no capacitance at all
b) There is considerable capacitance, but we ignore it for simplifying calculation
c) There is very small capacitance and can be ignored

3. Which combination is true for short lines?

a) A = 1, B = Z, C = 0, D = 1.
b) A = 0, B = 1, C = Z, D = 1.
c) A = 1, B = 1, C = Z, D = 0.
d) A = 0, B = 0, C = 1, D = Z.

4. Interconnected systems have the advantage(s) of:

a) Improved load factor, diversity factor
b) Reduced reversed plant capacity.
c) All of the above.
d) None of the above

5. In a separately excited DC motor, the stator field is feed by:

a) a small permanent magnate
b) a wounded coil connected to an external supply
c) a series wound coil connected to the armature

With my Best Wishes **Prof. Magdi El-Saadawi**

8/6/2015

Mansoura University
Faculty of Engineering
Dept. of Elec. Engineering

BME Program
Elec. Power Systems
Course Code: FCR 141

Time Allowed: 2 Hours *Total Marks: 50 Marks*

Final Exam June 2015

First Question (18 Marks)

1-a) A single-phase transformer has a voltage ratio of 6:1 and the high voltage winding is supplied at 540 V. The secondary winding provides a full load current of 30 A at a power factor of 0.8 lagging. Neglecting losses, find (a) the rating of the transformer, (b) the power supplied to the load, (c) the primary current.

1-b) A single phase a.c. system supplies a load of 200 kW and if this system is converted to 3-phase, 3-wire a.c. system by running a third similar conductor, calculate the 3-phase load that can now be supplied if the voltage between the conductors is the same. Assume the power factor and transmission efficiency to be the same in the two cases.

1-c) The maximum demand of a consumer is 25A at 220 V and his total energy consumption is 9750 kWh. If energy is charged at the rate of 20 Egyptian piastres per kWh for 500 hours use of maximum demand plus 5 Egyptian piastres per unit for all additional units, estimate his annual bill and the equivalent flat rate. Take the load factor and power factor to be unity

Second Question (15 Marks)

2. Answer Only Five of the following questions:

2.1) What is the difference between ideal and practical transformer? Explain your answer by drawing the equivalent circuit of each of them.

2.2) Define Ferranti effect, what is the purpose of its occurrence? How to reduce it?

2.3) Describe the desirable characteristics of a tariff.

2.4) Discuss the effects of high load factor on the operation of power plants.

2.5) Explain the difference between: Flat rate tariff and Block rate tariff.

2.6) With the help of neat sketch compare between Tap changing transformer and Regulating transformers (Boosters) for voltage control in power system.

2.7) Define: Depreciation, Peak load, reserve capacity.

2.8) Derive an expression to determine economic choice of conductor size.

2.9) Discuss the principle of operation of a DC motor.

لاحظ أن أسئلة الامتحان من صفحتين

Mansoura University
Faculty of Engineering
Dept. of Elec. Engineering

BME Program
Elec. Power Systems
Course Code: FCR 141

Time Allowed: 2 Hours *Total Marks: 50 Marks*

Final Exam June 2015

Solution Model

First Question (18 Marks)

1-a) A single-phase transformer has a voltage ratio of 6:1 and the high voltage winding is supplied at 540 V. The secondary winding provides a full load current of 30 A at a power factor of 0.8 lagging. Neglecting losses, find (a) the rating of the transformer, (b) the power supplied to the load, (c) the primary current.

Solution

$$\frac{V_1}{V_2} = \frac{6}{1} \quad \text{and} \quad V_1 = 540\,\text{V} \quad \text{hence,} \quad V_2 = \frac{540}{6} = 90\ \text{V} \quad \text{and} \quad I_2 = 30\ \text{A}$$

(a) **Rating of transformer** = $V_2 I_2 = 90 \times 30 =$ **2700 VA** or **2.7 kVA**

(b) Since power factor = cos ϕ = 0.8, then

Power supplied to load = V I cos ϕ = (2700)(0.8) = **2.16 kW**

(c) $\frac{V_1}{V_2} = \frac{I_2}{I_1}$ from which, **primary current,** $I_1 = I_2\left(\frac{V_2}{V_1}\right) = (30)\left(\frac{1}{6}\right) =$ **5 A**

1-b) A single phase a.c. system supplies a load of 200 kW and if this system is converted to 3-phase, 3-wire a.c. system by running a third similar conductor, calculate the 3-phase load that can now be supplied if the voltage between the conductors is the same. Assume the power factor and transmission efficiency to be the same in the two cases.

