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RV COLLEGE OF ENGINEERING®

(An Autonomous Institution affiliated to VTU)

I/II Semester B. E. Supplementary Examinations May-2024

Common to all Branches

ELEMENTS OF ELECTRICAL ENGINEERING

Time: 03 Hours *Maximum Marks: 100*

Instructions to candidates:

1. Answer all questions from Part A. Part A questions should be answered in first three pages of the answer book only.
2. Answer FIVE full questions from Part B. Question number 2 is compulsory. Choose any one full question from 3 or 4, 5 or 6, 7 or 8 and 9 or 10.

PART-A

			M	BT	CO
1	1.1	Define renewable and non-renewable energy sources.	02	1	3
	1.2	What is synchronous generator? What is the principle of operation of synchronous generator?	02	1	1
	1.3	List the raw material required for power generation in case of hydel, thermal, nuclear and *PV* power plants.	02	1	1
	1.4	What do you mean by lagging power factor and leading power factor?	02	1	2
	1.5	List any four advantages of three phase system.	02	1	2
	1.6	What do you mean by 1*unit* of electricity?	02	1	2
	1.7	What is the difference between fuse and *MCB*?	02	1	1
	1.8	What is the difference between transformer and auto transformer?	02	1	3
	1.9	Define slip of induction motor.	02	1	1
	1.10	Why DC series motor should never be started without any load on it?	02	2	3

PART-B

2	a	With neat sketch, explain the operation of Hydel power plant.	06	1	1
	b	Explain $I-V$ and $P-V$ characteristics of a PV cell.	06	1	4
	c	What is a Battery? Why batteries are connected in: i) Series, ii) Parallel	04	2	2
3	a	With circuit and phasor representation obtain current, voltage and power relations in a series *RL* crcuit.	06	2	2
	b	Define the following terms: i) Real power ii) Reactive power iii) Apparent power, and iv) Power factor	04	1	2
	c	A delta connected load consists of a resistance of 10Ω and a capacitance of $100\mu F$ in each phase. A supply of $410V$ at $50Hz$ is applied to the loads. Find the line current, power factor and power consumed by the loads.	06	1	2

OR

4	a	Derive the relation between phase and line voltages and current in a star connected system.	06	4	2
	b	With phasor representation show that Two wattmeters are sufficient to measure the power in a three phase system.	06	2	2
	c	Find an expression for the current and calculate the power, when a voltage of $e = 283\sin(100\pi t)$ is applied to a coil having $R = 50\Omega$ and $L - 0.159\,H$.	04	1	2
5	a	What are the different types of Electric wiring schemes? Explain with diagram any two types.	06	1	1
	b	Discuss the power ratings of different household appliances.	04	2	1
	c	List the merits and demerits of fuse, *MCB* and *ELCB*.	06	1	1
		OR			
6	a	What is earthing? Why earthing is required? Explain anyone type of earthing.	06	1	1
	b	With block diagram, explain the working of Uninterrupted power supply.	04	1	2
	c	Estimate Total Daily Energy Requirement for the following loads:			

Name of the appliance	*Power Rating (W)*	*Avg. Daily Usage Hrs*	*No. of Appliances*
CFL	12	6	4
Fan	50	8	2
TV (21")	150	2	1
Computer	250	3	1
Water heater	1000	2	1

		Take electricity cost to be *Rs.* 5 per unit.	06	2	2
7	a	What is a transformer? From basics, derive *EMF* equation of transformer.	06	1	3
	b	Discuss about the losses that occur in a transformer. Hence write efficiency equation of the transformer.	04	2	3
	c	A $250kVA$, single phase transformer has an efficiency of 96% on full load $0.8pF$ lagging and at half $0.85pF$ lagging. Find the iron loss and full load copper loss.	06	1	3
		OR			
8	a	Explain how rotating magnetic field is generated in a $3-phase$ induction motor.	06	1	3
	b	Discuss about the different types of rotors used in a three phase induction motor.	04	2	3
	c	A 4 pole $50Hz$, induction motor has a slip of 1% at no load. When operated at full load, the slip is 2.5%. Find the change in speed from no load to full load.	06	2	3
9	a	With a cross sectional view, explain the construction and operation of a *DC* motor.	06	1	3
	b	Draw and explain torque v/s current and speed v/s current characteristics of *DC* shunt motor.	04	1	3

