

1058703

ENGINEERING SERVICES  
EXAMINATION-2016

A-HUF-P-GEB

# ELECTRICAL ENGINEERING

## Paper II

### (Conventional)

*Time Allowed : Three Hours*

*Maximum Marks : 200*

### INSTRUCTIONS

*Please read each of the following instructions carefully before attempting the questions :*

*There are SEVEN questions in the paper.*

*Candidates are required to attempt FIVE questions in all.*

*Question no. 1 is compulsory.*

*Out of the remaining SIX questions, attempt any FOUR questions.*

*The number of marks carried by a question/part is indicated against it.*

*Unless otherwise mentioned, symbols and notations have their usual standard meanings.*

*Assume suitable data, if necessary and indicate the same clearly.*

*Neat sketches are to be drawn to illustrate answers, wherever required.*

*All parts and sub-parts of a question are to be attempted together in the answer book.*

*Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly.*

*Answers must be written in ENGLISH only.*

*Any page or portion of the page left blank in the answer book must be clearly struck off.*

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1. (a) A single-phase transformer has primary and secondary windings on each limb of the core. The cross-section of the magnetic core is  $12 \text{ cm}^2$  and the length of the magnetic path is 50 cm. The core has a relative permeability of 20000. The primary and secondary windings have 500 and 1000 turns, respectively.

(i) If the primary winding is supplied with a current of 10 A, while the secondary winding is open-circuited, calculate the self-inductance  $L_{11}$  of the primary winding and the mutual inductance  $L_{12}$  between the two coils.

(ii) If the primary winding is de-energized, while the secondary winding is connected to a source from which it draws 8 A, calculate the self-inductance  $L_{22}$  of the secondary winding and the mutual inductance  $L_{21}$  between the two coils. 4

(b) Draw the V-curve of a salient pole synchronous motor operating at no-load. What do you mean by normal excitation ? Explain physically why the motor operates at leading power factor under over-excitation. 4

- (c) A dc shunt generator is developing rated terminal voltage at some speed. Answer the following with a brief explanation.

Will the generator build-up, if

- (i) the direction of rotation is reversed ?
- (ii) in addition to the reversal of direction, the residual magnetism is also reversed ?
- (iii) only the field winding terminals of the original machine are interchanged ?
- (iv) only the residual magnetism of the original machine is reversed ?
- (v) both the direction of rotation and field winding connections of the original machine are reversed ?

4

- (d) A 3-phase, 4-pole slip ring induction machine is connected to a 3-phase, 50 Hz supply. If the rotor terminals are shorted, the machine runs in clockwise direction seen from one end. Now the rotor terminals are opened and the machine is made to run with the help of a prime mover. What will be the frequency of the voltage across the slip rings, if

- (i) the machine is not running ?
- (ii) the machine is rotating at a speed of 1500 rpm in clockwise direction ?

(iii) the machine is rotating at a speed of 1450 rpm in anticlockwise direction ?

(iv) the machine is rotating at a speed of 1550 rpm in clockwise direction ?

