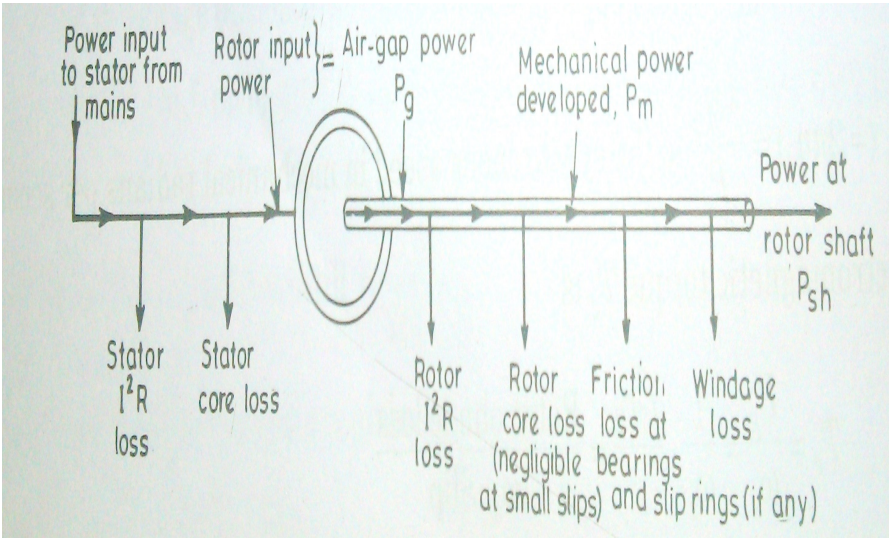
Important suggestions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and communication skills)
4) While assessing figures, examiner may give credit for principle components indicated in a figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q.1 A)	**Attempt any THREE of the following :**	**12 Marks**
i)	**What is the energy conservation? List its benefits.**	
Ans:	**Energy conservation:** **(2 Marks)** Reduction in the amount of energy consumed in a process or system, or by an organization or society, through economy, elimination of waste, and rational use is referred as energy conservation. **OR** It is defined as reducing growth of energy consumption by avoiding unnecessary usages of energy by applying the energy conservation techniques. **Benefits of energy conservation:** **(Any two benefits: 2 Marks)** 1. Helps us Save Money. OR Reduces rise in energy cost. 2. Energy Conservation Products Have a Longer Life Span. 3. Decreases Air Pollution 4. helps us Being Safer and Have Better Health. 5. Saves Natural fuel.	

	6 It reduces load shedding 7 It reduces energy demand
ii)	**State and explain following lighting terms : (1) CRI (2) ILER (3) Luminous flux (4) Luminaire**
Ans:	**1) CRI (Colour Rendering Index):** **(1 Mark)** The CRI is the scale to quantify the ability of light source to import colour of objects with reference to standard colour or natural colour. **OR** It indicates true colour of the object ,that count is known as CRI **2) ILER (Installed load efficiency Ratio) :-** **(1 Mark)** The installed load efficiency if the ratio of the average maintained illuminance (illumination) provided on the horizontal working plane per circuit wattage to the target illuminance on horizontal working plane. $ILER = \frac{Actual\ Lux/W/m^2}{Target\ Lux/W/m^2}$ **3) Luminous flux :-** **(1 Mark)** The luminous flux is the total energy radiated by the light source in all direction. **4) Luminaire:** **(1 Mark)** It is a device that distributes or transmits light emitted by one or more lamps. It includes all parts necessary for fixing and protecting the lamps, circuit's auxiliaries for connecting to supply. It works based on principle of reflection, absorption, transmission and refraction.

iii)	**Draw power flow diagram of electrical motor and suggest methods of improving power quality in it.**
Ans:	**Power flow diagram of induction motor: (Flow Diagram : 2 Marks & Methods: 2 Mark)**



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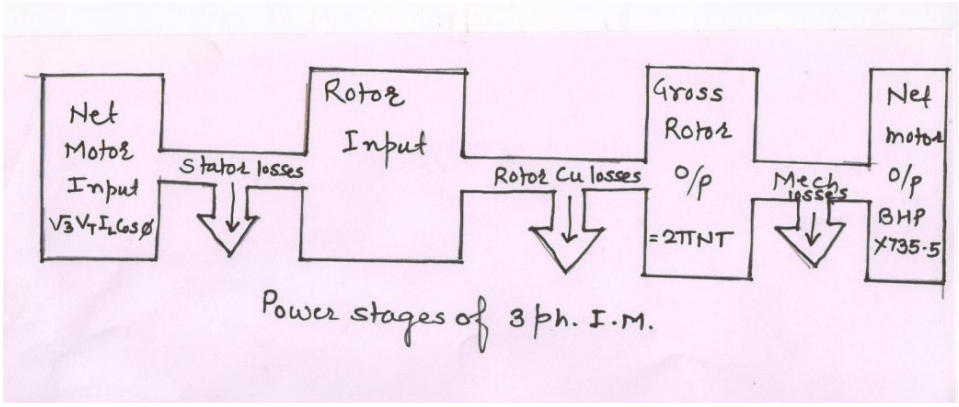


Methods of improving power quality in it:- (Any Two methods expected)

1) Keeping 3-ph voltage constant
2) Balancing Phase current
3) By improving power factor
5) Voltage improvement and maintaining frequency at appropriate levels.
6) Increase power flow capacity.
7) Reduce losses.
8) Pollution free supply system.

9) Use quality anti-friction bearings & lubricants,

10) Use effective methods of cooling.

OR

Power quality is defined by the closeness of the following to specified values:

1) Voltage :

2) Frequency **(voltage & frequency should be within the tolerance limit without harmonics)**

1) **Voltage:** Maintaining the voltage at the rated value for motors results in the properly expected torque speed characteristics available to drive the load. Lower voltage leads to excessive current drawn due to which the line losses increase, machine copper losses increase, line voltage drops increase. Even if voltage is above required value higher flux density results in motors that leads to higher iron losses. These lead to decrease in efficiency. Hence proper voltage has to be maintained.

