Questions

Q.2 a. State and explain Fleming's left hand rule.

b. Compare magnetic and electric circuit.

c. A coil consisting of 100 turns is placed in the magnetic field of 0.8 mWb. Calculate the average emf induced in the coil when it is moved in 0.08 s from the given field to the field of 0.3 mWb.

Q.3 a. State and explain Superposition theorem with example.

b. A capacitor of 100 µF is connected across a 200 V, 50 Hz single phase supply. Calculate :
1) **the reactance of the capacitor.**
2) **rms value of current**
3) **maximum current**

Q.4 a. Explain the principle of operation of a DC motor.

b. The armature of a 6 - pole dc shunt motor has a lap winding accommodated in 50 slots, each containing 24 conductors. If the useful flux per pole is 25 m Wb, calculate the total torque developed, when the armature current is 45 A.

Q.5 a. Explain the basic principle of operation of single phase transformer.

b. A 3- phase induction motor runs at almost 1000 rpm at no load and 940 rpm at full load when supplied with power from a 50 Hz, 3- phase line. calculate:
1) **number of poles,**
2) **slip at full load**

Q.6 a. Explain Insulator, Semiconductor & conductor with help of energy band structure.

b. Explain DC load line analysis of a diode circuit with the help of suitable example.

Q.7 a. Draw the circuit diagram of a bridge rectifier and explain its operation with the help of necessary wave form.

b. Draw and explain clamping circuit.

Q.8 a. Sketch and explain the input and output characteristics of CE configurations of transistors.

b. With the help of circuit diagrams, explain working of voltage-divider biasing circuits. What are its advantages over other type of biasing method?

Q.9 a. Explain working of single stage CE amplifier with the help its circuit diagram.

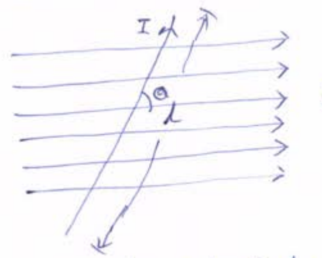
b. Draw circuit diagram of BJT phase shift oscillator and explain its working?

Answers

Q 2(a) Fleming's left hand Rule

Flemings left hand Rule states that "stretch the fore finger, sencond finger and the thumb of the left hand mutully at the right angle to each other. If fore fingers points the direction of current through the conductor, than the thumb will indicate the direction of force, i.e. motion of the conductor.

Consider a conductor of length l metre carrying a current of I ampere and placed in a uniform magnetic field of flux density B Wb/m², making an angle θ with the direction of field,



So, for any current element of length dl, the force experiewed is give by

$$dF = BI\ dl\ \sin\theta.$$

and direction of force can be determined by Fleming's left hand rule as stated above.

Q2(b) Following are the similarities and dissimilarities in magnetic and electric circuit.

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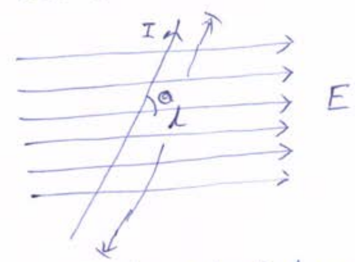

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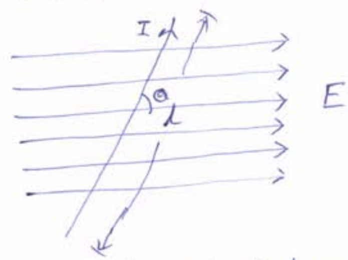

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Similarities in Electric and Magnetic circuit.

Electric circuit	Magnetic Circuit.
(I) Current flows in the circuit	(i) Flux is assume to flow
(ii) The path of current is Called electric circuit	(ii) Path of flux is called Magnetic circuit.
(iii) Current flows due to emf	(iii) Flux flows due to mmf
(iv) Flow of current is restricted by resistance of the circuit.	(iv) Flow of flux is restricted by reluctance of the circuit.
(V) Current = emf/Resistance	(V) Flux = mmf/Reluctance
(Vi) Resistance $R = \frac{l}{\sigma A}$	(Vi) Reluctance $S = \frac{l}{\mu A}$

Dissimilarities in Electric & Magnetic circuit

Electric circuit	Magnetic circuit
(I) Current actually flows in the circuit	(I) Flux does not flow, it is only assumed to flow.
(ii) Energy is needed till the current flows	(ii) Energy is needed to create the magnetic flux.
(iii) Resistance of the circuit is independent of the current	(iii) Reluctance of the circuit changes with the magnetic flux.