Solution:

Fig. (i) shows the single phase 2-wire a.c. system, whereas Fig. (ii) shows 3-phase, 3-wire system. Suppose that V is the voltage between the conductors in the two cases. Let R be the resistance per conductor and cos φ the power factor in each case.

(*i*) (*ii*)

Single phase 2-wire system. Referring to Fig. (*i*),

$$\text{Power supplied, } P_1 = V I_1 \cos\phi$$

$$\text{Power loss, } W_1 = 2 I_1^2 R$$

$$\%\text{ age power loss} = \frac{2 I_1^2 R}{V I_1 \cos\phi} \times 100 \quad \text{— (1)} \quad ...(i)$$

3-phase, 3-wire a.c. system. Referring to Fig. (*ii*),

$$\text{Power supplied, } P_2 = \sqrt{3} V I_2 \cos\phi$$

$$\text{Power loss, } W_2 = 3 I_2^2 R$$

$$\%\text{ age power loss} = \frac{3 I_2^2 R}{\sqrt{3} V I_2 \cos\phi} \times 100 \quad \text{— (1)} \quad ...(ii)$$

As the transmission efficiency in the two cases is the same, therefore, percentage power loss will also be the same *i.e.*,

$$\text{exp. } (i) = \text{exp. } (ii)$$

or $$\frac{2 I_1^2 R}{V I_1 \cos\phi} \times 100 = \frac{3 I_2^2 R}{\sqrt{3} V I_2 \cos\phi} \times 100 \quad \text{— (1)}$$

or $$2 I_1 = \sqrt{3} I_2$$

or $$I_2 = \frac{2}{\sqrt{3}} I_1 \quad \text{— (1)}$$

Now, $$\frac{P_2}{P_1} = \frac{\sqrt{3} V I_2 \cos\phi}{V I_1 \cos\phi} = \frac{\sqrt{3} V \frac{2}{\sqrt{3}} I_1 \cos\phi}{V I_1 \cos\phi} = 2 \quad (1)$$

As the power supplied by single phase, 2-wire (*i.e.*, P_1) is 200 kW,

∴ Power supplied by 3-phase, 3-wire a.c. system is

$$P_2 = 2P_1 = 2 \times 200 = \mathbf{400\ kW} \quad (1)$$

It may be seen that 3-phase, 3-wire system can supply 100% additional load.

1-c) The maximum demand of a consumer is 25A at 220 V and his total energy consumption is 9750 kWh. If energy is charged at the rate of 20 Egyptian piastres per kWh for 500 hours use of maximum demand plus 5 Egyptian piastres per unit for all additional units, estimate his annual bill and the equivalent flat rate. Take the load factor and power factor to be unity

Solution:

Assume the load factor and power factor to be unity.

∴ Maximum demand = (220 ×25 ×1)/1000 = 5.5 kW

(i) Units consumed in 500 hrs = 5·5× 500 = 2750 kWh

Charges for 2200 kWh = LE 0·2× 2750 = LE 550

Remaining units = 9750 − 2750 = 7000 kWh

Charges for 6560 kWh = LE 0·05× 7000 = LE 350

∴ Total annual bill = LE (550 + 350) = **LE 900**

(ii) Equivalent flat rate=LE 900/9750=LE 0.092= **9.2 piastres**

Second Question (15 Marks)

2. Answer Only Five of the following questions:

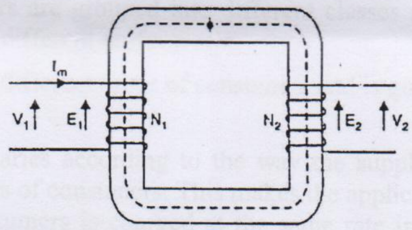
1) What is the difference between ideal and practical transformer? Explain your answer by drawing the equivalent circuit of each of them.

An ideal transformer is one that has:

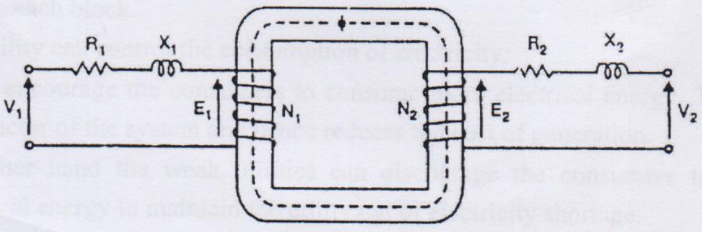
(i) No winding resistance

(ii) No leakage flux i.e., the same flux links both the windings

(iii) No iron losses (i.e., eddy current and hysteresis losses) in the core



A practical transformer differs from the ideal transformer in many respects. The practical transformer has (i) iron losses (ii) winding resistances and (iii) magnetic leakage, giving rise to leakage reactances.