2) **Frequency:** It governs the speed related losses and iron losses. If its value is more than rated these losses increase as speed is directly proportional to the frequency the speed dependent friction & windage losses increase that will decrease the efficiency. Lower value of frequency leads to lower speed that affects the output power. Hence frequency has to be maintained at rated value.

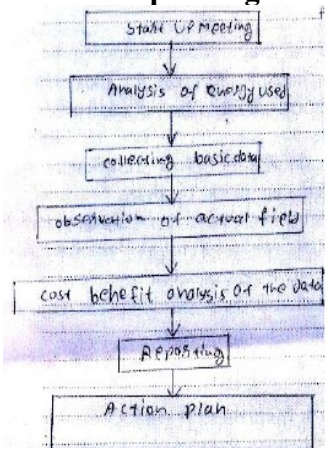
3) When the supply waveform is purely sinusoidal the harmonics are absent which means no iron & copper losses due to harmonic voltage & currents. Also the harmonics even if very small lead to production of unwanted harmonic torques and over heating in motors which need to be overcome & this requires energy which is wasteful. Hence the supply voltage must be as near as possible to sine wave in case of AC motors.

iv) State any four advantages of VFDs.

Ans: **Following are the advantages of VFDs (variable frequency drive):**

(Any Four advantages expected: 1 Mark each)

1) Energy saving.
2) Better process control.
3) Cost saving.

	4) Less maintenance cost. 5) Large life for bearing & motors. 6) Improved power quality. 7) Smooth starting. 8) Improved power factor 9) Reduced M.D. Charges. 10) Increases efficiency 11)
Q.1 B)	**Attempt any ONE of the following :** **06 Marks**
i)	**What is the effect of following on induction motors: (1) Voltage unbalance (2) Harmonic distortion**
Ans	**i) Effect of voltage unbalance:** **(3 Mark)** For three phase motors this leads to unequal currents in the three phase windings that result in unbalance in the fields produced due to which negative phase sequence currents are produced that cause oppositely rotating magnetic field to the normal one, leading to overheating in rotor. Over voltage produces excessive amount of current which increases I^2R losses and motor efficiency reduces. **ii) Effect of harmonic distortion:** **(3 Mark)** Due to distortion of the main frequency waveform by harmonics produced due to solid state devices, electromagnetic devices, arcing devices the high frequency harmonics lead to increased copper losses and iron losses that results in over heating of motors (due to the harmonic voltages and resulting currents thereon). This leads to motor failures, lower life and improper torque speed characteristics.
ii)	**Explain with the flow chart energy audit procedures.**
Ans:	**Detailed energy audit procedure Depending:** **(Figure : 3 Mark & Explanation : 3 Mark)**  or equivalent figure

A) **Start up meeting**: For this programmer, we proceed with this meeting. If then continue us until implementation of energy saving measures.

B) **Analysis of energy used**: Identify where energy used & it shows on which area should be concentrate.

C) **Collecting basic data:** At site load, some of the following important points:

1.Operating hours 2.Duty cycle 3.Actual power consume

D) **Observation of actual field**: After collecting data, we start actual field work. It means we have find out process where energy saving can be done. Always apply the 80 by 20 rule. It means concentrate on opportunities that require 20% input & givens 80% of the saving.

E) **Cost benefit analysis of the data:** The energy conservation opportunities analysis should be in terms of cost of carrying out that project v/s the benefit that can be earned.

F) **Reporting:** We have to submit the detail report. Then we have to take sanction of that report from final Authority.

G) **Action plan**: In this all the measure steps must be included in the action plan for the proper implementation.

OR

1. **Collect information about the plan:**

In this information, the measured energy used, raw material required & components required for the plant are considered.

2. **Collect production process:**

In this process, the design the flowchart of production process, the schedule of operation & its time frame is also considered.

3. **Energy and utility system**:

In this step, load variation in pumps, fans & compressors are considered, the analysis of energy loss and measurement of insulation level is also considered.

4. **Bridge description of each utility**:

In this step, the electricity the steam, water, cooling water an compressed air is to be considered.

5. **Detailed process flow diagram:**

In this step the flow chart, the flow rate & boiler efficiency is to be considered.

6. **Energy efficiency in utility & process system**:

In this step, consider the following things i) specific energy consumption ii) furnace iii) DG set performance analysis iv) lighting system.

7. **Energy conservation option & recommendation:**

The energy conservation & recommendation of better energy source is to be considered.

OR **(Any Six point expected: 1 Mark each)**

1) Depending on the nature and complexity of the organization, a comprehensive audit can take from several weeks to several months to complete.

2) Detail studies to establish and investigate energy & materials balances for specific organization departments of process equipment are carried out.

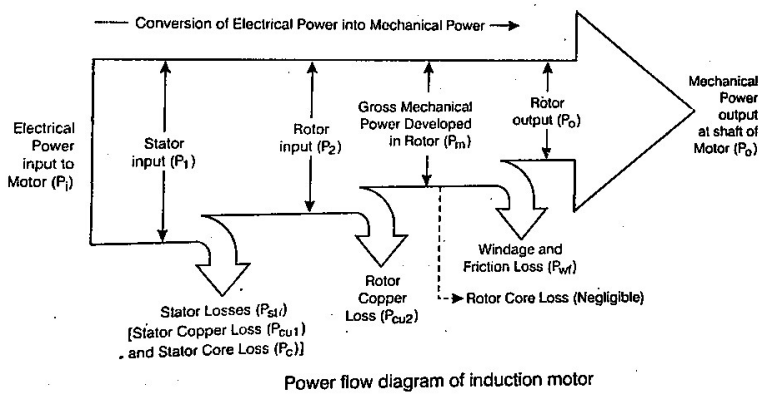
3) Whenever possible checks of organization operations are carried out over extended periods of time at nights and at weekends.

4) The audit report will include a description of energy inputs and product outputs by major departments & will evaluate the efficiency of each step of the manufacturing process.

5) The improve this efficiency will be listed and at least a preliminary assessments of the cost of the improvement will be made to indicate the expected payback on any capital investment needed.