Q2(c) Given No. of turns = 100 = N

Time = 0.08 S

change in flux $d\phi = 0.3 - 0.8 = -0.5 mWb$.

Induced emf in the coil placed in a magnetic field with relative change between the two is given by

$$e = -N\frac{d\phi}{dt}$$

$$d\phi = 0.3 - 0.8 = -0.5\ mWb = -0.5\times10^{-3}\ Wb.$$

This change is brought about in time $dt = 0.08$ sec

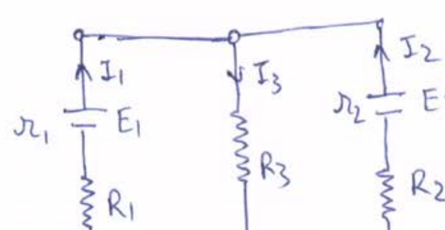
$$\therefore \text{induced emf} = -100 \times \frac{(-0.5)\times10^{-3}}{0.08}$$

emf = 0.625 Volt

— X — X —

Q3(a) Superposition Theorem State that "in a linear network Containing more than one source of emf, the resultant current in any branch is the algebraic sum of the currents, that would have been produced by each source of emf taken separately, with all the other sources of emf being replaced meanwhile by their respective internal resistances."

Explanation:- Consider the circuit given below to find out the current flowing through resistances R_1, R_2 and R_3. Let the resultant current flowing through



the resistances R_1, R_2 and R_3 be I_1, I_2 and I_3. As per the theorem, let us first solve the above circuit with the emf E_1 acting alone, replacing the other source of emf E_2 by its internal resistance r_2 as shown in figure (a)

This circuit can easily be solved for the currents I_1', I_2' and I_3'. Similarly solve the circuit with emf E_2 acting alone, replacing emf E_1 by its internal resistance r_1 as shown in figure(b) below.

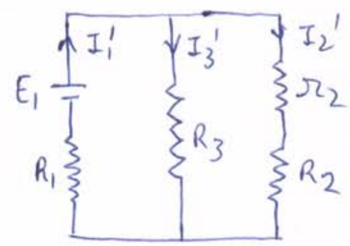


Fig (a)

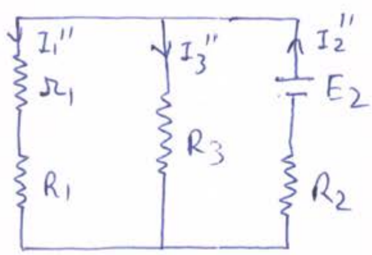


Fig (b)

The circuit of Fig (b) is solved for the current I_1'', I_2'' and I_3''. Now applying superposition theorem to combine the results in order to find out the resultant current in the various branches:

Resultant current in Resistor R_1, $I_1 = I_1' - I_1''$

Resultant current in Resistor R_2, $I_2 = I_2' - I_2''$

Resultant current in Resistor R_3, $I_3 = I_3' - I_3''$

———— Y ———— Y ————

P.T.O

Q3(b) Given $C = 100 \mu F$

$f = 50 Hz$.

(i) Capacitive reactance $X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$

$$= \frac{1}{2 \times 3.14 \times 50 \times 100 \times 10^{-6}}$$

$$X_C = 31.84 \Omega$$

(ii) RMS value of applied Voltage = 200V

RMS value of current drawn by the Capacitor

$$I = \frac{V}{X_C} = \frac{200}{31.84} = 6.29 A$$

(iii) Maximum current

$$I_{max} = \sqrt{2} \times \text{RMS current}$$

$$= \sqrt{2} \times 6.29$$

$$I_{max} = 8.88 A.$$

—x— —x— —x—

Q4(a) Principle of operation of DC Motor

Figur shows a coil ABCD wound on an armature, the ends of which are connected to two halves of a ring properly insulated from each other forming the split ring or the commutator. Carbon brushes B_1 and B_2 press

(7)

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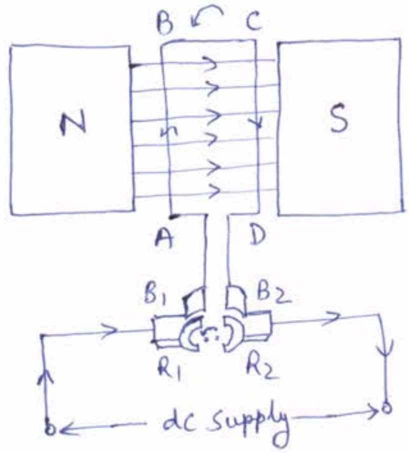
against the commutator by means of spring. The armature is placed between the two poles N and S of a strong electromagnet, over which a field winding is placed.