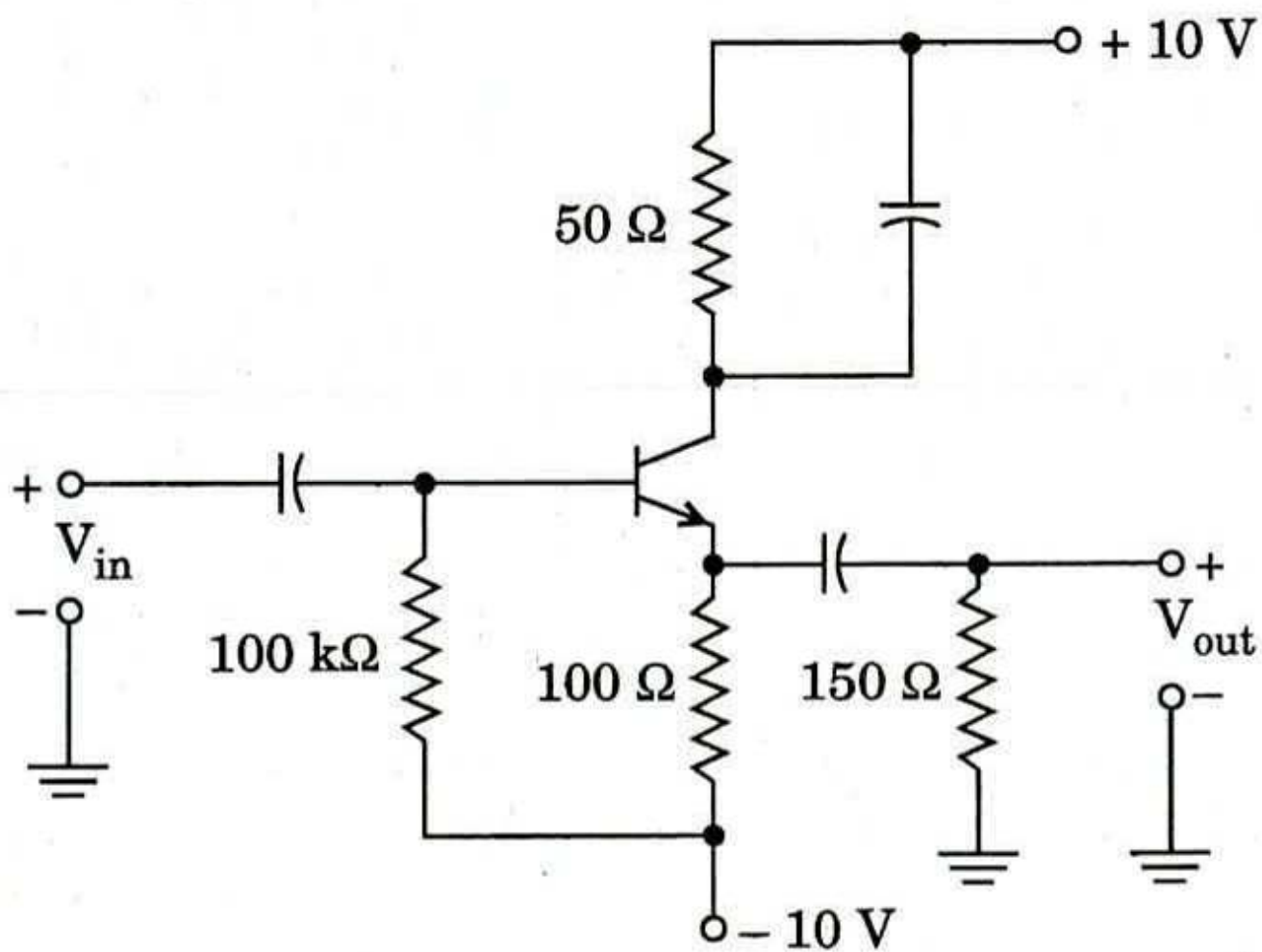
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(e) What are the internal registers of 8259 ? Explain each one of them.

4

(f) Find the Q-point and the maximum symmetrical  $V_{out}$  for the transistor amplifier shown in the following figure. Show both dc and ac load lines. Assume standard design rules.

4



(g) What is the difference between PM and FM ? Explain how FM can be generated using PM.

4

(h) A single-phase fully controlled converter feeding power to R-L load is triggered at a firing angle of  $120^\circ$ . Draw output voltage, output current and input source current waveforms. Explain the flow of power in the circuit.

4

(i) A 240 V series motor takes 40 A when giving its rated output at 1500 rpm. Its resistance is  $0.3 \Omega$ . Find what resistance must be added to obtain rated torque at (a) starting, and (b) at 1000 rpm.

4

(j) On a short circuit test, a 12-pole, 3-phase, 50 Hz induction motor with an equivalent standstill rotor resistance equal to the stator resistance took 250 A, and 100 kW. Find the starting torque developed.

4

2. (a) A single-phase, 25 kVA, 2300/230 V, 50 Hz distribution transformer has the following characteristics :

Core loss at full voltage = 250 W

Copper loss at half load = 300 W

- (i) Determine the efficiency of the transformer when it delivers rated load current at 0.866 power factor lagging.
- (ii) The transformer has the following (24-h) load cycle :

$\frac{1}{4}$  full load for 4 hours at 0.8 power factor

$\frac{1}{2}$  full load for 10 hours at 0.8 power factor

$\frac{3}{4}$  full load for 6 hours at 0.8 power factor

Full load for 4 hours at 0.9 power factor

Find the all-day efficiency.

