I.E.S. (Conv.) - 2006

ELECTRICAL ENGINEERING

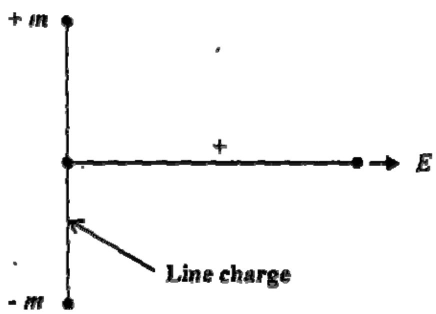
PAPER – I

Time Allowed: 3 Hours **Maximum Marks: 200**

Candidates should attempt SIX questions, selecting TWO question from Section - A, ONE from Section - B, ONE from Section - C and TWO from Section – D. Assume suitable data, if necessary and indicate the same clearly.

SECTION A

1. (a)

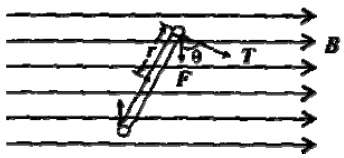


A line charge of length of 2 m has a linear charge density of ρ_L (Cm^{-1}). Show that the Electric field at a distance r perpendicular to the line charge from its middle point as shown in the above figure is

$$E_r = \frac{\rho_L}{2\pi\varepsilon_0 r\sqrt{\left(\frac{r}{m}\right)^2+1}}$$

12

(b)



Write the Lorentz Force equation and explain its significance. Calculate the maximum torque of a rotor shown in the above figure when I = 60 A, r = 8cm, B = 0.1 web/m^2 and length L = 12cm.

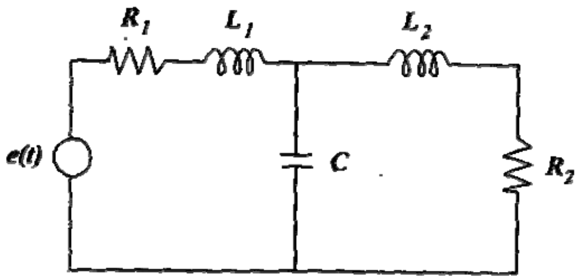
10

(c) Draw a sketch of Electric and Magnetic field lines for a two conductor transmission lines and mark the field cell.

Show that the cell impedance (intrinsic impedance of medium) for air or vacuum medium Z = $Z_{cell} = \sqrt{\mu_0/\varepsilon_0} = 377\Omega$

10

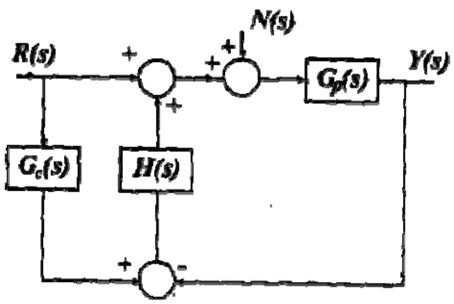
2. (a) What is meant by mathematical modelling of a physical system?



Obtain the state diagram for the network shown in the above figure. Write the state variable equation.

12

(b)



In a feedback control system shown in the above figure $G_p(s)$ denotes the controlled process and $G_c(s)$ and H(s) are the controller Transfer functions. There are two inputs namely R(s) and N(s)

Derive the following transfer functions

(i) $\left.\dfrac{Y(s)}{R(s)}\right|_{N(s)=0}$

(ii) $\left.\dfrac{Y(s)}{N(s)}\right|_{R(s)=0}$

And also find the output response y(t) when n(t) = 0 and r(t) = unit step. Assume $G_p(s) = G_c(s) = \dfrac{100}{(1+s)}$

10

(c) Obtain the polar plot for a system whose characteristic equation is $s^3 + 3s^2 + 2s + 4 = 0$ and also obtain the Gain Margin.

10

3. (a) What are the methods for determining the stability of Linear Control System?

A third order control system has the characteristic equation $s^3 + 3408.3s^2 + 1204000s + 1.5 \times 10^7 K = 0$. Find the value of K for which the system is marginally stable. For such a value of K determine the frequency of the undamped sinusoid in rad/sec of the zero input response.