When the dc supply to the system is switched on, the direction of current, flowing in the coil ABCD is as shown in figure above. As a result, a force will act on each arm of the coil, the direction of which is given by Fleming's left hand rule. The system thus forms a couple acting on the armature of the system which sets in to rotation, till the coil complete half revolution.

As soon as a half rotation of the coil is completed, segment R_1 of the commutator comes in contact with the brush B_2 and segment R_2 with brush B1, thereby reversing the direction of current in the coil. Since the positions of arms AB and CD of the coil are also interchanged, the direction of rotation of the armature remains unchanged and it keeps on on rotating in one direction.

Q 4(b) Given that

Number of pole $P = 6$

The winding on the armature is lap type, hence the number of parallel paths on the armature winding $A = 6$

Armature current $I_a = 45\,A$

Total conductor on the armature $Z = 50 \times 24 = 1200$

Flux per pole $\phi = 25 \times 10^{-3}\,Wb$

The torque developed by the armature of a dc motor is given by

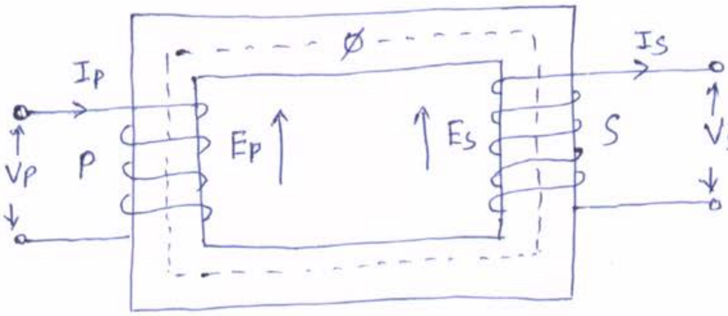
$$T_a = 0.159 \frac{P \phi I_a Z}{A}\ Nm$$

$$= \frac{0.159 \times 6 \times 25 \times 10^{-3} \times 45 \times 1200}{6}$$

$$T_a = 214.65\ Nm$$

Q 5(a) A transformer consists of a rectangular or stepped laminated magnetic core forming the magnetic frame. The primary coil P and the secondary coil S are wound upon the two cores of the magnetic frame as shown in figur. The primary and the secondary coils P and S are properly insulated from each other. When an alternating voltage V_p Volts is applied across the primary coil P, a current I_p flows in it producing the magnetic flux in the transfer core, the path of which has been.

shown by dotted lines in Fig.



As the current in the primary coil is alternating, the magnetic flux setup in the core will also be alternating in nature, that is its magnitude and direction will change with time. As per Faraday's laws of electromagnetic induction, a statically self-induced emf is set up in the primary coil is given by

$$E_P = -N_P \frac{d\phi}{dt}$$

where, N_P is the number of turns in the primary coil P and ϕ the alternating flux linking the coil P. The induced emf in the primary coil is nearly equal and opposite to the applied voltage V_P.

As the leakage of flux has been assumed to be negligible, the same magnetic flux ϕ, which is alternating in nature, links with each and every turn of the secondary coil S. As such, a statically mutual-induced emf is setup in the secondary coil S, the magnitude of which is given by

$$E_S = -N_S \frac{d\phi}{dt}$$

where, N_S = No. of turns in secondary coil S
& ϕ = Common flux linking the secondary coil.

—— x —— x —— x ——

Q5(b)(i) Speed at no load is almost 1000 rpm, This indicates that the synchronous speed of the rotating magnetic field is 1000 rpm i.e.

$$N_s = 1000\,rpm$$

Frequence of the supply to the stator $f = 50\,Hz$.