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- (b) An 8085A system is configured using 74LS373 data latch, two 2732 EPROM, two 6116 RAM and two 8255 PPI. The relevant control pins of these chips are given below :

2732 A EPROM (4k×8) :  $\overline{\text{OE}}$ ,  $\overline{\text{CE}}$

6116 RAM (2k×8) :  $\overline{\text{OE}}$ ,  $\overline{\text{WE}}$ ,  $\overline{\text{CE}}$

8255A PPI :  $\overline{\text{RD}}$ ,  $\overline{\text{WR}}$ ,  $\overline{\text{CE}}$ , A1, A0, RESET

The peripheral devices are interfaced with the processor using memory mapped I/O. Draw a neat connection diagram for interfacing these chips to the system bus including Power-ON RESET circuit. Use 74LS138 for decoding. Give the addresses of all memory chips and peripheral devices.

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- (c) A three-phase, 50 Hz, completely transposed transmission line has the following constants :

Resistance per mile per phase =  $0.25 \Omega$

Inductance per mile per phase =  $2.0 \text{ mH}$

Capacitance per mile per phase =  $0.014 \mu\text{F}$

The transmission line is 60 miles long, and line-to-line voltage at the receiving end is 132 kV. The load connected at the receiving end is 70000 kW at 0.8 power factor lagging. Using T-model of the line,

- (i) Determine the current and the line-to-line voltage at the sending end.
- (ii) Find the voltage regulation.
- (iii) Calculate the real and reactive power at the sending end.
- (iv) Find the efficiency of the transmission line.

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- (d) The antenna current of an AM transmitter is 8 A when only the carrier is sent, but it increases to 8.93 A when the carrier is modulated by a single sine wave. Find the percentage modulation. Determine the antenna current when the depth of modulation changes to 0.8. Derive the expressions used.

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3. (a) A 25 kVA, 230 V, three-phase four-pole, 50 Hz, wye-connected synchronous generator has a synchronous reactance of 1.5  $\Omega$ /phase and negligible stator resistance. The generator is connected to an infinite bus of 230 V, 50 Hz.

- (i) Determine the excitation voltage when the machine is delivering rated kVA at 0.8 power factor lagging.
- (ii) The field excitation is increased by 20% without changing the prime mover power output. Find the armature current, power factor and reactive power supplied by the machine.
- (iii) With the field excitation current as in part (i), the input power from the prime mover is increased very slowly. What is the steady state limit? Determine the stator current, power factor and reactive power.