2) Define Ferranti effect, what is the purpose of its occurrence? How to reduce it?

Ferranti effect: is the phenomenon of the increases of the receiving end voltage beyond the sending end voltage in case of light loading or no load operation of transmission system.

Purpose of occurrence: It is due to the voltage drop across the line inductance (due to charging current) being in phase with the sending end voltages. Therefore both capacitance and inductance is responsible to produce this phenomenon.

It can be reduced by: using shunt reactors and series capacitors. Series capacitors are placed at different places along the line while shunt reactors are often installed in the stations at the ends of line.

3) Describe the desirable characteristics of a tariff.

1. **Proper return:** the total receipts from the consumers must be equal to the cost of producing and supplying electrical energy plus reasonable profit.
2. **Fairness:** The tariff must be fair so that different types of consumers are satisfied with the rate of charge of electrical energy. A consumer whose load conditions non-variable should be charged at a lower rate than the one whose load conditions change appreciably from the ideal.
3. **Simplicity:** The tariff should be simple so that an ordinary consumer can easily understand it.
4. **Reasonable profit:** The profit element in the tariff should be reasonable. An electric supply company is a public utility company and generally enjoys the benefits of monopoly. This calls for the profit to be restricted to 8% or so per annum.

4) Discuss the effects of high load factor on the operation of power plants.

- ***Reduces cost per unit generated:*** A high load factor reduces the overall cost per unit generated. It is because higher load factor means that for a given maximum demand, the number of units generated is more. This reduces the cost of generation.
- ***Reduces variable load problems:*** A high load factor reduces the variable load problems on the power station. A higher load factor means less variations in the load demands at various times. This avoids the frequent use of regulating devices installed to meet the variable load on the station.

5) Explain the difference between: Flat rate tariff and Block rate tariff.

Flat rate tariff: the consumers are grouped into different classes and each class of consumers is charged at a different uniform rate.

Advantages: it is more fair to different types of consumers and is quite simple in calculations.

Disadvantages:

(i) Since the flat rate tariff varies according to the way the supply is used, different meters are required for different types of consumers. This makes the application of such a tariff expensive.

(ii) A particular class of consumers is charged at the same rate irrespective of the magnitude of energy consumed. However, a big consumer should be charged at a lower rate as in his case the fixed charges per unit are reduced.

Block rate tariff: the energy consumption is divided into blocks and the price per unit is fixed in each block.

Advantages the utility can control the consumption of electricity:

- It can encourage the consumers to consume more electrical energy. This increases the load factor of the system and hence reduces the cost of generation.
- On other hand the weak utilities can discourage the consumers to consume more electrical energy to maintain the utility out of electricity shortage.

Disadvantages:

- It does not recover the fixed charges which depend upon the maximum demand of the consumer but are independent of the units consumed.

6) With the help of neat sketch compare between Tap changing transformer and Regulating transformers (Boosters) for voltage control in power system.

a) Tap changing transformer:

There are two types of tap changing transformers.

i) Off-load tap changing transformers.

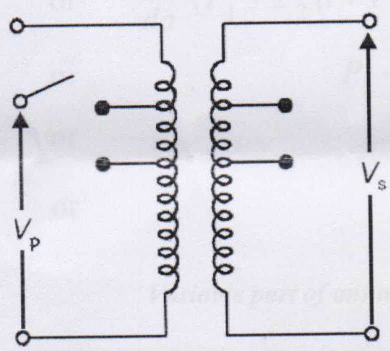
ii) Tap changing under load (TCUL) transformers.

The off-load tap changing transformer requires the disconnection of the transformer when the tap setting is to be changed. Figure gives the connection of off-load tap changing transformer. A typical off-load tap changing transformer might have four taps in addition to the nominal setting.