	c	A 4 *pole* 220*V* lap connected *DC* shunt motor has 36 *slots*, each slot containing 16 conductors. It draws a current 40 *amps* from the supply. The field resistance and armature resistance are 110Ω and 0.1Ω respectively. The motor develops an output power of 6*kW*. The flux per pole is 40*mWb*. Calculate the: i) Speed ii) The torque developed by the armature, and iii) The shaft torque.	06	2	3
		OR			
10	a	What is the significance of back *EMF* in a *DC* motor?	04	1	3
	b	Derive an equation for the torque developed in the armature of a *DC* motor.	06	4	3
	c	Explain the construction and working principle of stepper motor.	06	1	3

[redacted] and Solution

Jan-2022
UG

Course: Elements of Electrical engineering

1.1) Renewable energy sources: energy that gets replenish itself at the rate it is used

Non Renewable energy sources: That is not replenished with the speed at which it is consumed.

1.2) Synchronous generator: generates AC voltage. Here field is rotating & armature is stationary. When rotor rotates the stator cuts the flux & hence emf is induced.

1.3) hydel - water, thermal - coal, Nuclear - uranium
PV - sun rays.

1.4) Lagging Pf = current lags voltage
Leading Pf = current leads voltage

1.5) Adv of 3φ ⇒ more efficient, less cost & size than single phase for a given power, requires less material to transfer power, 3φ motors are self starting etc

1.6) 1 KWHr.

1.7) Fuse = burns out & need to be replaced when over current flows.
MCB = trips & No need to replace.

1.8) transformer = 2 winding
Autotransformer = 1 winding

1.9) % Slip = $\frac{N_s - N}{N_s} \times 100$

1.10) 

at no load Ia is very small & ~~hence~~ speed will be dangerously high. $N \propto \frac{1}{I_a}$

2a) Hydel power plant
Simple sketch — 3
& operation — 3
— 6

2b) IV PV characterising of PV cell.

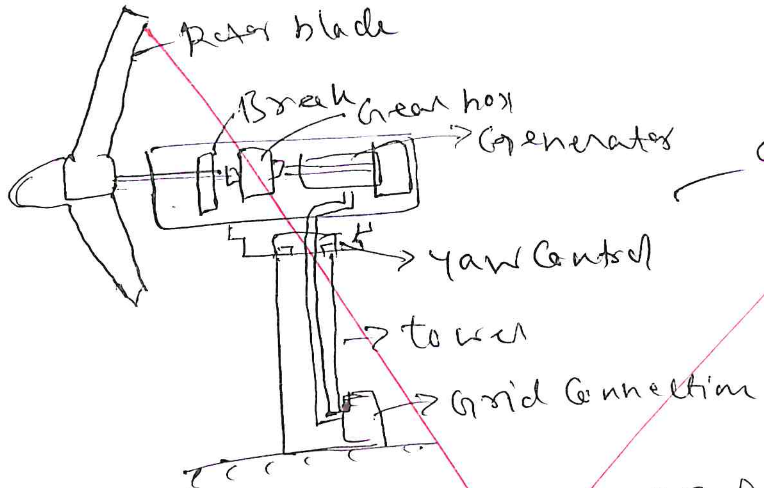
explanation-2 — 6

2 c) Battery ⇒ A device that converts chemical energy into electrical energy by means of an electro chemical oxidation reduction reaction. — 2

Series connection is done to increase voltage rating — 1

Parallel — " — " — current — 1 — 4

3 a)