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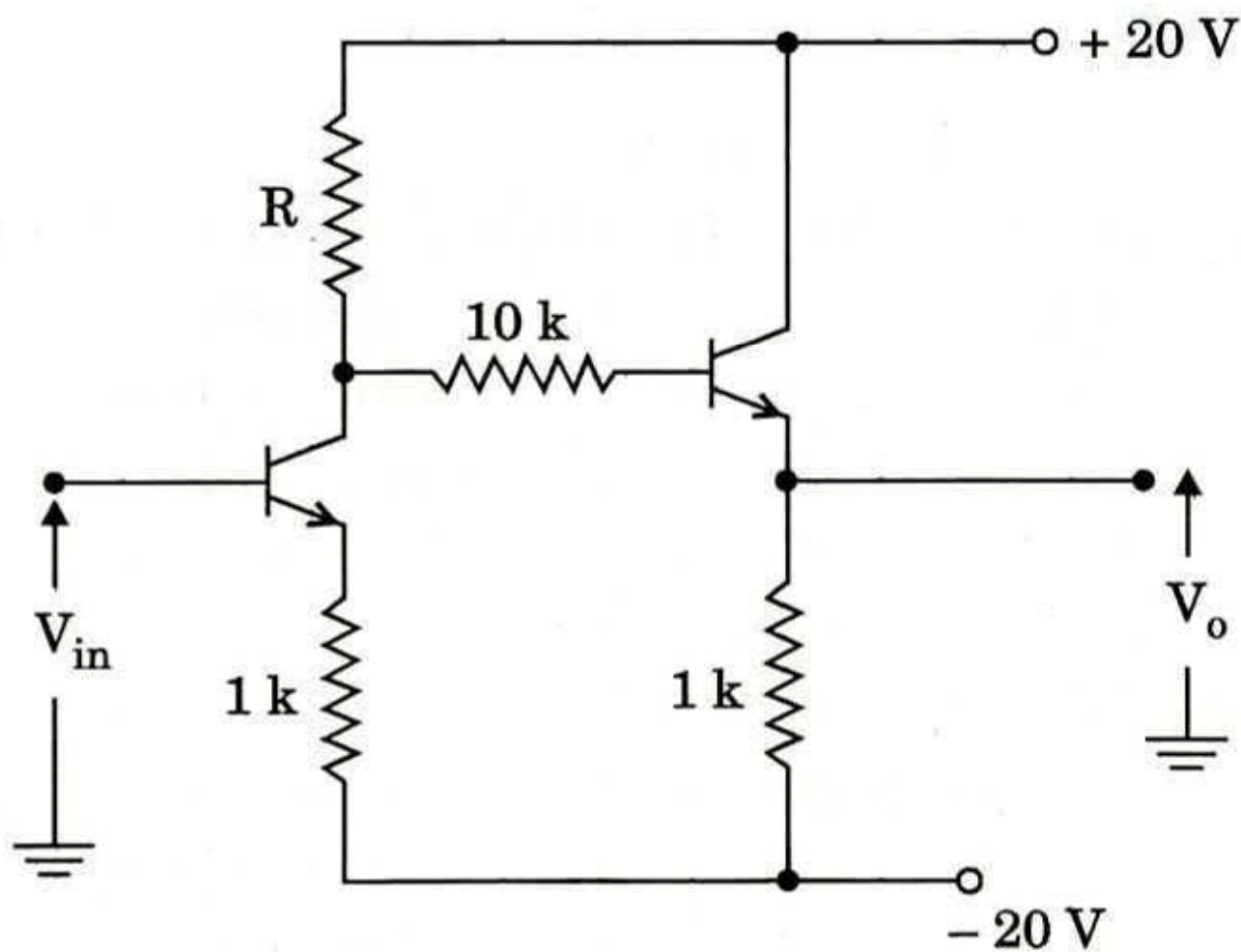


- (b) Discuss the unipolar control of a single-phase sinusoidal PWM inverter. Explain the effect of modulation index and carrier frequency on inverter performance.

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- (c) Find  $R$  such that at dc,  $V_{out} = 0$  for the circuit shown in the following figure. Also find  $I_{CQ1}$  and  $I_{CQ2}$ . Assume that  $V_{BE} = 0.7 \text{ V}$  and  $\beta = 100$  for both transistors.

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4. (a) A three-phase, 25 hp, 230 V, 50 Hz, induction motor draws 60 A from the source at 0.866 lagging power factor. The motor losses include the following :

$$\text{Stator copper loss } P_{\text{cus}} = 850 \text{ W}$$

$$\text{Magnetic core loss } P_{\text{core}} = 450 \text{ W}$$

$$\text{Rotor copper loss } P_{\text{cur}} = 1050 \text{ W}$$

$$\text{Rotational loss } P_{\text{rot}} = 500 \text{ W}$$

Determine the following :

