This is a closed book exam. The exam consists of two pages. Attempt all questions

Q.1 Write true or false with correcting the wrong statement ***[10 marks]***

1) **Energy is broadly classified into two main types renewable and non-renewable. (T)**
2) **The Egyptian transmission voltage levels are 500 kV, 220 kV, 132 kV, 66 kV. (T)**
3) **Nonrenewable resources cannot be replaced or are replaced much more slowly than they are used. (T)**
4) **Energy storage devices are discharged when they absorb energy. (F, charged)**
5) **Energy storage based on lithium-ion battery provides reliable and fast frequency response. (T)**
6) **Flywheel is the type of storage system uses mechanical energy to store energy. (T)**
7) **Compressed air is an energy storage system which is usually built in abandoned mines. (T)**
8) **Energy resources that are renewable can be used up. (F, cannot)**
9) **Disconnect switch provides visible circuit separation and can be operated only in no-load condition. (T)**
10) **The purpose of the electric transmission system is the efficient interconnection of the generating stations with the loads. (T)**
11) **Charge and discharge normally require power conversion devices, to transform electrical energy (AC or DC) into a different form of electrical, thermal, mechanical or chemical energy. (T)**
12) **Electricity stored during off-peak time can be used during no-peak hours so that home/commercial owners can cut peak demand and electricity cost. (T)**
13) **Pumped hydro storage, compressed air energy storage, hydrogen and thermal storage are characterized by their ability to store energy over time (several hours). (T)**
14) **For accurate modeling of the transmission line, the parameters are assumed to be distributed throughout line. (T)**
15) **Incandescent lamps and electric heaters are common examples of inductive loads. (F, resistive)**
16) **The load factor is the ratio of average load over designated period of time to the peak load occurring in that period. (T)**
17) **The Egyptian strategy for energy supply and use aims to increase the renewable energy share of the total energy demand to 20% by 2020 with contribution 12% from solar. (False, wind)**
18) **Engineering, Procurement and Construction (EPC) is a form of contracting arrangement where the EPC contractor is made responsible for all from design, procurement, construction, commissioning and handover of the project to the end-user or owner. (T)**
19) **Homopolar lines are those in which the line has one conductor only and the earth is used as the return conductor. (False, Monopolar)**
20) **Geothermal energy caused by the heating of Earth's crust. This energy can be converted into electrical energy at power plants. (T)**

Q.2 **[10 marks]**

a) Explain clearly what is meant by good quality supply, discuss the effect of bad supply on the performance of the system.

b) A bridge connected rectifier is fed from 220 kV / 110 kV transformer, operates with (commutation angle ά=20º and overlap angle γ=10º). (a) Determine the necessary line secondary voltage of the rectifier transformer, if it is required to obtain a d.c. output voltage of 87 kV, (b) Determine the tap ratio required and (c) Determine the d.c. output current, if the effective reactance per phase 9.25 Ω.

a) The need for ensuring a high degree of service reliability in the operation of modem electric systems can hardly be over-emphasized. The supply should not only be reliable but should be of good quality i.e. The voltage and frequency should vary within certain limits, otherwise operation of the system at subnormal frequency and lower voltage will result in serious problems especially in case of fractional horse-power motors. In case of refrigerators reduced frequency results into reduced efficiency and high consumption as the motor draws larger current at reduced power factor. The system operation at subnormal frequency and voltage leads to the loss of revenue to the suppliers due to accompanying reduction in load demand. The most serious effect of subnormal frequency and voltage is on the operation of the thermal power station auxiliaries. The output of the auxiliaries goes down as a result of which the generation is also decreased. This may result in complete shut-down of the plant if corrective measures like load shedding is not resorted to. Load shedding is done with the help of under frequency relays. Which automatically disconnect blocks of loads or section the transmission system depending upon the system.