∴ Number of Poles

$$P = \frac{120f}{N_s} = \frac{120 \times 50}{1000} = 6$$

(ii) Full load speed $N_r = 940\,rpm$

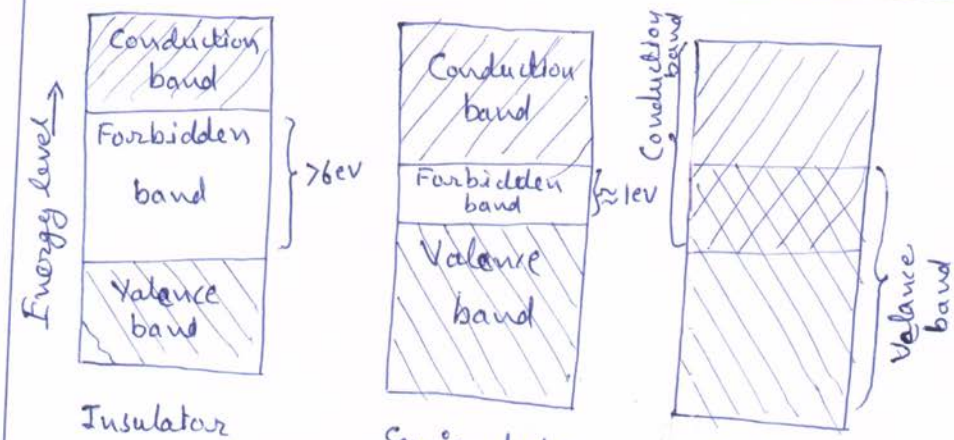
$$\text{percentage slip at full load} = \frac{N_s - N_r}{N_s} \times 100$$

$$= \frac{1000 - 940}{1000} \times 100$$

$$= 6\,\%$$

—x——x——x—

Q6(a) As shown in energy band diagram, insulators have a wide forbidden gap, semiconductors have a narrow forbidden gap, and conductors have no forbiddengap at all. In the case of insulators there are pracically no electrons in the conduction band of energy levels, and the valance band is filled. Also, the forbidden gap is so wide that it would require the application of very large amount of energy approximately 6 eV to cause an electron to cross from the valence band to the conduction band. Therefore, when a voltage is applied to an insulator, conduction cannot normally occure either by electron or hole.



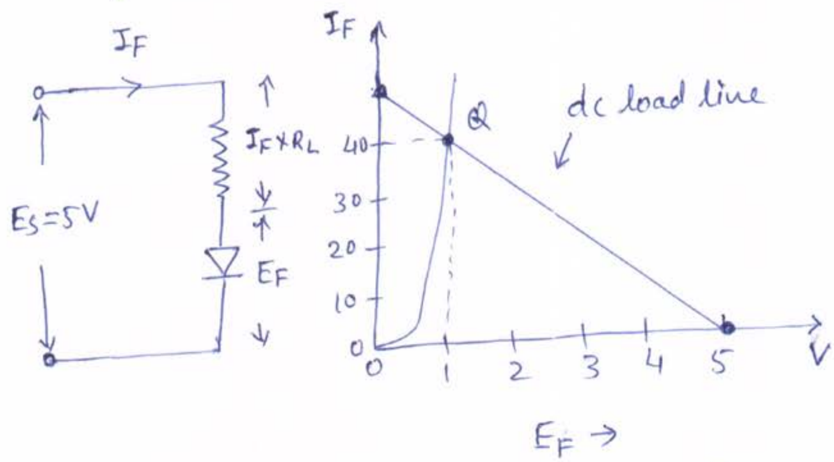
For Semiconductors at a temperature of absolute zero (-273°C) the valence band is usually full, and there may be no electrons in the conduction band. However, as shown in figur above, the forbidden gap in a semiconductor is very much narrow approximate 1.2 eV for silicon and 0.785 eV for germanium can raise electrons from the valence band to the conduction band. Sufficient thermal energy for this purpose is made available when the semiconductor is at room temperature. If a potential is applied to the semiconductor, conduction occurs both by electron movement in the conduction band by hole transfer in the valence band.

In case of conductors there is no forbidden gap, and the valence and conduction energy bands overlap.

Typical resistance values are

Conductor	$10^{-6}\Omega$
Semiconductor	10Ω
Insulator	$10^{14}\Omega$

Q 6 b. Let a diode connected in series with 100Ω resistance R_L and supply voltage E_S. The polarity of E_S is such that the diode is forward biased; the current in the circuit is I_F.



To determine the voltage across the diode and the current flowing through it, a dc load line must be superimposed on the diode forward characteristics. The d.c. load line shown all dc conditions that could exist with in the circuit for given values of E_S and R_L. Since the load line is always straight, it can be constructed by ~~plo~~ plotting any two corresponding current and voltage points and then drawing a straight line through them.