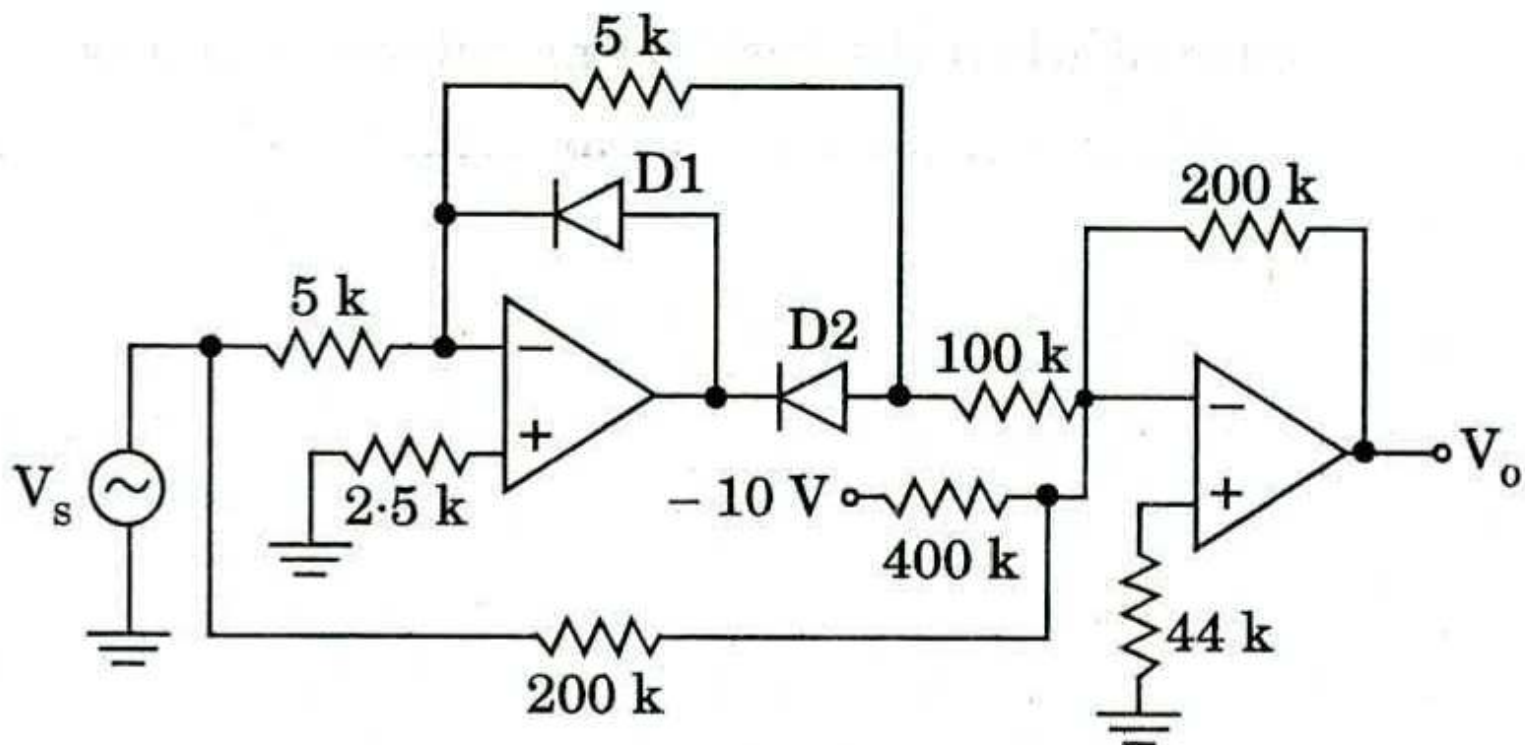
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- (i) Air-gap power  $P_{\text{ag}}$
- (ii) Slip  $s$
- (iii) Mechanical power developed
- (iv) Output power
- (v) Efficiency of the motor

- (b) A 3-phase transmission line, operating at 33 kV and having a resistance and reactance of  $6 \Omega$  and  $21 \Omega$  respectively, is connected to the generating station bus-bars through a 3000 kVA step-up transformer which has a reactance of 5%. Three alternators are connected to the bus-bar; two alternators are of 10000 kVA with a reactance of 15% and the third alternator is of 5000 kVA with a reactance of 10%. Calculate the kVA at the short-circuit fault between the phases occurring (i) at the high voltage terminals of the transformer, and (ii) at the load end of the transmission line.