6) The audit report should conclude with specific recommendations for detailed engineering studies & feasibility analysis which must be performed to justify the implementation of those conservation measures that require investments.

OR



Power flow diagram of induction motor

Methods of Improving Power Quality:

1) By applying rated input voltage.

2) By maintaining rated frequency of input voltage.

3) By maintaining perfect sinusoidal wave shape of input voltage.

1) By Applying Rated Input Voltage:

Applying and maintaining the voltage at the rated value for motors results in the properly expected torque speed characteristics available to drive the load. Lower voltage leads to excessive current drawn due to which the line losses increase, machine copper losses increase, line voltage drops increase, line voltage drop increase. Even if voltage is above required value higher flux density results in motors that leads to higher iron losses. These lead to decrease in efficiency. Hence proper voltage has to be maintained.

2) By Maintaining Rated Frequency of Input Voltage:

It governs speed related losses and iron losses. If its value is more than rated then these losses increases as speed is directly proportional to the frequency also speed dependent friction & windage losses increase that will decrease the efficiency. Lower value of frequency leads to lower speed that affects the output power. Hence frequency has to be maintained at rated value.

3)By maintaining perfect sinusoidal wave shape of input voltage:

When the supply voltage waveform is purely sinusoidal the harmonics are absent which means no iron & copper losses due to harmonic voltages & currents. The harmonics even if very small, leads the production of unwanted harmonic torques which in turn waste of energy . Hence the supply voltage must be as near as possible to of sine wave shape in case of AC induction motors.

Q.2	**Attempt any FOUR of the following :**	**16 Marks**
a)	**State any four energy conservation techniques in lighting systems.**	

Ans: **Energy conservation techniques in lighting systems:**

(Any four point expected: 1 Mark each, Total 4 Mark)

1. Use of energy efficient lamp instead of conventional fluorescent lamp.
2. Use of CFL in case of incandescent lamp.
3. Metal halide lamp can be used to replace mercury and sodium vapour lamp..
4. By replacing lamp source as per our requirement.
5. By using the energy efficient luminaries in our lighting system.
6. By using proper light controlled gears.

	7. The lux level on working plane should be uniform. 8. By installing the separate transformer or servo stabilizer. 9. By proper cleaning, marinating the lighting device. 10. Grouping in lighting device manually or automatic.
b)	**State any four places in which luminance level is required.**
Ans:	**Recommended luminance level of any four different Places:** **(Any Four Luminance level is expected: 1 Mark each, Total 4 Marks)** i) Homes, restaurants, general lighting, emergency lighting : 8-18 lumens/watts ii) Offices, shops, hospitals, homes : 46-60 lumens/watts iii) Hotels, shops, homes, offices : 40-70 lumens/watts iv) General lighting in factories, garages, car parking, flood lighting :44-57 lumens/watts v) Display, flood lighting, stadium exhibition grounds, construction areas: 18-24 lumens/watts vi) General lighting in factories, ware houses, street lighting : 67-121 lumens/watts vii) Roadways, tunnels, canals, street lighting: 101-175 lumens/watts. **OR** **Hospital :** 1. Reception & Nursing 250 to 300 lux station 2. Corridors & circulation 40 to 60 lux areas 3. Patient wards - 100 to 200 lux 4. Operation theatres - 600 to 1000 lux 5. ICU - 500 to 700 lux 6. General ward 100 to 200 lux **Sports:** 1. Badminton court 750 Lux 2. Carom Hall 500 Lux 3. Table Tennis Hall 500 Lux 4. Basket Ball Court 500 Lux 7 Special ward 150 to 250 lux etc.

	Residential purpose: 1. Living Room 300 Lux 2. Bedroom 200 Lux 3. Kitchen 200 Lux 4. Stairs 100 Lux 5. Dining Room 150 Lux 6. Dressing table 200 Lux 7. Bathroom mirror 700 Lux 8. Study table 300 Lux
c)	**Explain any one energy conservation techniques related to transformer.**
Ans:	**Following are the (Opportunities) for energy conservation techniques related to transformers:** **(4 Marks)** 1. Use of energy efficient transformer. 2. Use amorphous core containing ferromagnetic elements like iron, cobalt alloy. This material has high resistivity than silicon steel. Due to this core losses are reduced so less energy wasted. 3. Use encapsulated dry type transformer. 4. Use tapped transformer, usually auto transformer leading to saving in copper. 5. Use thinner laminations of superior CRGO steel in transformer core to reduce iron losses. 6. Carry out periodic maintenance of transformer. 7. Use better quality low resistance copper conductors to reduce copper losses. 8. Maintain operating voltage and frequency at the rated values (power quality) so that losses are minimized. 9. Use better quality insulation materials to improve overload capacity and decrease dielectric leakages. 10. Use of optimum capacity of transformer and parallel combination of transformers.

d)	**How parameters of transmission line affects performance of transmission lines?**
Ans:	**Following parameters of transmission line affects performance of transmission lines:** **(Any Four point expected: 1 Mark each, Total 4 Marks)** 1. A transmission line always has, series Resistance, series Inductive Reactance and shunt capacitive reactance. 2. The resistance is dependent upon the material from which the conductor is made 3. The inductance is formed, as the conductor is surrounded by the magnetic lies of force 4. The capacitance of the line is formed as the conductor is carrying the current acts as a capacitor with the earth which is always at lower potential than the conductor and the air between them forms a dielectric medium. 5. Thus, the performance of transmission lines is dependent upon these three line constants. For instance, the voltage drop in the line depends upon the values of the above three line constants. Similarly, the resistance of the transmission line conductors is the most important cause of power loss in the line and determines the transmission efficiency. 6. Due to the power system parameters voltage regulation differs. 7. Ferranti Effect at light load is possible due to the system parameters.
e)	**What adequate maintenance program is followed for lighting systems?**
Ans:	**Following point adequate maintenance program for energy conservation in lighting system:** **(Any four point expected: 1 Mark each)** ➢ Illumination level reduces due to accumulation of dirt on lamps and luminaries. ➢ By carrying periodic survey & deciding/carrying the maintenance i.e. cleaning, dusting of lamps and luminaries will improve the light output / luminance. ➢ **Group relamping:** In this methods the all lamps are changed in the group whenever they are in use & attend 80% of there life & start decreases there illumination efficiency. It is the preventive maintenance. ➢ **Spot relamping:** It is the failure approach in which the lamps are changed immediately after their failure. ➢ As part of maintenance programme, periodic surveys of installation, lightning system with

respect lamp positioning and illumination levels.