12

(b) What is state variable feedback design? Explain how the poles of an original system can be shifted to another location say $-\lambda_1$ and $-\lambda_2$ for a second order system.

10

(c) Draw a neat sketch of a hydraulic proportional controller and explain its working.

10

SECTION B

4. (a) Describe Hall effect and find out the value of Hall coefficient, based on classical approach with specific charge carrier.

12

(b) Draw the energy band diagram of an n type semiconductor. State the factors on which the position of Fermi level depends. A sample of n-type semiconductor has a resistivity of 0.1 ohm cm and a Hall co-efficient of 100 cm^3/coulomb. Assuming only electrons as carriers, determine the electron density and mobility.

12

(c) Explain with graphical representation the variation of mobility with temperature.

12

5. (a) Describe the phenomena of superconductivity.

12

(b) Explain the dependence of transition temperature of superconductor on external magnetic field with graphical representation.

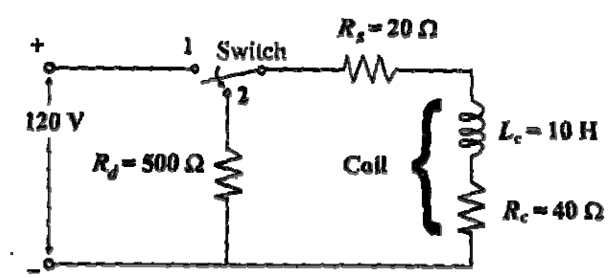
12

(c) Describe the salient features of type I and type II superconductors.

12

SECTION C

6. (a)



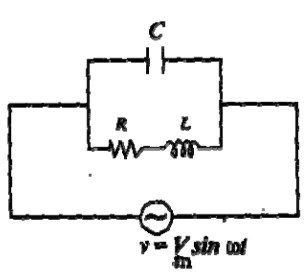
In the circuit shown above the switch is initially in position I. Find the voltage across the coil at the instant at which the switch is changed to position 2.

12

(b) An inductive load of resistance 20 Ω and inductance 0.1 H is switched on to an ac voltage v 100 sin(ωτ + α). Find the switching angle α such that there is no transient. ω = 314 rad/s.

12

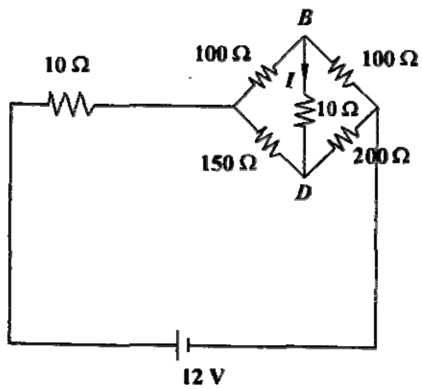
(c)



Find out the resonant frequency of the circuit shown above in terms of circuit parameters.

12

7. (a)



Calculate the current I flowing through the 10 Ω resistor in the circuit shown above. Apply Thevenin's theorem.

12

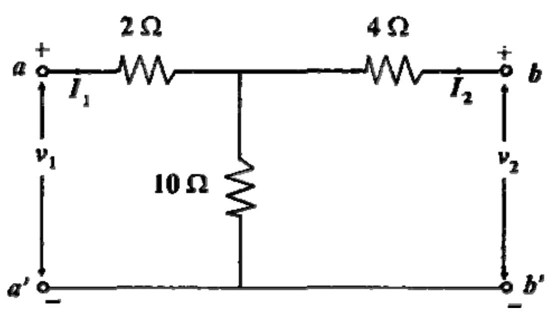
(b) An unbalanced star connected load is fed from a three - phase three wire balanced 400 V supply. The load impedances in the three phases are

$Z_R = (4 + j8)\Omega$; $Z_Y = (3 + j4)\ \Omega$; $Z_B = (15 + j20)\Omega$

Assuming the phase sequence to be RYB, calculate the total power absorbed by load.

14

(c)



Find the ABCD parameters for the circuit shown above.

SECTION D

8. (a) A capacitor bushing forms the arm AB of a high voltage Schering bridge, a standard capacitor of 500 μμF and negligible loss forms the arm AD. Arm BC consists of a non-inductive resistance of 300 Ω. The bridge is balanced with the arm CD having a resistance of 72.6 Ω and capacitance of 0.148 μF in parallel. 50 Hz supply is connected between A and C. Calculate from first principles the capacitance and dielectric loss angle of bushing.