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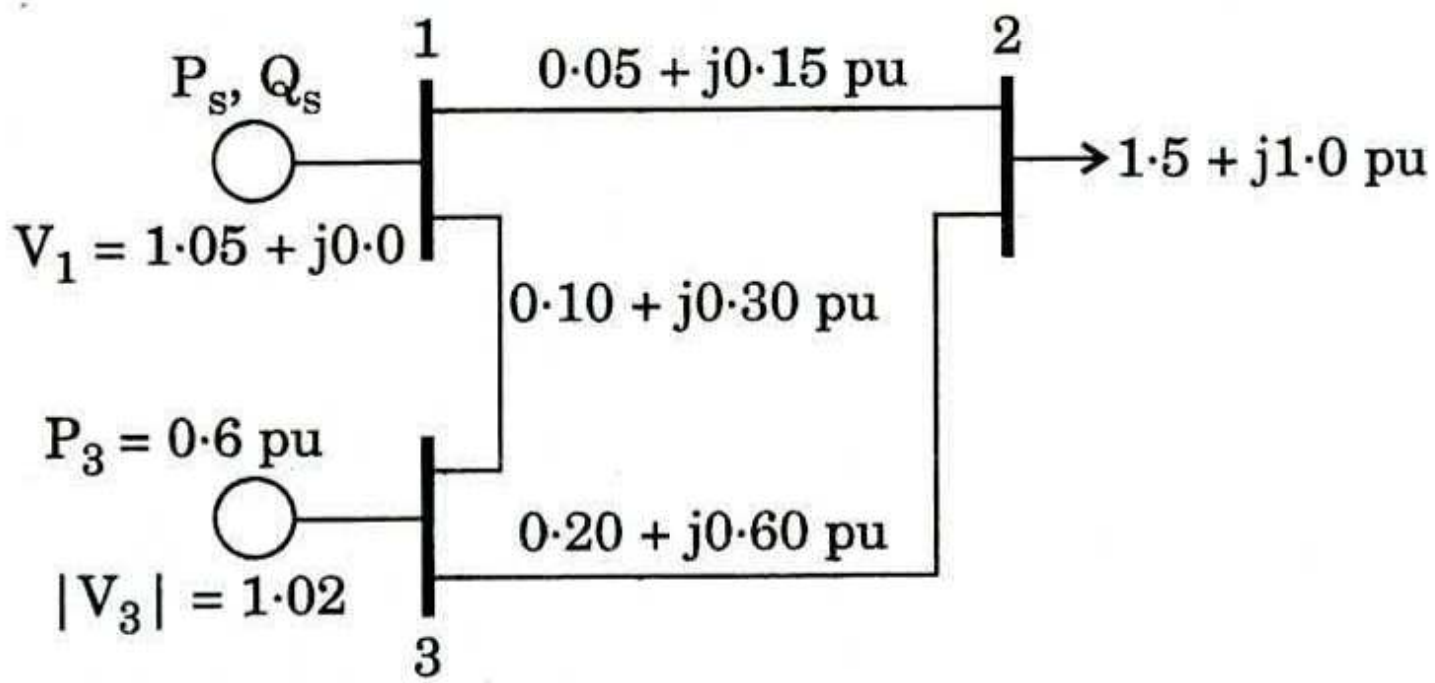
- (c) Draw the transfer characteristic  $\frac{V_o}{V_{in}}$  of the OP-AMP circuit shown in the following figure. 10



- (d) A single-phase uncontrolled diode bridge rectifier is used to charge a battery of  $V_B$  volts. A small inductance  $L$  is connected in series with the battery to limit the charging current. The source voltage is  $V_s$  of frequency  $\omega$ . Draw the output voltage, load current and inductor voltage waveforms. Derive the expression for charging current. 10

5. (a) For the power system shown in the following figure, the bus admittance matrix  $Y_{\text{bus}}$  is given by

$$Y_{\text{bus}} = \begin{bmatrix} 3.0 - j9.0 & -2.0 + j6.0 & -1.0 + j3.0 \\ -2.0 + j6.0 & 2.5 - j7.5 & -0.5 + j1.5 \\ -1.0 + j3.0 & -0.5 + j1.5 & 1.5 - j4.5 \end{bmatrix}$$



The per-unit bus voltages and power injections are also given in the figure.

- (i) For each bus  $k$ , specify the bus type, and determine which of the variables  $V_k$ ,  $\delta_k$ ,  $P_k$ , and  $Q_k$  are input data and which are unknown.
- (ii) Assume an initial estimate of  $V_2 = 1.0 \angle 0^\circ$ , and  $\delta_3 = 0^\circ$ , and calculate the bus real and reactive power mismatches to be used in the first iteration of the Newton-Raphson power flow method.
- (iii) Set up the linearized system of equations that are solved at each iteration.