- Proper operation of control gears should be conducted to take advantage of energy conservation opportunities as user requirements changes.
- Use energy saving fluorescent lamps/LED lamps without disturbing the CRI.
- Use the recommended optimal level of illumination levels at different places.
- Sectionalize/group the load using proper switches by functional sections so that they can be switched on or off as per the requirements of the particular loads.

f) What is the difference between Energy efficient motors and Standard motors?

Ans: **(Any Four Point expected: 1 Mark each, Total 4 Marks)**

S.No	Particulars	Energy efficient motors	Standard motors
1	Material used	They are manufactured with higher quality conducting, electromagnetic & insulating material & techniques	They are manufactured with lower quality conducting, electromagnetic & insulating material & techniques
2	Losses	They usually have higher service factors & bearing lives, less waste heat output all of which increase reliability, Less losses	High losses
3	Starting torque	Good optimum value with soft starter	Depends on starting method
4	Speed	Smooth speed over a required range & less vibrations	Speed may not be so smooth, jerks, vibrations may be involved
5	Maintenance	Negligible maintenance, longer warranties, low failure rates	More maintenance, less warranty, High failure rates
6	Operating temperature	Can withstand high temperature without any problem	At high temperature some problems may arise in the operation
7	Noise	Noise and vibration level is less	Noise is More
8	Cost	More	Less
9	Effect of Voltage fluctuations	Less	More

10	Efficiency	More efficient	Less efficient
11	Core length	More	Less
12	Power factor	High	Less
13	Air Gap	Optimum	More

Q. 3 **Attempt any FOUR of the following :** **16 Marks**

a) **Explain the role of motor surveying achieve energy conservation in induction motors.**

Ans: **The role of motor surveying achieve energy conservation in induction motors: (4 Marks)**

Large industries have a massive population of LT motors. Load survey of LT motors can be taken-up methodically to identify improvement options.

i) Sampling Criteria: Towards the objective of selecting representative LT motor drives among the motor population, for analysis, the criteria considered are:

- Utilization factor i.e., hours of operation with preference given to continuously operated drive motors.
- Sample representative basis, where one drive motor analysis can be reasoned as representative for the population. e.g. Cooling Tower Fans, Air Washer Units, etc.
- Conservation potential basis, where drive motors with inefficient capacity controls on the machine side, fluctuating load drive systems, etc., are looked into

ii) Measurements:

Studies on selected LT motors involve measurement of electrical load parameters namely volts, amperes, power factor, kW drawn.

Observations on machine side parameters such as speed, load, pressure, temperature, etc., (as relevant) are also taken. Availability of online instruments for routine measurements, availability of tail-end capacitors for PF correction, energy meters for monitoring is also looked into for each case.

iii) Analysis

Analysis of observations on representative LT motors and connected drives is carried out towards following outputs:

- Motor load on kW basis and estimated energy consumption.
- Scope for improving monitoring systems to enable sustenance of a regular inhouse Energy Audit function.
- Scope areas for energy conservation with related cost benefits and source information.

The observations are to indicate:

% loading on kW, % voltage unbalance if any, voltage, current, frequency, power factor, machine side conditions like load / unload condition, pressure, flow, temperature, damper / throttle operation, whether it is a rewound motor, idle operations, metering provisions, etc.

The findings / recommendations may include:

- Identified motors with less than 50 % loading, 50 – 75 % loading, 75 – 100 % loading, over 100 % loading.
- Identified motors with low voltage / power factor / voltage imbalance for needed improvement measures.
- Identified motors with machine side losses / inefficiencies like idle operations, throttling / damper operations for avenues like automatic controls interlocks, variable speed drives, etc.

Motor load survey is aimed not only as a measure to identify motor efficiency areas but equally importantly, as a means to check combined efficiency of the motor, driven machine and controller if any. The margins in motor efficiency may be less than 10 % of consumption often, but the load survey would help to bring out savings in driven machines / systems, which can give 30 – 40 % energy savings.

b) How efficiency of transformer is improved by epoxy resin cast material?

Ans: **Due to following point efficiency of transformer is improved by epoxy resin cast material:**

(Any four point expected: 1 Mark each)

1. Core used is of CRGO M4-M3 circular size therefore minimum leakage reactance and hence core losses will be less.

	2. Winding consist of flexible rope of copper instead of rectangular strips or rod. Therefore current carry capacity is more and better cooling effect. 3. Insulation consists of high quality epoxy resin which is capable to withstanding high temperature and also provides minimum clearance as per voltage requirement. 4. As the transformer is fully encapsulated, routine maintenances is less. 5. As cooling oil is absent the total weight of transformer is less. 6. Due to less weight loading & unloading of the transformer is easy. 7. In the absence of oil there is no need of testing the dielectric strength of oil or no filtration of oil.
c)	**Explain how energy conservation can be achieved in induction motors by operating in star mode.**
Ans:	**Energy conservation can be achieved in induction motors by operating in star mode:** **(4 Marks)** i) Lesser than 30% load means torque required by load is less than 30%. Hence current requirement is reduced. ii) When connected in star, the phase voltage reduces to $(1/\sqrt{3})$ times that in delta mode. As the torque generated by motor is directly proportional to the (applied voltage per phase)^2 the torque produced falls to 1/3 compared to delta mode. iii) Due to decreased phase voltage, the iron losses decrease to nearly 1/3, as total iron losses are proportional to (applied voltage per phase)^2 before saturation. iv) Due to reduction in phase voltage the current drawn in the lines also reduces leading to lower copper losses in motor and decrease line losses.
d)	**Differentiate between epoxy resin cast and encapsulated dry type transformer.**
Ans:	**1) Epoxy Resin Cast Dry Type Transformer:** **(2 Marks)** ➢ Cast resin dry type transformer (CRT) is used in the high moisture prone areas. It is because of its primary and secondary windings are encapsulated with epoxy resin. This encapsulation helps to prevent moisture to penetrate to affect the winding material. ➢ Complete protection is achieved by this cast resin encapsulation so that the

transformer can work without disruption in highly moisture prone area. Thus this transformer is non hygroscopic.