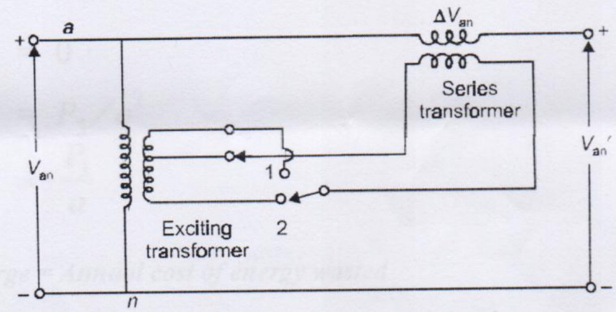
b) Booster transformers are used to change the voltage magnitude and phase angle at an intermediate point in a line rather than at the ends as with tap-changing transformers or the system may not warrant the expense of tap-changing. The following Figure shows the connection of a booster transformer for phase *a*. The secondary of the exciting transformer is tapped and the voltage obtained from it is applied to the primary of the series transformer. The corresponding secondary voltage of the series transformer is added to the input voltage. Therefore, the output voltage is:

$$V'_{an} = V_{an} + \Delta V_{an}$$

The polarity of the voltage across the series transformer can be made reversed by changing the switch position from S_1 to S_2, such that V'_{an} is less than V_{an}.



a) Tap changing transformer



b) Booster transformers

7) Define: Depreciation, Peak load, reserve capacity.

Depreciation: The decrease in the value of the power plant equipment and building due to constant use is known as depreciation.

Peak load: The various peak demands of load over and above the base load of the station

Reserve capacity: A power station is so designed that it has some reserve capacity for meeting the increased load demand in future.

Reserve capacity = Plant capacity - Maximum demand.

8) Derive an expression to determine economic choice of conductor size.

(i) Annual charge on capital outlay.

$$\textit{Annual charge} = P_1 + P_2\, a \qquad ...(i)$$

where P_1 and P_2 are constants and a is the area of X-section of the conductor.

(ii) Annual cost of energy wasted.

$$\text{Annual cost of energy wasted} = P_3/a \qquad ...(ii)$$

where P_3 is a constant.

$$\text{Total annual cost, } C = \text{exp. } (i) + \text{exp. } (ii)$$

$$= (P_1 + P_2\, a) + P_3/a$$

$$\therefore \quad C = P_1 + P_2\, a + P_3/a \qquad ...(iii)$$

In exp. (iii), only area of X-section a is variable. Therefore, the total annual cost of transmission line will be minimum if differentiation of C with respect to a is zero i.e.

$$\frac{d}{da}(C) = 0$$

$$\text{or} \quad \frac{d}{da}(P_1 + P_2\, a + P_3/a) = 0$$

$$\text{or} \quad P_2 - \frac{P_3}{a^2} = 0$$

$$\text{or} \quad P_2 = P_3/a^2$$

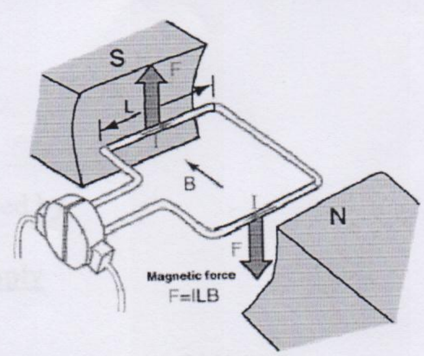
$$\text{or} \quad P_2\, a = \frac{P_3}{a}$$

i.e.

Variable part of annual charge = Annual cost of energy wasted

9) Discuss the principle of operation of a DC motor.

- Consider a coil in a magnetic field of flux density B (as shown in Fig). When the two ends of the coil are connected across a dc voltage source, current I flows through it. A force F is exerted on the coil as a result of the interaction of magnetic field and electric current.
- In a dc motor, several such coils are wound on the rotor, all of which experience force, resulting in rotation.
- The greater the current in the wire, or the greater the magnetic field, the faster the wire moves because of the greater force created.
- At the same time this torque is being produced, the conductors are moving in a magnetic field. At different positions, the flux linked with it changes, which causes an emf to be induced.
- This voltage is opposite to the voltage that causes current flow through the conductors and is referred to as a back emf (E_b).



Third Question (12 Marks)

Choose the correct answer

1. For a single-phase transformer with 6 kVA rating, a secondary terminal voltage of 487.5 V, and a voltage ratio of 100V/500 V, the transformer regulation is:
   a. 2.50% **b. 2.56%** c. 3.5%

2. A generator rated 1000 VA and 200 V has internal impedance of j10 Ω. Its per-unit reactance is
   a. j0.025 **b. j0.25** c. j 2.5

3. A 200 km long 3-Φ transmission line having sending end voltage of 44 kV and current of 178 A. If the line supplies load of 20 MW at 0.9 p.f. The transmission efficiency is:
   a. 92 %. **b. 94 %.** c. 95 %. d.96 %.