b)

$$V_d = \frac{V_0}{2}\left[\cos\alpha + \cos(\alpha+\gamma)\right]$$

$$87 = \frac{V_0}{2}\left[\cos 20^0 + \cos\left(20^0 + 10^0\right)\right]$$

$$V_0 = \frac{87}{0.903} = 96.36 \text{ kV}$$

$$V_0 = \frac{3\sqrt{3}V_m}{\pi} = \frac{3\sqrt{3}\left(\sqrt{2}V_{rms}\right)}{\pi} = \frac{3\sqrt{2}\left(\sqrt{3}V_{rms}\right)}{\pi} = \frac{3\sqrt{2}\left(V_{L-Lrms}\right)}{\pi}$$

$$V_{L-L_{rms}} = \frac{\pi V_0}{3\sqrt{2}} = \frac{\pi\times 96.36}{3\sqrt{2}} = 71.35 \text{ kV}$$

(a) The necessary line secondary voltage of the rectifier transformer is 71.35 kV

(b) The tap ratio is 220 kV / 71.35 kV

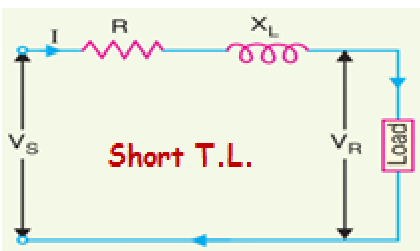
(c) The d.c. output current is $I_d = \frac{\pi V_0}{6X}\left[\cos\alpha - \cos(\alpha+\gamma)\right]$

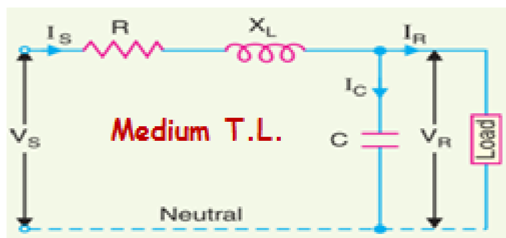
$$I_d = \frac{\pi \times 96.36}{6\times 9.25}\left[\cos 20^0 - \cos\left(20^0 + 10^0\right)\right] = 401.82 \text{ A}$$

Q.3 ***[10 marks]***

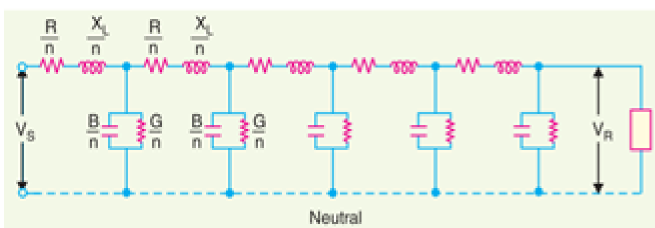
a) Compare between types of overhead transmission lines.

	length	voltage	capacitor
Short T.L.	< 50 Km	< 20 KV	Not Used
Medium T.L.	50Km – 150 Km	20KV - 100 KV	Used
Long T.L.	> 150Km	> 100KV	Used





Long T.L.



b) A single-phase overhead transmission line delivers 1.1MW at 33 kV at 0.8 p.f. lagging. The total resistance and inductive reactance of the line are 10 Ω and 15 Ω respectively. Calculate: (i) sending end voltage (ii) sending end power factor and (iii) transmission efficiency.

Solution.

Load power factor, $\cos\phi_R = 0{\cdot}8$ lagging

Total line impedance, $\vec{Z} = R + jX_L = 10 + j\,15$

Receiving end voltage, $V_R = 33$ kV = 33,000 V

$$\text{Line current, } I = \frac{kW \times 10^3}{V_R \cos\phi_R} = \frac{1100 \times 10^3}{33{,}000 \times 0.8} = 41.67 \text{ A}$$

$$\text{As } \cos\phi_R = 0.8 \quad \therefore \quad \sin\phi_R = 0.6$$

$$\vec{V_R} = V_R + j\,0 = 33000 \text{ V}$$

$$\vec{I} = I(\cos\phi_R - j\sin\phi_R)$$

$$= 41.67\,(0.8 - j\,0.6) = 33.33 - j\,25$$

(*i*) Sending end voltage,
$$\vec{V_S} = \vec{V_R} + \vec{I}\,\vec{Z}$$
$$= 33{,}000 + (33.33 - j\,25.0)\,(10 + j\,15)$$
$$= 33{,}000 + 333.3 - j250 + j500 + 375$$
$$= 33{,}708.3 + j\,250$$

$$\therefore \quad \text{Magnitude of } V_S = \sqrt{(33{,}708.3)^2 + (250)^2} = \mathbf{33{,}709\ V}$$