- This type of transformer is available in ratings of 25 KVA to 12,500 KVA with insulation class of F (90 C Temp. Rise).

This type of transformer has some featured advantages. They are-

1. Beater over load capacity.
2. Low partial discharge along with low loss. Hence efficiency is very good.
3. As it is with non inflammable winding insulation, it offers zero risk to fire hazard. So it is suitable for indoor installation.
4. Can be filed outdoor in IP 45 enclosure.
5. And off course non hygroscopic.

2) Encapsulated dry type transformer /Vacuum Pressure Impregnated Transformer (VPI): **(2 Marks)**

- This type of transformer is made with minimum flammable material as insulation of windings.
- The windings of this transformer are made in foil or strip in a continuous layer. But for higher voltages, the winding is made of disks that are connected in series or parallel as per power rating with respect to voltage level.
- The insulation of the winding is void free impregnation that is made with class H polyester resin. The primary and secondary winding with core are laced safely within a vacuum protective box. Moisture Ingress Protection is high and it never gets affected by moisture.
- This type of transformer is available from 5KVA to 30MVA with insulation grade F(155 C) and H(180 C). It's with Protection up to IP56.

The main advantages of dry type transformer are given below.

1. Safety for people and property.
2. Maintenance and pollution-free solution.

	3. Easy installation. 4. Side clearance is less. 5. Environmentally friendly. 6. Excellent capacity to support overloads. 7. Reduced cost on civil installation works and fire protection systems. 8. Excellent performance in case of seismic events. 9. No fire hazard. 10. Excellent resistance to short circuit currents. 11. Long lasting due to low thermal and dielectric heating. 12. Suited for damp and contaminated areas.
e)	**How power factor and load factor contributes to technical losses in transmission and distribution system?**
Ans:	**Power factor contributes technical losses in T & D system following reason:** **(Any four point expected: 1/2 Mark each)** 1. The power factor of the system depends upon the load. 2. The quality of load may differ. Due to this if the power factor is poor for the same connected load current flowing through the line will be increase. 3. To improve the power factor the shunt capacitors, phase advancer, synchronous condenser can be used. 4. Due to this reactive power flow is controlled hence technical loss is minimized. 5. Sometime s to control the reactive power flow the static VAR compensators & flexible AC transmission system (FACTS) are to be installed. 6. Due to this power factor improvements the energy losses in the line will be less. **Load factor contributes technical losses in T & D system following reason:** **(Any four point expected: 1/2 Mark each)** 1. When load factor will be improved average demand and maximum demand will be nearly equal and hence load fluctuation will be less 2. Due to less fluctuation the load system will work at higher efficiently.

	3. Due to improved load factor there will be incentive in energy bill. 4. Due to improved load factor, reduces maximum demand. 5. The load factor will be economical to big industrial consumers because there load factor is more.
Q.4 A)	**Attempt any THREE of the following : 12 Marks**
i)	**State the objectives of tariff systems.**
Ans:	**Following are the objectives of tariff systems:** **(Any Four objective expected: 1 Mark each, Total 4 Marks)** 1. The main objective of tariff is satisfactorily recovery of total expenses and reasonable profit. 2. All expenses like interest and depreciation (I &D) i.e. recovery of cost of producing electrical energy at the generating station. 3. Interest & Depreciation on capital investment made on T&D line. 4. Recovery of cost of operation and maintenance of supply of electrical energy (Energy bill). 5. Recovery of fuel cost should be considered while calculating tariff. 6. To recover all expenses made on generation, transmission and distribution. 7. Total recovery of all taxes , duties and other charges should be considered 8. Expenses on premium (installment) paid to insurance company. 9. T&D losses also considered while calculating tariff. 10. We should also think that electricity cannot be stored economically. It has to be consumed as soon as it is generated while calculating tariff. 11. Additional supply charges (ADC) should be recovered to compensate the costly purchase energy (power) from outside to reduce the load shading. 12. We should also think about investment required for future expansion.
ii)	**List the advantages of cogeneration.**
Ans:	**Advantages of co-generation:** **(Any four point expected: 1 Mark each)** 1) Co-generation can meet both power & heat needs. 2) Less cost than conventional generation. 3) Higher system efficiency as energy wastage is highly reduced.

4) Reduction in emission of pollutants due to reduced fuel consumption.

5) A much more efficient use of primary energy can be achieved than with a separate production of electricity & heat.

6) In this system, heat generated is by-product in electricity generating process.

7) Due to decentralization of electricity supply it avoids transmission losses & makes system more flexible.

iii) List various types of tariff and explain the two part tariff structure.

Ans: Various types of Tariff:- **(Any Two types expected: 1 Mark each)**

1) Flat-demand Tariff

2) Simple-demand Tariff or Uniform Tariff

3) Flat-rate Tariff

4) Step-rate Tariff

5) Block-rate Tariff

6) Two-part Tariff

7) Maximum demand Tariff

8) Three-part Tariff

9) Power factor Tariff :- a) KVA maximum demand Tariff

b) Sliding Scale Tariff or Average P.F. Tariff

c) KW and KVAR Tariff

10) TOD (Time of Day) Tariff

i)Two part Tariff: **(2 Marks)**

- In this type of tariff energy bill is split into two parts.