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(b) Show that a full adder can be constructed with two half adder circuits and a logic gate. 10

(c) A 500 MVA, 20 kV, 50 Hz, four-pole synchronous generator is connected to an infinite bus through a purely inductive network. The generator has an inertia constant  $H = 6.0$  M/MVA and is delivering power of 1.0 pu to the infinite bus at steady state. The maximum power that can be delivered is 2.5 pu. A fault occurs that reduces the generator output power to zero.

(i) Find the angular acceleration.

(ii) Find the speed in rpm at the end of 15 cycles.

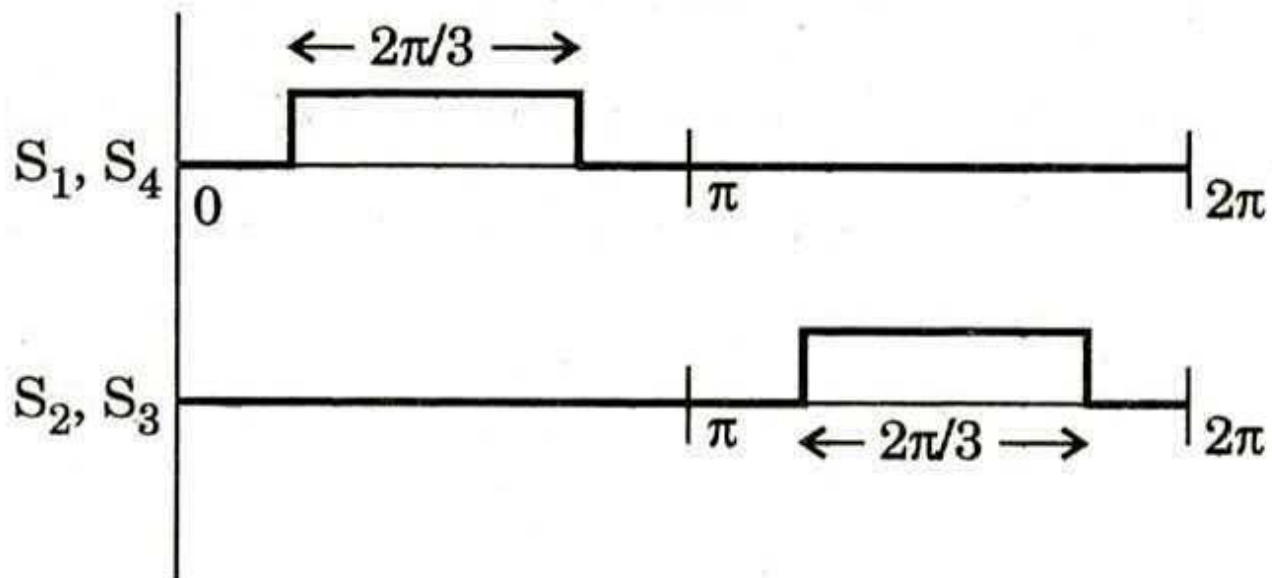
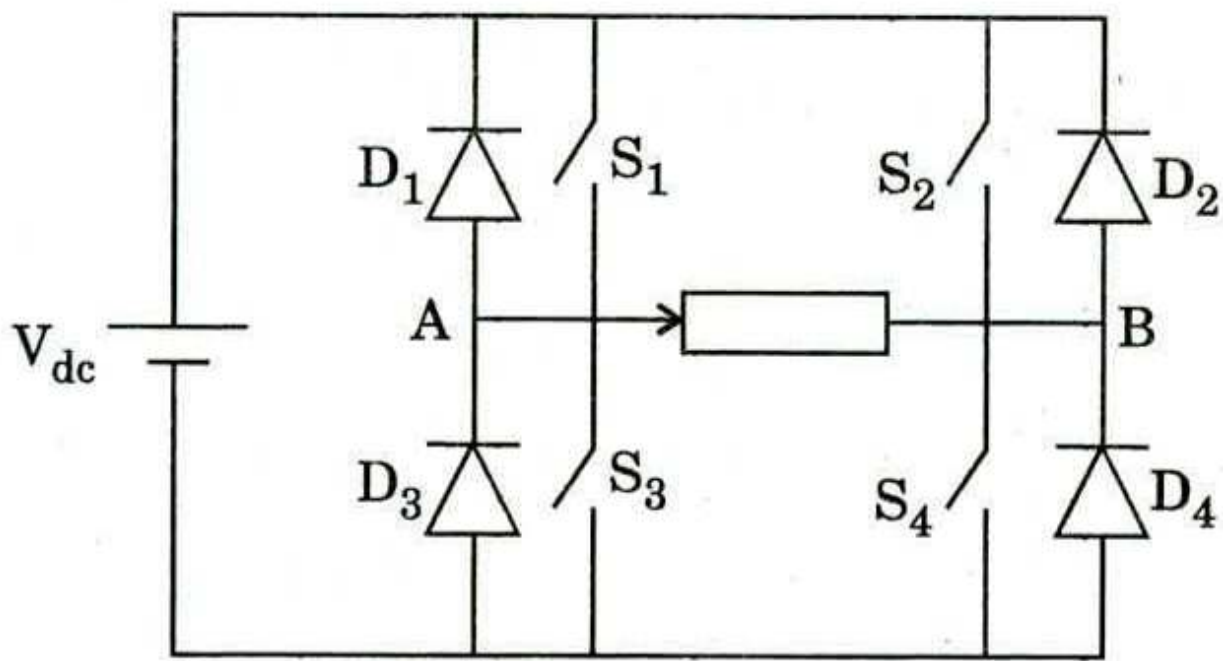
(iii) Find the change in angle  $\delta$  at the end of 15 cycles. 15