(*ii*) Angle between $\vec{V_S}$ and $\vec{V_R}$ is

$$\alpha = \tan^{-1}\frac{250}{33{,}708.3} = \tan^{-1} 0.0074 = 0.42^\circ$$

$\therefore$ Sending end power factor angle is

$$\phi_S = \phi_R + \alpha = 36.87^\circ + 0.42^\circ = 37.29^\circ$$

$$\therefore \quad \text{Sending end p.f.,} \quad \cos\phi_S = \cos 37.29^\circ = \mathbf{0.7956\ lagging}$$

(*iii*)
$$\text{Line losses} = I^2R = (41.67)^2 \times 10 = 17{,}364 \text{ W} = 17.364 \text{ kW}$$

$$\text{Output delivered} = 1100 \text{ kW}$$

$$\text{Power sent} = 1100 + 17.364 = 1117.364 \text{ kW}$$

$$\therefore \quad \text{Transmission efficiency} = \frac{\text{Power delivered}}{\text{Power sent}} \times 100 = \frac{1100}{1117.364} \times 100 = \mathbf{98.44\%}$$

Note. V_S and ϕ_S can also be calculated as follows :

$$V_S = V_R + I R \cos\phi_R + I X_L \sin\phi_R \text{ (approximately)}$$
$$= 33{,}000 + 41{\cdot}67 \times 10 \times 0{\cdot}8 + 41{\cdot}67 \times 15 \times 0{\cdot}6$$
$$= 33{,}000 + 333{\cdot}36 + 375{\cdot}03$$
$$= 33708{\cdot}39 \text{ V which is approximately the same as above}$$

$$\cos\phi_S = \frac{V_R \cos\phi_R + I R}{V_S} = \frac{33{,}000 \times 0{\cdot}8 + 41{\cdot}67 \times 10}{33{,}708{\cdot}39} = \frac{26{,}816{\cdot}7}{33{,}708{\cdot}39}$$
$$= 0{\cdot}7958$$

Q*.4** ***[10 marks]

a) Enumerate the different types of rechargeable batteries and discuss the performance characteristic of the battery which influences the design. Illustrate your answer with necessary curves.

Lead Acid Batteries for Solar Energy

1- Flooded Lead Acid.
2- Valve Regulated Lead Acid:
A- Wet
B- AGM
C- Gel

Another classification for solar energy batteries (flat or tubular plate).

b) Discuss in detail different types of energy storage systems.
1- Battery storage.
2- Compressed air storage.
3- Water pump storage.
4- Thermal storage.

c) The daily load on a power system varies as shown in Table (1). Using the given data compute the average load and the daily load factor.

Table 1. Daily System Load

Interval, hr	0 - 3	3 - 7	7 – 10	10 - 13	13 - 17	17 - 20	20 – 22	22 - 24
Load, MW	1	2	3	4	5	8	9	6

Sum (Dt) = (3-0) +(7-3) +(10-7) +(13-10) +(17-13) +(20-17) +(22-20) +(22-24) = 24 hours

W= P*Dt = 1*(3-0) +2*(7-3) +3*(10-7) +4*(13-10) +5*(17-13) +8*(20-17) +9*(22-20) +6*(22-24) = 82 MW.hr

P_{avg} = W/ Sum (Dt) = 82/24 = 3.416667 MW

P_{peak} = 9 MW

Load Factor = Pavg / Ppeak = 3.416667/ 9 = 0.37963