12

(b) For measurement by ammeter and voltmeter method, what should be the accuracy of the instruments so that the overall measurement error is minimum?

10

(c) In an indicating PMMC type ammeter, the current through the coil for full-scale deflection is 5mA. Coil resistance is 5Ω and swamping resistance is 4Ω. The meter is to be used for measuring current up to 1 ampere, Calculate the value of shunt resistance required.

What arrangement is required to be made to compensate for temperature changes which may occur? Derive necessary expression.

10

9. (a) A moving iron voltmeter designed to read up to 100 volts has resistance of 20000 and inductance of 0.6 henry. How it can be modified to read up to 300 volts?

How the modified voltmeter can be made to read without error on both dc and 50 Hz ac?

10

(b) For power measurement in a 3-phase load, two wattmeter methods were used. With 3-phase, 440 volt system of supply and the current coils of two wattcmeters are connected in B and B phases, determine the line currents, reading of each wattmeter and total input power. The load is resistive with 10Ω, 15Ω, 20 Ω (in star) respectively in R, Y and B phases.

(c) What are the advantages of digital voltmeters and limitations compared to analog indicating type voltmeters?

Explain with the help of a block diagram, the configuration of counter ramp type DVM.

10

10. (a) Explain the piezoelectric phenomenon. Name two piezoelecthc materials.

Draw the equivalent circuit with appropriate cable connection model and charge amplifier. Obtain transfer function between amplifier output and input displacement to the piezoelectric device.

12

(b) A four arm resistive bridge is used with a temperature sensor (RTD) having resistance temperature coefficient α = a 0.042 Ω/°C in one of the arms, Initially the bridge is balanced with all arms having a resistance of 400Ω. DC supply to the bridge is limited by a maximum permissible current of 30 mA through the temperature sensor. Bridge output is connected to a current responding meter having input resistance of 100Ω and deflection sensitivity of 2°/μA. Determine the deflection in the output meter if the temperature sensor undergoes a temperature rise of 30° C.

10

(c) Explain the principle of operation of a dual slope integrator type of analog to digital converter with the help of block and timing diagram.

An analog voltage signal with highest significant frequency of 1 KHz is to be digitally coded, with a resolution of 0.1% covering the range of 0 - 10 volts. To avoid loss of information determine

The minimum sampling rate, minimum number of bits in the digital code, analog value of least significant bit and the dynamic range of A/D convener in dB.

19

I.E.S. (Conv.) - 2006

ELECTRICAL ENGINEERING

PAPER - II

Time Allowed: 3 Hours **Maximum Marks: 200**

Candidates should attempt FIVE questions in all. Question No. 1 is compulsory. The remaining Four question are to be attempted by selecting at least ONE question from each of the Sections A, B, C and D. Assume suitable data, if necessary and indicate the same clearly.

1. (A) Choose and write the correct answer IC) x 2 = 21)

(a) A 220 V D.C. machine has an armature resistance IΩ. If the full-load current is 20 A, the difference in induced voltage when the machine is running as a motor, and as a generator is

(i) 20V (ii) 0V

(iii) 40 V (iv) 60 V

(b) A 4-pole, 50 Hz, 3 phase induction motor has blocked rotor reactance per phase which is four times the rotor resistance per phase. The speed at which maximum torque develops is

(i) 1125 rpm

(ii) 1500 rpm

(iii) 1050 rpm

(iv) 1210 rpm

(c) In load flow studies of a power system, a voltage control bus is specified by

(i) Real power and reactive power

(ii) Reactive power and voltage magnitude

(iii) Voltage and voltage phase angle

(iv) Real power and voltage magnitude

(d) Which of the following circuit breakers is generally used in railway electrification?

(i) Air blast circuit breaker

(ii) Minimum oil circuit breaker

(iii) Bulk oil circuit breaker

(iv) SF6 circuit breaker

(e) The output frequency of a decade counter that is clocked from a 50 kl-Iz signal is

(i) 12.5 kHz (ii) 50 kHz

(iii) 5 kHz (iv) 500 kHz

(f) When two amplifiers each of bandwidth, f_H = 10kHz are cascaded, the overall bandwidth becomes

(i) 10 kHz (ii) 6.4 kHz

(iii) 5 kHz (iv) 20 kHz

(g) The ______ instruction allows control to transfer to a subroutine, which when complete, issue the _____ instruction to return control to the main programe.