4. A generating station has a connected load of 43MW, a maximum demand of 20 MW; and the units generated being $61{\cdot}5 \times 10^6$ kWh/year. The demand factor is:
   a. 2.15 b. 0·351 **c. 0·465**

Fourth Question (5 Marks)

Choose the correct answer

1. Per unit conversion affects:
   a) Angles only
   b) Magnitudes only
   c) Both the magnitudes and values

2. A short transmission line is represented without any shunt capacitors because
   a) There is no capacitance at all
   b) There is considerable capacitance, but we ignore it for simplifying calculation
   c) There is very small capacitance and can be ignored

3. Which combination is true for short lines?
   a) A = 1, B = Z, C = 0, D = 1.
   b) A = 0, B = 1, C = Z, D = 1.
   c) A = 1, B = 1, C = Z, D = 0.
   d) A = 0, B = 0, C = 1, D = Z.

4. Interconnected systems have the advantage(s) of
   a) Improved load factor, diversity factor
   b) Reduced reversed plant capacity.
   c) All of the above.
   d) None of the above

5. In a separately excited DC motor, the stator field is feed by
   a) a small permanent magnate
   b) a wounded coil connected to an external supply
   c) a series wound coil connected to the armature

Prof. Magdi El-Saadawi 8/6/2015

Mansoura University — **Final Exam (16/6/2016)**

Faculty of Engineering — **Full Mark: 50**

MTE&BME Programs — **Time : 2 Hours**

Electrical Power (FCR141)

Please Answer the Following Questions:

Question # 1:(6 Points)

Attempt any three parts of the following: (3x2pts)

- **a- Discuss why there is a need for alternative energy forms.**
- **b- How Nuclear Power Works.**
- **c- Discuss briefly the advantages and disadvantages of solar power.**
- **d- State the two ways to increase the transported power.**

Question # 2: (10 Points)

A positive sequence balanced Y-connected source (a, b, c) supplies a balanced Δ-connected load (A, B, C). If the line current $I_{aA}=20\angle{-36^{\circ}}$ A and load impedance is (12 +j18) Ω/phase, find:

- **a- Phase currents of theload. (3 pts)**
- **b- Phase voltages of the load and phase voltages of the supply.(5 pts)**
- **c- Active power consumed by the load.(2 pts)**

Question #3: (9 Points)

A 6 kVA, 200/600V, single-phase transformer has the following parameters referred to the low voltage side, R_{eq1}=0.8Ω, X_{eq1}=1.5 Ω, R_o=400 Ω, X_o=100 Ω. If the transformer supplies a load current of 10 A at 0.8 power factor lagging, calculate:

- **a- The no-load current and transformer core loss.(3 pts)**
- **b- The secondary terminal voltage under loading conditions.(2 pts)**
- **c- Transformer cupper loss and its efficiency.(4 pts)**

P.T.O

Q4(3+3+4 mark)

4-a)-Explain with a diagram the construction of a dc machine.

4-b)-Draw speed –torque-current characteristics for separate, shunt and series motors and compare between them.

4-c)-A series-connected dc motor has an armature resistance of 0.5Ω and field winding resistance of 1.5Ω. In driving a certain load, where the output shaft power and output shaft torque are 3450W and 27Nm respectively. from a voltage source of V = 220V. The efficiency of this motor is 78 %. Find (i) the motor current, (ii) the speed (iii) power developed and (iv) the rotational loss.

Q5(4+4mark)

5-a)-Explain the construction, advantages, disadvantages and applications of printed circuit (disc) DC motor.

5-b)-A stepper motor has a resolution of 1000 steps/rev in the half step mode operation. If it is operated in full step mode, determine (i) resolution and (ii)number of steps required to turn the rotor through 72^{o}.

Q6(3+4mark)

6-a)-Explain the principle of operation of the 3 phase induction motor and showing why cannot run at the synchronous speed?

6-b)-A 480-V, 60 Hz, 50-hp, three phase induction motor is drawing 70A at 0.9 PF lagging. The stator copper losses are 2 kW, and the rotor copper losses are 600W. The friction and windage losses are 500 W, the core losses are 1700W, and the stray losses are negligible. Find the following quantities: (i) The air-gap power (ii) The power converted (iii) The output power (iv)The efficiency of the motor.