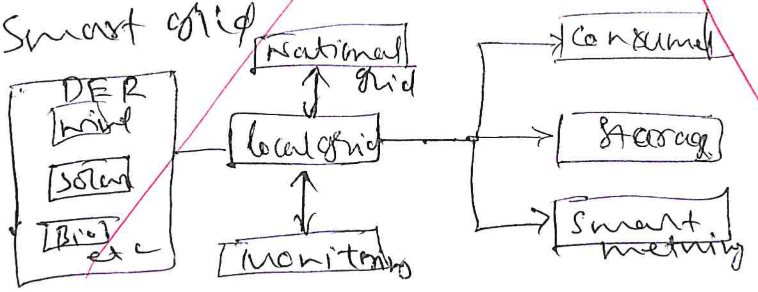
dia - 3
explanation - 3 — 6

3 b) Advantages & disadvantages of Solar Plant

Renewable	not continuous
pollution free	Need more space
free of cost	High initial cost
reach remote places	Needs battery for storage

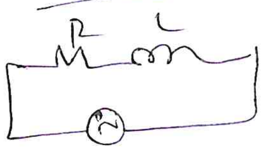
4 adv - 2
4 disadv - 2 — 4

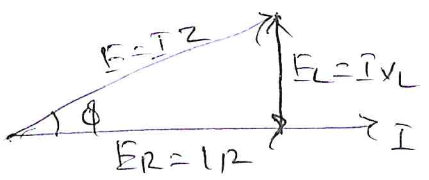
3 c) Smart grid



Block diagram - 3
explanation - 3 — 6

3 4 a) RL circuit

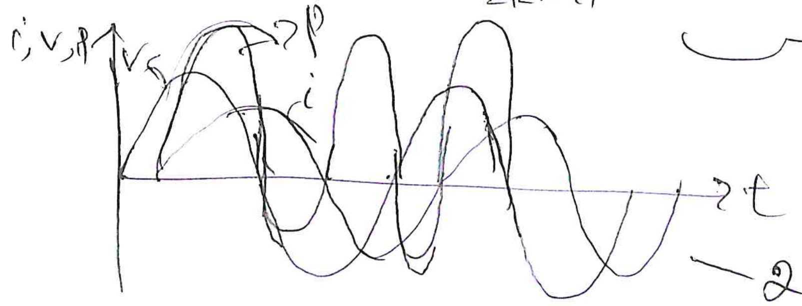




$Z = \sqrt{R^2 + X_L^2}$ $\quad i = I_m \sin(\omega t - \phi)$

$\phi = \tan^{-1} \frac{X_L}{R}$

$P = \frac{1}{2} E_m I_m \cos\phi = EI \cos\phi$ — 2

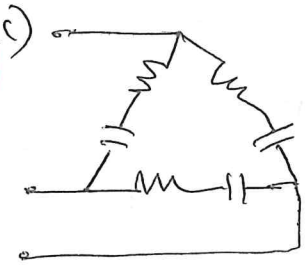


— 2

explanation - 2 — 6

4b) defining $1\angle\phi$ — (4)

4c) 3



$X_C = \frac{1}{2\pi fc} = 31.85\Omega$ — (1)

$Z_{ph} = \sqrt{10^2 + 31.85^2} = 33.38\Omega$

$V_{ph} = V_L = 410V$ (1)

$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{410}{33.38} = 12.28A$ (1)

$I_L = \sqrt{3} I_{ph} = 21.27A$ — (1)

$pf = \frac{R}{Z} = \frac{10}{33.38} = 0.3$ leading

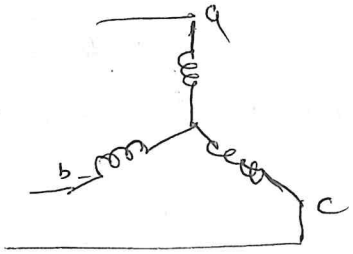
$P = \sqrt{3} V_L I_L \cos\phi = 4531.41 W$ — (1)

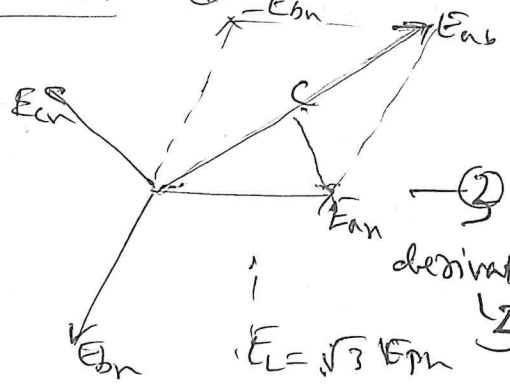
(1) (6)