(i) CALL, JMP (ii) CALL, RET

(iii) CALL, RSTI (iv) El, Dl

(h) One of the advantages of base modulation over collector modulation of a transistor Class C amplifier is

(i) the lower modulating power required

(ii) higher power output per transistor

(iv) better efficiency

(v) better linearity

(i) Which of the following configurations is used for both motoring and regenerative breaking?

(i) First quadrant chopper

(ii) Second quadrant chopper

(iii) Two quadrant chopper

(iv) Four quadrant chopper

(j) In ac applications, a different measure of harmonics is needed. The total harmonic ratio (THR) is given by:

(i) $\sqrt{\dfrac{f_{rms}^2 - f_{1rms}^2}{f_{rms}}}$

(ii) $\sqrt{\dfrac{f_{rms}^2 - f_{1rms}}{f_{1rms}^2}}$

(iii) $\sqrt{\dfrac{f_{1rms}^2 - f_{1rms}}{f_{rms}}}$

(iv) $\sqrt{\dfrac{f_{1rms}^2 - f_{rms}}{f_{1rms}}}$

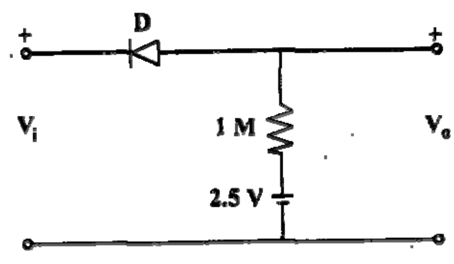
(B) (a) What are the methods of starting of synchronous motors?

4

(b) Explain the limits of AC transmission lines.

4

(c) A symmetrical 5 kHz square wave whose output varies between + 10 V and -10 V is impressed upon the clipping circuit shown. Assume $R_f = 0$, $R_\gamma = 2\ M\Omega$ and $V_\gamma = 0$. Sketch the steady state waveform indicating numerical values of the maximum, minimum and constant portion.



4

(d) Explain RIM and SIM instructions of 8085 microprocessor, with accumulator data format.

4

(e) A 100/1 A bar primary current transformer supplies an over current relay setting at 50% pick up and it has a burden of 2 VA. Determine the knee point voltage and cross section of the core if the CT has 50 turns on its secondary and the fault current is 15 times the relay setting. Assume the flux density as 1.4 Wb/M^2 and frequency = 50 Hz.

4

SECTION A

2. (A) A 1500 kVA, 6.6/1.1 kV, 3 phase delta-star connected transformer has the following test result:

S.C. test: (Instruments placed on h.v. side)

300 V, 131.21 A, 30 kw

Calculate its percentage resistance, percentage reactance drops, percentage efficiency and percentage regulation on full load at 0.8 power factor lagging. The iron loss during O.C. test with rated voltage supplied is 25 kW.

14

(b) A star-connected 3-phase alternator delivers a 3-phase star- connected load at a power factor of 0.8 lagging. A wire connects the load and the alternator. The terminal voltage at no-load is 2500 V, and at full-load of 1460 kW it is 2200 V. Determine the terminal voltage when it delivers a 3 phase star-connected load having a resistance of 6 Q and reactance 8 (2 per phase respectively. Assume constant current and field excitation.

14

(c) (i) Interpret the following instructions and mention their addressing mode and flag affected, if any

XRA A; DAA; DCR M; ADD B.

8

(ii) What is the difference between Accumulator (ACC) and Instruction Register (IR)?

4

3. (a) (i) With connection diagrams for both shunt and separately excited D.C. generators, draw the important characteristics of these generators.

6

(ii) Calculate the rms value of the induced emf per phase of a 10 pole, three phase, 50 Hz alternator with 2 slots per pole per phase and 4 conductors per slot in two layers. The coil span is 150°. The flux per pole is 0.12 wb.