ENERGY BILL= FIXED CHARGE which depends on load (KW) + RUNNING CHARGE which depends on actual energy consume (KWH)

	➢ Fixed charge which depends on load (KW) which is declared by consumer on test report. ➢ There is no separate meter is installed to measure load. ➢ Only one energy meter is used to measure number of units consumed. ➢ This type of tariff system is used for residential and commercial consumers.(up to 20 KW) ➢ This type of tariff is not used for industrial consumers. **OR** ➢ To decide these tariff the all types of fixed charges, variable charges & semi fixed charges are taken into account. ➢ The fixed charges & variable charges are similar to two part tariff but semi fixed charges are depends upon the maximum demand, the power factor of the load etc ➢ To decide the semi fixed charges, the load factor, the plant capacity factor, the power factor & diversity factor is also considered. ➢ If there are more losses to the consumer side there will be penalty to him & if there are less losses it will be incentive to him in the semi fixed charges. ➢ This tariff system is applicable for large commercial load consumers & industrial consumers.
iv)	**State how tariff is useful in reducing energy bills and energy conservations.**
Ans:	**Following application tariff is useful in reducing energy bills and energy conservations.** **(Any four point expected: 1 Mark each)** Rate of payment/ schedule of rates on which charges to be recovered from electricity consumer or Rate at which electrical energy is supplied to consumer is defined as Tariff. Following are some points from which energy bills can be reduced by proper tariff:- 1. **EC by improving Reducing Fixed /Demand charges :** ➢ By reducing unnecessary load, optimization of power consumption by equipments, proper load distribution /scheduling. 2. **EC by improving Reduced Energy charges:** ➢ Switching off unwanted load, shifting load to off-peak period, Using energy efficient lamps and apparatus. 3. **EC by improving Prompt payment of bills and taking advantages of incentive / discount**.

- (Prompt payment discount of 1% on monthly energy bill excluding taxes & duties).
- creating awareness of Self discipline among consumers for less energy consumption

4. **EC by improving Power Factor Incentive:**
   - By improving p.f. and maintaining at > 0.95, (incentive is 1% of amount of monthly bill including energy charges, ASC, FAC & fixed /demand charges but excluding taxes & duty for every 1% improvement in p.f. above 0.95)
5. **EC by improving Load Factor Incentive:**
   - load factor above 75% up to 85% will be entitled to a rebate of 0.75% on energy charges for every percentage point increase in load factor from 75% to 85%
   - Consumers having a load factor above 85% will be entitled to a rebate of 1%
   - Consumers will be entitled to a total rebate of 15% .
   - Generate load curve which helps to observe energy use trend (Monitor power consumption and max. demand)
   - Rescheduling of loads, storage of products, shedding of non-essential loads.
6. **EC by Avoiding penalty for exceeding contract demand:**
   - In case a high tension consumer exceeds his contract demand he will be billed at the appropriate demand charges for demand actually recorded and will be charged at the rate of 150% of the prevailing demand charges for the excess demand over the contract demand
   - Re calculate and estimate existing connected load and assuming proper DF, decide max. demand.
7. **EC by improving Reactive power compensation:**
   - Some utilities charge for reactive power consumption.
   - By providing capacitor bank and maintaining optimum p.f.(also reduces max. demand)

OR

1. Energy Bill is decided by following points also :
   - Load factor of the consumer
   - Maximum demand of the consumer

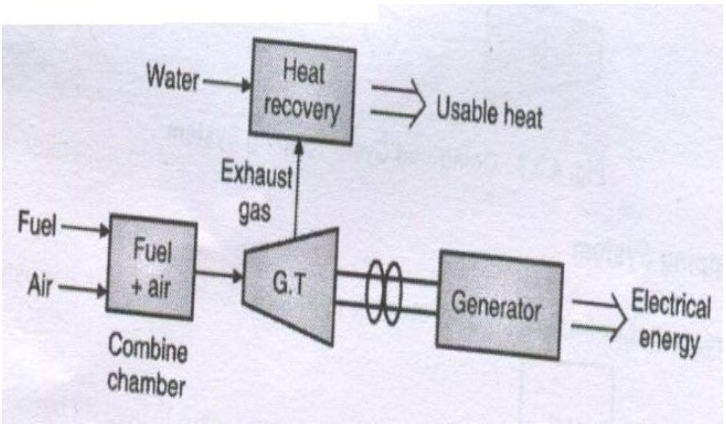
	➢ Power factor of the consumer. ➢ TOD tariff system 2. Time of use metering:- ➢ In this method the day, month & year are divided into tariff slots. ➢ Then apply higher tariff rates at peak load periods & low tariff rates at off peak load periods. ➢ Therefore automatic control on use of energy is done by customer. ➢ It is customer's responsibility to control his own use & pay accordingly. 3. Domestic use meter:- ➢ Domestic variable rate meters normally gives peak & off peak tariffs. ➢ In such installation a simple electromechanical time switch may be used. 4. Getting benefit by improving energy efficiency:- ➢ Power factor incentives can be taken by installing power factor correcting devices at Consumer level. ➢ Give discount on the monthly energy bill is available to all consumer categories if bill are ➢ Paid within seven days from issue of the bill.
Q. 4B)	**Attempt any ONE of the following : 06 Marks**
i)	**Explain contribution of following factors in increasing transmission and distribution losses :(1) Low p.f (2) Low transmission voltage (3) Transmission line voltage unbalance**
Ans:	**Contribution of following factors in increasing transmission and distribution:** **1) Low power factor : (2 Marks)** ➢ For a certain real power load low p. f leads to increase in the current in the different conducting sections. As 'I' = P/(V x p.f). ➢ This increased current leads to higher copper losses in the concerned system conductors. Hence losses increase with fall in power factor. **2) Low transmission voltage: (2 Marks)** ➢ Motoring devices supplied with lower voltage draw excess current to handle the load as 'I' = (o/p)/[η V p.f]. ➢ This excess current leads to increased copper losses in the supply lines & machine windings that lead to decrease in efficiency.