5a) 4a) Balanced system

$V_L = \sqrt{3} V_{ph}$

$I_L = I_{ph}$





(2)

derivation — 6

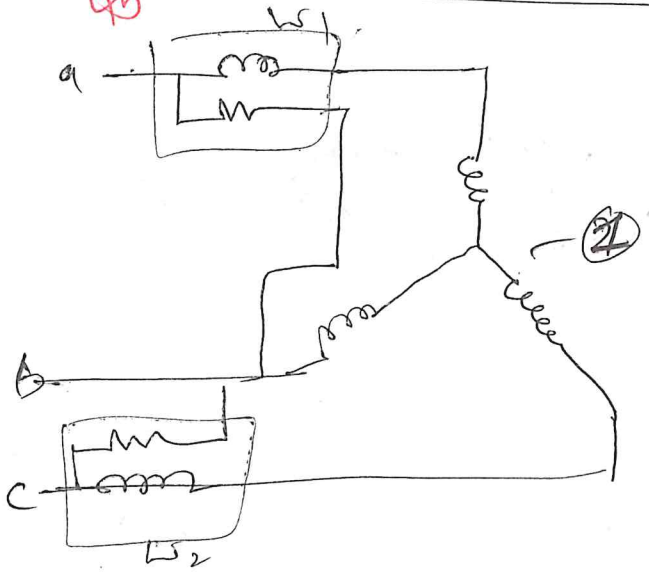
3

$E_L = \sqrt{3} E_{ph}$

$P = 3 \times E_{ph} I_{ph} \times \cos\phi = 3 \times \frac{E_L}{\sqrt{3}} \times I_L \times \cos\phi$

$= \sqrt{3} E_L I_L \cos\phi$

5b) 4b) Two wattmeter method



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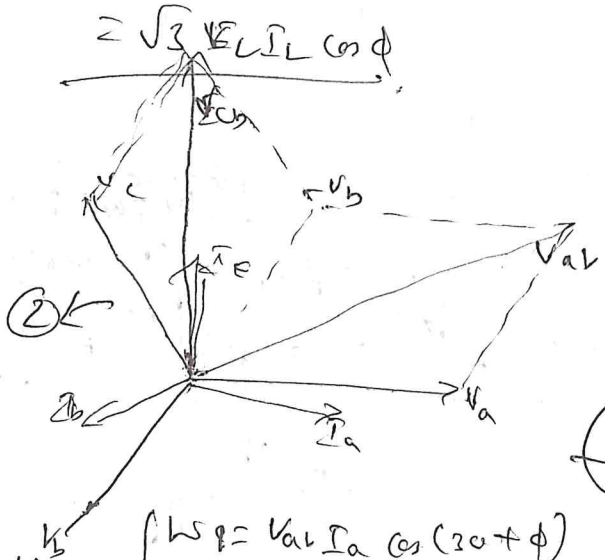


(2) (6)

derivation

$W_1 = V_{ab} I_a \cos(30+\phi)$

$W_2 = V_{cb} I_c \cos(30-\phi)$

(1) $W_1 + W_2 = \sqrt{3} V_L I_L \cos\phi$

$\cos\phi = \cos\left[\tan^{-1}\left(\frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2}\right)\right]$

5c) 4c) $X_L = WL = 100\pi \times 0.159 = 49.93\Omega$

$Z = \sqrt{R^2 + X_L^2} = \sqrt{50^2 + 49.93^2} = 70.71\Omega$ — 1

$\phi = \tan^{-1}\frac{X_L}{R} = 45^\circ$ lag

$I_m = \frac{E_m}{Z} = \frac{283}{70.71} = 4A$ — 1 — (4)