8

(b) Two alternators working in parallel supply a lighting load of 3000 kW and a motor load aggregating to 5000 kW at a p.1 of 0.72. One machine is loaded up to 5000 kW at 0.8 p.f. lagging. What is the load and power factor of the other machine?

14

(c) Consider a two stage synchronous counter (both stages receive the pulses at the C_K input). In each counter K = 1. If Q_1 and J_1 Q_0, draw the circuit. From a truth table of Q_0 and Q_1 after each pulse, demonstrate that this is a 3 : 1 counter.

12

SECTION B

4. (a) A two-machine power system delivers a load of 25 MW at 0.8 p.f. lag and has a double circuit. The system reactance is 150 percent on 100 MVA base. A sudden symmetrical line-to-ground fault occurs in one of the circuits which reduced the power supplied to 40% which is subsequently cleared by simultaneous action of the circuit breakers on both sides of the faulted line. Calculate in the electrical degrees the “critical clearing angle”. Assume that during fault conditions the system reactance attains such a value that the maximum power becomes 30% of the normal maximum value, when the faulty line is isolated the maximum power of the system becomes 60% of the normal maximum power.

14

(b) For a certain industrial organization the maximum and minimum power demands are 50 MW and 10 MW respectively. Its load duration curve can be approximated as shown in Fig. 4. (b), below. The hydro power available at the time of minimum regulated flow is just sufficient to take a peak load of 60 MWh per day. Further, it is observed that it will be economical to pump water form tail race to the reservoir tank by utilizing the steam power plant during off peak periods and thus running the station at 100 per cent load factor. If the efficiency of the steam electric conversion is 60%, calculate the maximum capacity of each type of plant.

14

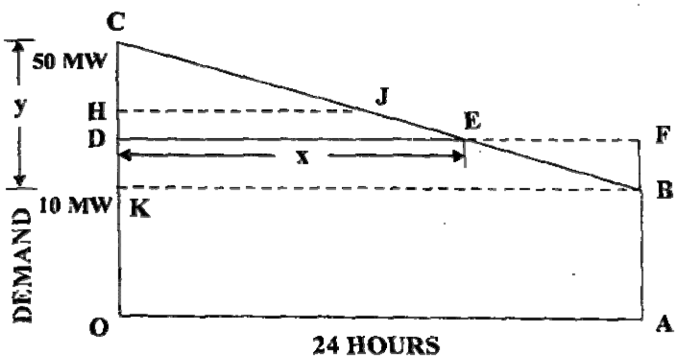


Fig 4 (b) : Load duration curve

(c) A BCD number between 0 and 99 is stored in an RI'W memory location called the input Buffer. Write a main program & a conversion subroutine (BCDBTN) to convert the BCD number into its equivalent binary number in 8085. Store the result in a memory location defined as Output Buffer.

12

5. (a) What do you understand by Ferranti effect?

Determine the sending end voltage and efficiency by π method of a line, given resistance of line ($R = 0.2 \times 120 = 24\Omega$), inductive reactance ($X_L = 48.98\ \Omega$) and capacitance reactive ($X_C = 1.2$).

14

(b) Two generating stations having short-circuit capacities of 1200 MVA and 800. MVA respectively and operating at 11 kV are linked by an interconnected cable having reactance of 0.5 ohm per phase. Determine the short-circuit capacity of each station.

14

(c) (i) Explain Foster-Seeley discriminator with neat circuit diagram and waveforms.

6

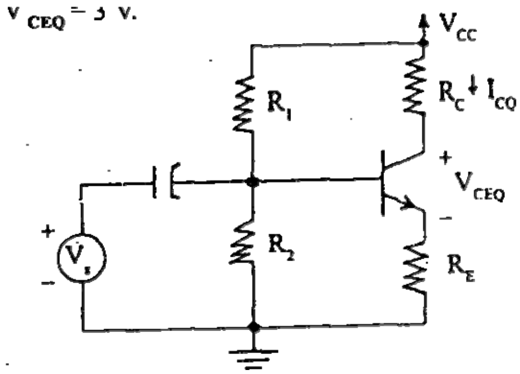
(ii) When the modulating frequency in FM system is 400 Hz and the modulating voltage is 2.4 V, the modulation index is 60. Calculate the maximum index, when the modulating frequency is reduced to 250 Hz & the modulating voltage is simultaneously raised to 3.2 V?