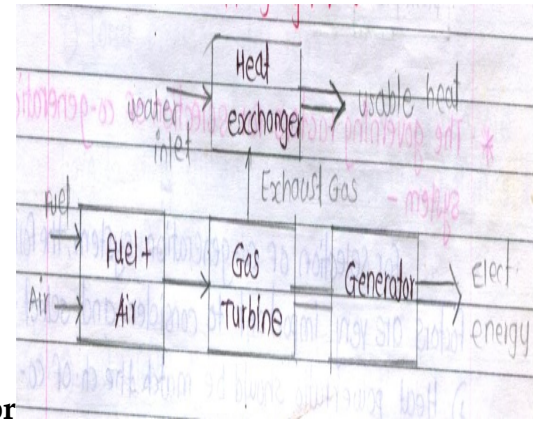
	3) Transmission line voltage imbalance: **(2 Marks)** ➢ Due to this the currents in the different phases will be unequal that will lead to higher currents in the neutral and hence increased losses especially in the motor loads. A 5% imbalance causes 40 % increase in motor losses. Also the negative phase sequence currents will be active and create extra losses.
ii)	**A consumer has M.D of 1000 KW at load factor 40%. If tariff is Rs. 100/KW of M.D. plus 20 paise/Kwh, find overall cost/ Kwh.**
Ans:	**Data Given:** M.D. = 100kW, p.f.= 0.8 Lag, L.F.= 40%= 0.4, Tariff is Rs. 100 / kVA of MD, and rate p.u. = 20 paise /kWh **i)** Units consumed / year: Max. Demand x L.F. x Hrs in years = (1000) x (0.4) x 8760 = 3504000 kWh ---------- **(2 Marks)** **ii)** Annual Bill Charges = Annual Max. Demand charges + Annual Energy charges = Rs. (100 x 1000) + (0.2) x 3504000 = Rs. 100000 + 700800 = Rs. 800800/- ---------- **(2 Marks)** **iii)** Overall cost per unit = (total bill) / (kWh for the year) = 800800/3504000 = Rs. 0.2285/kWh = 22.85 paise/ kWh ---------- **(2 Marks)**
Q.5	**Attempt any FOUR of the following :** **16 Marks**
a)	**List the commercial losses in transmission and distribution.**
Ans:	**Following are the commercial losses in Transmission and Distribution :** **(Any four commercial losses expected: 1 Mark each)** 1) Make unauthorized extension of loads. (Direct Hooking) 2) Errors in meter reading & recording (faulty meter). 3) By passing the meter. (unmetered supply & unmetered bills)

	4) Improper testing & calibration of meters. 5) Stopping the meters by remote control. 6) Changing the sequence of thermal wiring. 7) Changing the C.T. ratio. 8) Intentional burning of meters. OR 1) Power theft (Direct hooking) 2)Unmetered supply 3)Meter in accuracies 4)Meter discrepancies 5) Small unmetered loads 6) Billing issues 7)Lower collection efficiency
b)	**State the advantages of soft starters compared to DOL starters.**
Ans:	**Advantages of soft starters compared to DOL starters.** **(Any Four advantages expected: 1 Mark each)** 1) Motor starts (without jerk) smoothly. 2) Severe spikes of starting currents are eliminated. 3) Loss of energy during starting is minimized to about 40 to 50%. 4) Severe wear and tear of mechanical parts such as bearing etc. during starting is eliminated leading to longer life of bearings and other related components. 5) Very low mechanical stress. 6) As starting currents are highly inductively limiting their magnitudes results in improved power factor. 7) As current peaks are controlled the MD is reduced which may lead to lower MD billing. 8) Less mechanical maintenance. 9) Saving in operating costs. 10) Enhancement of motor starting duty by reducing the temperature rise in stator windings and supply transformer.

c)	Explain with block diagram gas turbine topping cogeneration systems.
Ans:	(Diagram: 2 Mark & Explanation: 2 Marks, Total: 4 Marks)

Block diagram gas turbine topping cogeneration systems:





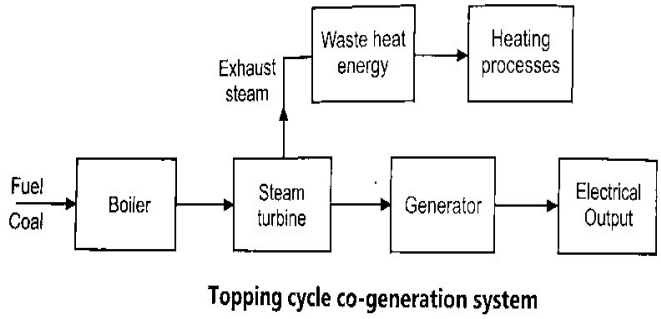
or

equivalent figure

Gas turbine cogeneration systems can produce all or a part of the energy requirement of the site. The energy released at released at height temperature in the exhaust stack be recovered for various heating cooling applications. The typical range of gas turbines varies from a fraction a MW to around 100 MW. Gas turbine cogeneration has probably experienced the most rapid development in the recent years due to the greater availability of natural gas, rapid progress in the technology, significant reduction in installation costs, & better environment performance.

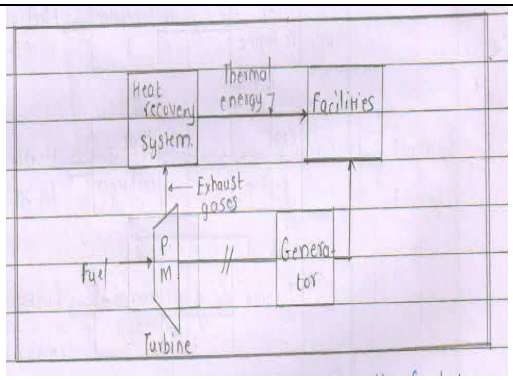
Gas turbine has a low short start up time and provides the flexibility of intermittent operation. Though it has a low heat to power conversion efficiency more heat can be recovered at higher temperatures. If the heat output is less than that required by the user it is possible to have supplementary natural gas firing by mixing additional fuel to the oxygen rich exhaust gas to boost the thermal output more efficiently . Steam generated from the exhaust gas of the gas turbine is passed through a backpressure of extraction condensing steam turbine to generate additional power. The exhaust or the extracted steam from the steam turbine provides the required thermal energy.