$\therefore i = I_m \sin(\omega t - \phi) = 4\sin(100\pi t - 45^\circ) A$ — 1

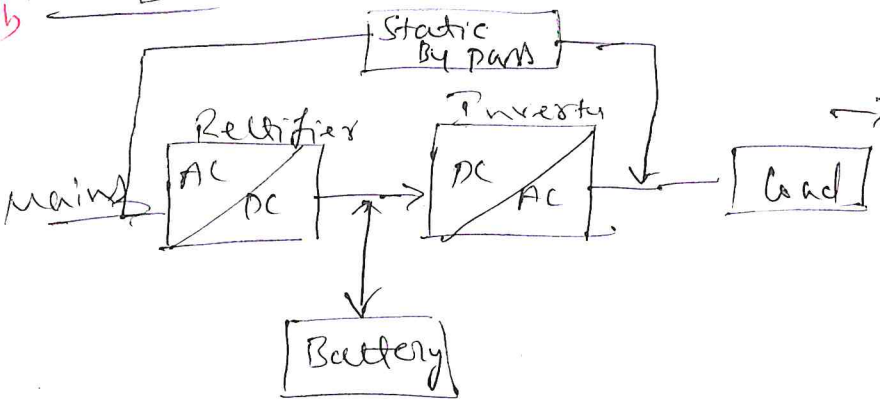
6a) 5a Wiring — cleat wiring
casing & piping
TRS wiring
metal sheathed wiring
Metal conduit wiring
→ (2) explaining any two – 2x2 (4) — (6)

6b) 5b power rating of home appliances — any four — (4)

6c) 5c merits & demerits of fuse, MCB, ELCB — 2 for each — (6)

7a) 6a earthing : (1) process of connecting the body of the electrical equipment to the general mass of earth by a wire of negligible resistance is earthing. Earthing brings the body of the equipment to zero potential & avoid shock. (1)
types → Pipe earthing
Plate earthing
fig + explination of any one type (4) — (6)

7b) 6b UPS



→ (2) + explination (2) — (4)

7c) 6c energy requirement problem. Pg. 22.69 — (6)

8a) 7a transformer = device that transfers electrical power from one electrical circuit to the other without changing frequency. (1)

emf eqn $E_1 = 4.44 f \phi_m N_1$
$E_2 = 4.44 f \phi_m N_2$
derivation of eqn-5 — (6)

8b) ~~7b~~ Losses = Iron loss + Copper loss.

Iron loss → eddy current loss + hysteresis loss — (1)

Copper loss → Copper loss in primary, Copper loss in secondary — (1)

$$\eta = \frac{P_{IP} - \text{losses}}{P_{IP}} = \frac{VI\cos\phi - I^2R - W}{VI\cos\phi} \quad — (2)$$

— (4)

8c) ~~7c~~

O/P at 90% FL & 0.8 pf ⇒ $10 \times 0.9 \times 0.8 = 7.2\,kW$ — (1)

P I/P at 90% FL = $\frac{O/P}{\eta} = \frac{7.2}{0.98} = 7.347\,kW$ — (1)

∴ Total losses = P I/P − O/P = 0.147 kW — (1)

When η is max $W_i = W_{cu} = \frac{0.147}{2} = 0.0735\,kW$ — (1)

W_{cu} at 90% FL = 0.0735 kW

∴ W_{cu} at FL $= \left(\frac{1}{0.9}\right)^2 \times 0.0735 = 0.0907\,kW$ — (1)

∴ η at FL, 0.6 pf is

$$\eta_{FL} = \frac{10 \times 0.6}{10 \times 0.6 + 0.0735 + 0.0907} = 97.34\%$$ — (1)

$W_i = 2777.8W$

$W_{cu} = 5555.5W$

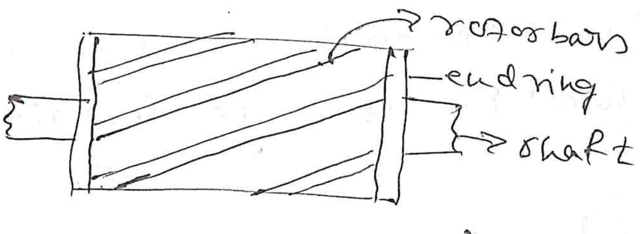
— (6)