6

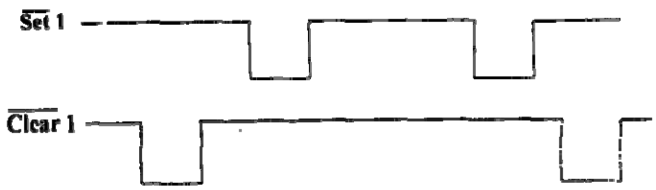
SECTION C

6. (a) Consider the circuit shown below. Let $V_{CC} = 5$ V, $R_C = 1$ kΩ, $V_{(BE(ON)} = 0.7$ V and $\beta = 120$. Choose R and determine R_1 and R_2 such that the circuit is bias stable and that $V_{CEQ} = 3$V.

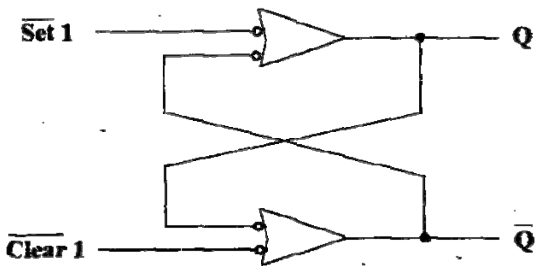
14



(b) The waveforms



are applied to the inputs of the latch



Draw the waveform at Q and explain.

14

(c) (i) List the major factors influencing the choice of the intermediate frequency (IF) in any particular system.

6

(ii) Which are frequencies band for AM, SW and FM broadcast system? Mention the IF values for these systems.

6

7. (a) (i) How sigma-delta modulation system is developed from delta modulation? Explain with block schematic.

8

(ii) A PCM system is to have SNR of 42.93 dB. The signals ate speech, and an rms to peak ratio of-10 dB is allowed for. Find the number of bits per code word required.

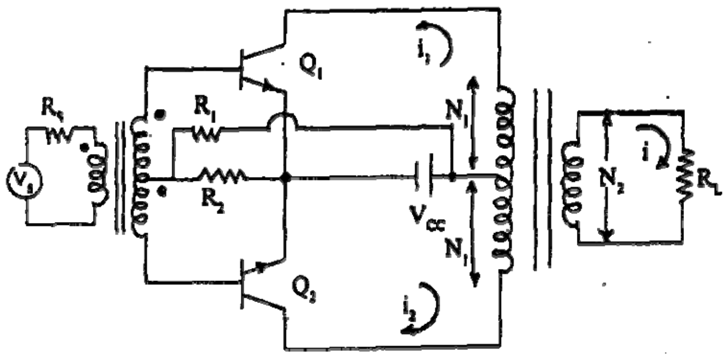
6

(b) (i) Justify that frequency modulation is much more immune to noise than amplitude modulation.

(ii) Sketch the typical IF, characters response for colour TV receiver. Indicate frequency and signal levels on curve.

6

(c) Consider the idealized push-pull Class B power amplifier as shown below:



Give that $R_2 = 0$, $V_{CC} = 20$ V, $N_2 = 2\ N_1$, $R_L = 20\ \Omega$ and the transistors have $h_{FE} = 20$. The input is a sinusoid. For the maximum output signal at $V_m = V_{CC}$, determine:

(i) the output signal power.

(ii) the collector dissipation in each transistor.

12

SECTION D

8. (a) The buck regulator in Fig. 8 (a) shown has an input voltage of $V_s = 12$ V. The required average output voltage is $V_a = 5$ V at $R = 500\ \Omega$ and the peak-to-peak output ripple voltage is 20 mV. The switching frequency is 25 kHz. If the peak-to-peak ripple current of inductor is limited to 0.8 A, determine

(i) the duty cycle K,

(ii) the filter inductance L,

(iii) the filter capacitor C and

(iv) the critical value of L and C.