OR



Topping cycle co-generation system

OR



or equivalent figure

1) The system employs the natural gas fired turbine which drives a generator to produce electrical power.
2) Again the exhaust gas from turbine is passed through heat recovery boiler.
3) This exhaust energy is converted to usable heat or steam
4) In most of the systems topping cycle, co-generation is widely used, and it is the most popular method of co-generation.

d) How efficiency of electric motor is improved by p.f. controller?

Ans: **Automatic Power factor control:** **(4 Marks)**

- The pf controller is used to maintain the pf at unity across the lines it is connected.
- Maintaining the pf at unity leads to reduction in the current through the lines as real power = apparent power x pf. The apparent power decides the MD for which the consumer is billed.
- For a certain motor the current in the lines will depend on its pf which is lagging. For higher pf near unity maintained at the motor terminals the line currents are minimized leading to lower MD and hence saving in MD charges.
- Also as the current is minimized line voltage drops and power losses are reduced leading to improvement in the motor power supply system efficiency. The pf controller does not efficiency.
- By using the IPFC (Intelligent power factor controller) smooth power factor control is possible.

e) Explain KVAR controller for distribution systems.

Ans: **kVAR Controller for Distribution System:** **(4 Marks)**

The power factor controller is used to maintain the system power factor at unity using capacitor banks across the line. It is controlled through microcontroller and contactor arrangement. Power factor of load is sensed and capacitors are connected /disconnected on

	the basis of KVAR demand. Maintaining the p.f. at unity leads to reduction in the current through the lines as Real power = apparent power x pf. The apparent power decides the MD for which the consumer is billed. The supply main terminals are connected to input of kVAR controller panel. Power factor is sensed by the CT & PT. As per the requirement the capacitor banks are operated to achieve the required power factor by microprocessor based relay automatically. In the kVAR controller for distribution system reactive power control is obtained by using shunt or series capacitors and reactors. In this method reactive power compensation is possible.
f)	**Explain any four advantages of centralized control equipment for conserving energy.**
Ans:	**Advantages of centralized control equipment for conserving energy:** **(4 Marks)** **1. Centralized control from a computer, smartphone, or tablet:** Centralized system management simplifies and streamlines management work. Everything is viewable on smartphones or tablets, so the work can be done efficiently from anywhere **2. Simple maintenance because everything is connected over a minimally wired network** Maintenance is easy and low-cost. Simplify maintenance, increase work efficiency **3. Visualize energy consumption to encourage conservation** Conserve energy: visualize energy consumption in real time to fully understand and curb wasteful consumption **4.Enhance security systems and reduce costs with centralized security control:** Centralized management of security with Smart AI reduces costs. The system automatically notifies users of intruders and other risks, enhancing security and reducing personnel costs.
Q.6	**Attempt any FOUR of the following :** **16 Marks**
a)	**What is ABC analysis? State its use.**
Ans:	**Definition:-** **(2 Marks)** ➢ ABC analysis provides a mechanism for identifying different categories of activities/stocks/items that will require different management and controls. ➢ "A class inventory" contains items that account for 70% of total value. ➢ "B class inventory" contains items that account for 20% of total value.

	➢ "C class inventory" contains items that account for 10% of total value. ➢ ABC analysis is the material management technique which helps energy audit process to achieve the goal of energy audit. **Use of ABC Analysis:** **(2 Marks)** An energy audit is an inspection survey and an analysis of energy flows for energy conservation in a building. It may include a process or system to reduce the amount of energy input into the system without negatively affecting the output. In commercial and industrial real estate,
b)	**State any four advantages of energy audit.**
Ans:	**Advantages of Energy Audit:** **(Any Four Point expected: 1 Mark each)** 1. It helps reduce energy costs in your facility. 2. With a reduction in production costs, the competitiveness of your company will be improved. 3. It helps reduce the dependence on foreign energy sources. 4. It helps reduce environmental damage and pollution. 5. It can increase the security of your energy supply. 6. It can reduce the consumption of natural resources. 7. It can reduce damage to the environment associated with the exploitation of resources. 8. It helps reduce the impact of greenhouse gas emissions. 9. It helps you to lower energy bills. 10. It enables you to increase the comfort of those in the facility. 11. It helps you to increase the life span of the equipment in your facility. 12. It discovers any unaccounted consumption that may exist at the facility.
c)	**Compare steam and gas types of generation.**
Ans:	**Steam generation:** **(2 Marks)** **In this steam turbine** rotate in the currents caused by the hot water vapour. They form part of a closed water cycle in which water condenses and is then heated until it evaporates again. Steam turbines therefore do not come into contact with the fuel deployed and work at temperatures between 500 and 650 °C. Several steam turbines are often arranged in a row so that configured for high, medium and low pressure they are able to optimally convert the respective steam pressure into rotational movement.

	Gas generation : **(2 Marks)** **In this gas turbine** rotate directly in the hot combustion gases. With temperatures up to 1500 °C, these gases are much hotter than those in steam turbines. For this reason the blades are cooled with air that flows out of small openings and creates a "protective film" between the exhaust gases and the blades. Without cooling, the blade material would quickly wear out.
d)	**State at least eight industries suitable for cogeneration.**
Ans:	**Industries suitable for co-generation of energy: (Any Valid industries may please be considered)** **(Any Eight industries expected: 1/2 each, Total: 4 Marks)** 1. Sugar mills 2. Rice mills 3. Petrochemical Industry 4. Distilleries 5. Cement Industry 6. Pulp and paper industry 7. Aluminium Industry 8. National parks 9. Wineries 10. Waste treatment plants
e)	**"Measurements are an essential part of energy audit". Justify the statement.**
Ans:	**Justification & Statement:** **(4 Marks)** Measurements of electrical parameters, Mechanical Parameters and thermal parameters is essential because from measurements we know the exact/ present values of various parameters and then they are compared with the standard or specified values, if measured value are different than the standard or specified values then necessary action will be taken accordingly therefore measurement is essential without measurement we cannot compare the values of parameters. After measurering the electrical parameters better feedback control is possible for better energy conservation.

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