6. (a) A total load of 10000 kW at 33 kV and power factor 0.8 lagging is delivered to a substation by two 3-phase feeders connected in parallel. One of the cables has a resistance of  $1.5 \Omega$  for each conductor and a reactance of  $1.4 \Omega$  per phase and delivers 6000 kW at a power factor of 0.75 lagging. Calculate the corresponding values of resistance and reactance of the second cable. 10

(b) An array of 8-bit signed numbers (in 2's complement) is stored in sequential memory locations starting from SGNDNOS. The length of the array is  $N (< 255)$ . Draw a flow chart and write an assembly language program to count positive non-zero numbers and store the result in sequential memory location 'POS'. Include the necessary remarks in the ALP. 10

- (c) In a single-phase full bridge inverter, feeding power to an inductive load, each self-commutating switch is triggered for  $2\pi/3$  radian as shown in the following figures. Assuming the load current to be continuous, draw one cycle of the load voltage and current waveforms if the load current passes through zero value at  $\omega t = 0, \pi, 2\pi$ , etc. Mention the conducting elements in the various intervals throughout the cycle.

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- (d) Define signal-to-noise ratio and noise figure of a receiver. Derive an expression to calculate noise figure.

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7. (a) Define string efficiency with reference to a suspension insulator assembly. Explain how this efficiency can be raised by the introduction of guard rings.

Each of the three insulators forming a string has a self-capacitance of  $C$  farads. The shunting capacitance of the connecting metal-work of each insulator is  $0.2 C$  to earth and  $0.1 C$  to the line. A guard ring increases the capacitance to the line of the metal-work of the lowest insulator to  $0.3 C$ . Calculate the string efficiency of this arrangement (i) with the guard ring, and (ii) without the guard ring.

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- (b) Discuss the operation of a Boost dc-dc converter with relevant waveforms. Draw the circuit diagram indicating the voltages across each element in both the operating modes. Derive the expressions for

- (i) Average output voltage,
- (ii) Minimum inductance for continuous current,
- (iii) Output voltage ripple.

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(c) A 220 V, 7 hp dc series motor is mechanically coupled to a fan. It draws 25 A and runs at 300 rpm when connected to rated supply. The torque required by the fan is proportional to the square of the speed. The resistance of armature and field windings are  $0.6 \Omega$  and  $0.4 \Omega$ , respectively. Neglect armature reaction and rotational loss.

- (i) Determine the power delivered to the fan and the torque developed by the machine.
- (ii) The speed is to be reduced to 200 rpm by inserting a resistance  $R_s$  in the armature circuit. Determine the value of this resistance and the power delivered to the fan.

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(d) A T flip-flop and a D flip-flop are interconnected as shown in the following figure. Draw a timing diagram showing their operation through six complete clock cycles. Assume  $Q_A Q_B = 00$  initially.

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