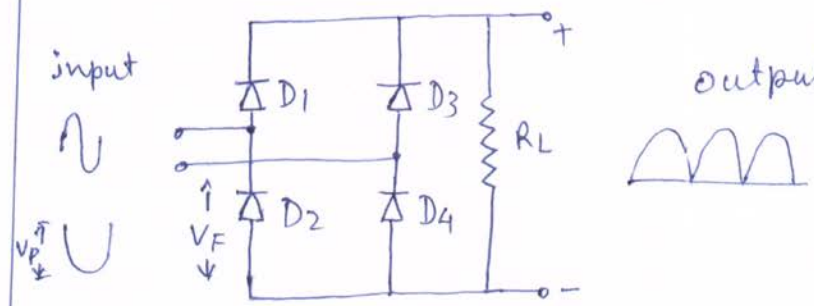
To determine two points on the load line, an equation relating voltage and current, and resistance must first be derived from the circuit

$$E_S = I_F R_L + E_F$$

———Y———Y———Y———

P.T.O

Q 7(a)



The bridge rectifier is shown above is the circuit most frequently used for full-wave rectification. During the positive half-cycle of the input Valtage the bridge rectifier, diode D_1 and D_4 conduct as shown. At the same time, diodes D_2 and D_3 are reverse biased. Diode D_2 and D_3 forward biased during the negative half cycle of the input, while D_1 and D_4 are reverse biased. The result is that both positive and negative half cycles of the input are passed to the load resistance R_L. Also, the negative half cycles are inverted, so that the output is a continuous series of positive half cycles of alternating voltage.

Since the bridge rectifier has two forward biased diode in series with the supply Voltage and R_L, the output voltage of amplitude is

$$E_P = V_P - 2V_F$$

The peak reverse (Inverse) Voltage across any diode is approximately equal to the peak input voltage.

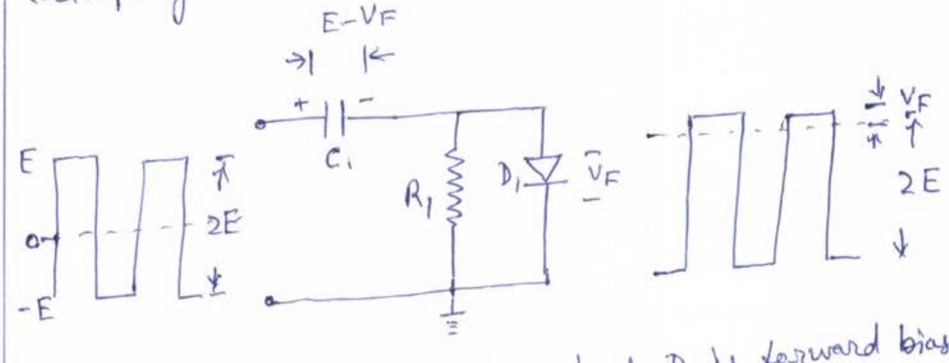
Therefore $V_P = (V_F \text{ for } D_3) + (V_R \text{ for } D_1)$

i.e. reverse Voltage across Diode is

$$V_R = V_P - V_F \approx V_P$$

———x———x———x———

Q 7(b) A clamper circuit (also known as dc restorer) changes the dc voltage level of the input, but does not change the input wave form. Consider the negative voltage clamping circuit shown below.



When the input is positive, diode D_1 is forward biased and the capacitor C_1 charges with the polarity shown. During the positive half cycle of input, the output voltage equals the diode forward voltage V_F. At this time, the voltage on the right-hand side of the capacitor is $+V_F$, while that on the left-hand side is $+E$. Thus, C_1 is charged to $(E - V_F)$ with the polarity shown.

When the input goes negative, the diode is reversed biased and has no further effect on the capacitor voltage. Also, R_1 has a very high resistance, so that it cannot discharge C_1 by very much during the negative (or positive) portion of the input wave form. While the input is negative, the output voltage is the sum of the input and capacitor voltage. Since the polarity of the capacitor voltage is the same as the input, the output is a negative voltage that is larger than the peak input level

$$\text{output} = -E-(E-V_F) = -(2E-V_F)$$

The Peak-to Peak output is the difference between the negative and positive levels

$$\text{Peak to Peak Output} = V_F - [-(2E - V_F)]$$

$$= 2E$$

It is seen that the amplitude of the output wave form from the negative voltage clamper circuit is exactly same as that of the input.