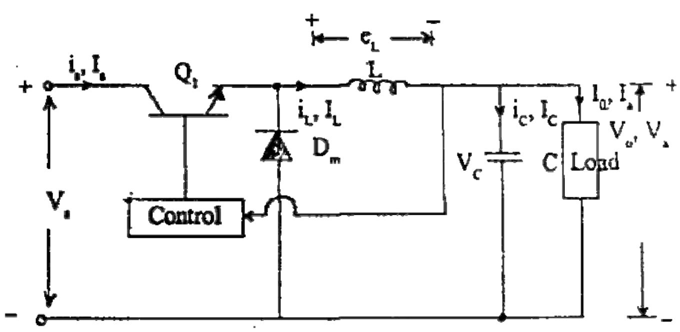


Fig. 8 (a) : Circuit diagram

(b) (i) Explain the transfer characteristics of n-channel and p-channel MOSFETS along with their output characteristics of an n-channel enhancement MOSFEE

8

(ii) The bipolar transistor in Fig. 8 (b) is specified to have β_F in the range of 8 to 40. The load resistance is $R_C = 11$ ohm. The d.c. supply voltage is = 200 V and the input voltage to the base circuit is $V_B = 10$ V. If $V_{CL(sat)} = 1.0$ V and $V_{BE(sat)} = 1.5$V, find

(1) the value of RB that results in saturation with an ODF of 5

(2) the β_{forced}, and

(3) the power loss P_T in the transistor.

6

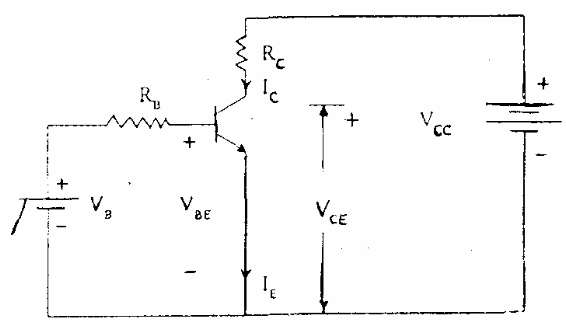


Fig. 8 (b): Transistor Switch

(c) An 8085-8155 based microcomputer is required to drive an LED connected to bit 0 of port A based on two switches inputs connected to bits 6 and 7 of port A. If both switches are either High or Low, turn the LED ON; otherwise turn it OFF. Assume that HIGH will turn the LED ON and that a ow will turn it OFF. Use port address of CSR and Port A as 20 H and 21 H, respectively. Program starts from 2000 H. Write an 8085 assembly language program.

12

9. (a) Point out the differences between latching current and hold current for the thyristor. What do you understand by string efficient related to thyristors? For a thyristor, maximum junction temperature is 125°C. The thermal resistances for thyristor-sink combination are θ_{jc} = 0.16 and θ_{cs} = 0.08°C/W. For a heat-sink temperature of 70°C, compute the total average power loss in the thyristor sink combination. In case the heat sink is brought down to 60°C by forted cooling, find the percentage increase in the device rating.

14

(b) A voltage source Inverter is to be used for a backup power application. This unit, shown in Fig. 9 (b), draws power from a set of lead-acid batteries with nominal output of 144 V and supplies upto 2 kW into a load. A resonant filter is to be used to provide an output sinusoidal at 120 V_{rms}, 60 Hz with THD < 3% at hill load. If the actual battery voltage will vary between 132 V and 156 V, what range of δ values will be used for this application? Select a series L-C pair to meet the requirements (δ - is the trigging angle). Utility supply variation ±5%. Assume only third harmonic is present.

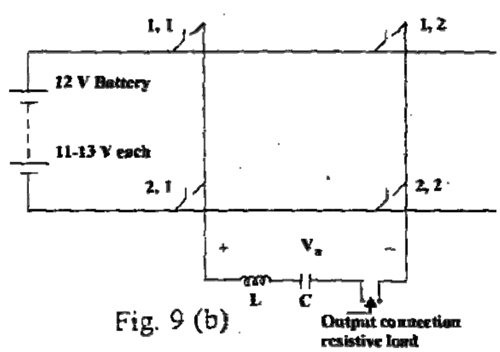


Fig. 9 (b)

(c) Derive the following for the 3 phase induction motor due to interaction of rotor and stator fields:-

(i) Torque developed

(ii) Starting torque.

(iii) Condition for maximum torque.

(iv) Effect of change in supply voltage on starting torque.

(v) Effect of change in supply voltage on torque and slip.

(vi) Full load torque and maximum torque.

12