9a) ~~8a~~ rotating magnetic field generation phasor dia — (4)

explanation (2) — (6)

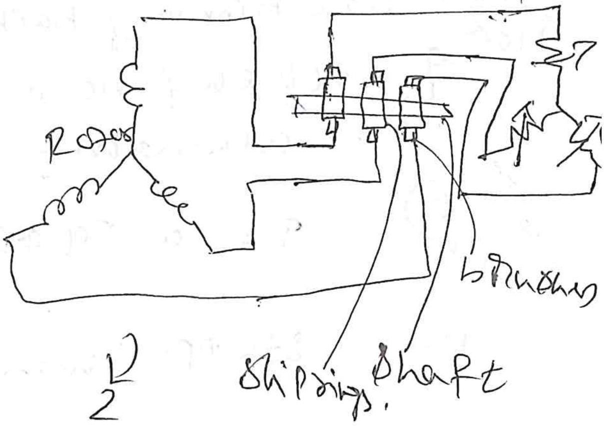
9b) ~~8b~~ rotors of 3 φ IM

squirrel cage rotor



2

Phase wound rotor



2

— (4)

~~9c~~ 8c On No load

$N_s = \frac{120f}{P} = \frac{120\times50}{4} = 1500$ rpm — (1)

$S = \frac{N_s - N}{N_s} = \frac{1500 - N_0}{1500} = 0.01$ — (1)

$\therefore N_0$ = No load speed = 1485 rpm — (1)

On full load

$S = \frac{N_s - N}{N_s} = 0.025 = \frac{1500 - N}{1500}$ — 6

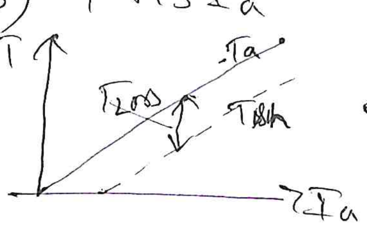
$\therefore N = 1462.5$ rpm — (1)

$\therefore$ Change in speed = 1485 − 1462.5 = 22.5 rpm — (2)

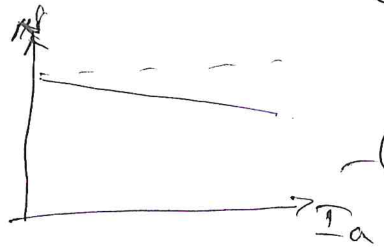
~~10a)~~ 9a Cross sectional view of DC Motor — fig – (3) — 6

explination (3)

~~10b)~~ 9b T V/S I_a

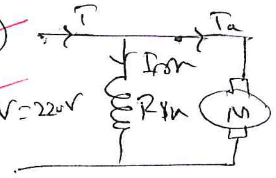


— (2)



— (2) — (4)

~~10c)~~ 9c



$I_{sh} = \frac{V}{R_{sh}} = \frac{220}{110} = 2A$ (1) ; $I_a = I_L - I_{sh} = 40 - 2 = 38A$ (1)

$E_b = V - I_aR_a = 220 - 38\times0.1 = 216.2V$ — (1)

$E_b = \frac{\phi Z N P}{60 A} \Rightarrow 216.2 = \frac{40\times10^{-3}\times 36\times16\times N\times4}{60\times4}$

$N \Rightarrow 563$ rpm — (1)

$T_a = \frac{E_b I_a}{2\pi \frac{N}{60}} = \frac{216.2\times38}{2\times3.14\times\frac{563}{60}} = 139.42$ Nm — (1) — (6)

$T_{sh} = \frac{6\times1000}{2\times3.14\times\frac{563}{60}} = 101.82$ Nm — (1)

~~11a)~~ 10a Significance of back emf in DC Motor :- In the absence of back emf no mechanical power can be developed by the armature — (4)

~~11b)~~ 10b $T = 0.159\,\phi\,Z\,I_a\left(\frac{P}{A}\right)$ N-m — derivation with basic — (6)

~~11c)~~ 10c Stepper motor construction. — dia – (3) — (6)

explination – (3)

~~[illegible]~~