—x—x—x—

Q 8(a)

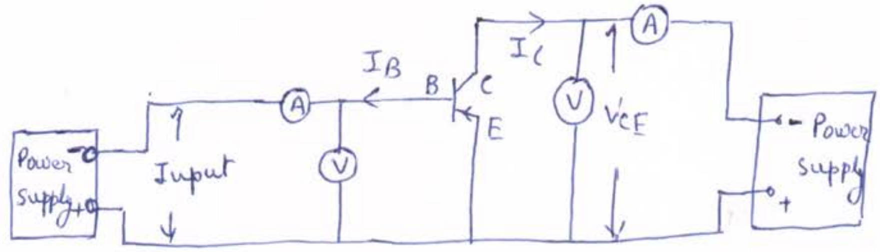


Figure shows the circuit arrangement for determining transistor common emitter characteristics. The input voltage is applied between B and E terminals and output is taken from C and E terminals.

Input characteristics :-

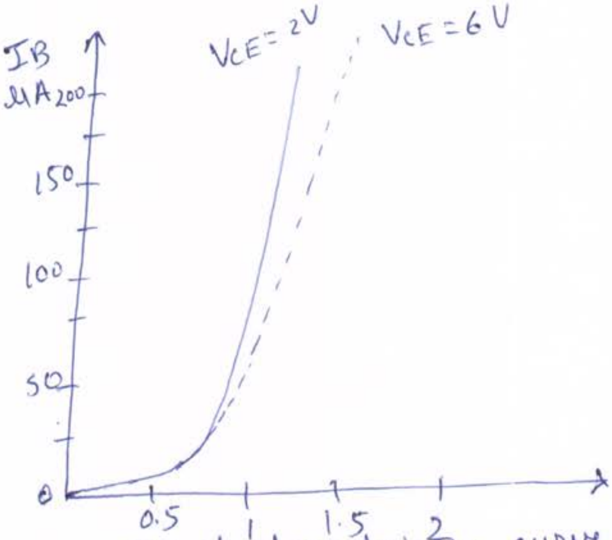
To determine the input characteristics, V_{CE} held constant and I_B levels are recorded for severals levels of V_{BE}. I_B is plotted versus V_{BE}. The following points may be noted from the characteristics.

(1) The characteristics resembles that of a forward biased diode curve as base emitter section of transistor is a diode and it is forward biased.

(2) I_B increases less rapidly with V_{BE} as compared to CB configuration.

Input impedance is given by

$$Z_{in} = \frac{\Delta V_{BE}}{\Delta I_B}\Bigg|_{\text{at constant } V_{CE}}$$



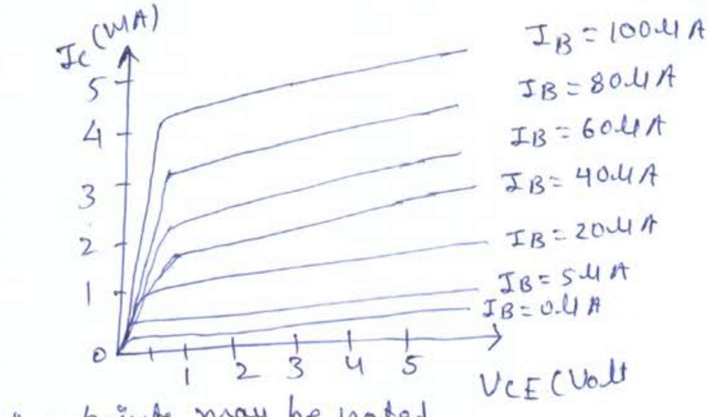
Input characteristic curve.

From above figure it is clear that, for a given level of V_{BE}, less I_B flows when higher levels of V_{CE} are employed. This is because the higher levels of V_{CE} provide greater CB junction reverse bias, resulting in greater depletion region penetration in to the base.

Output characteristics :-

For output characteristics, I_B maintained constant and each level of I_B, V_{CE} is adjusted in steps and the corresponding values of I_C are recorded. For each level of I_B, I_C is plotted versus V_{CE}. This give family of characteristics which are typically shown in figure below.

P.T.O



Following points may be noted from characteristics

(i) The collector current I_C varies with V_{CE} for V_{CE} between 0V to 1V only. After this, the collector current almost constant and independent of V_{CE}. This voltage is known as Knee Voltage.

(ii) Above Knee voltage, I_C is almost constance, however a small increase in I_C with increasing V_{CE} is caused by the collector depletion layer getting wider and capturing a few more majority carries before electron hole combination occur in the base area.

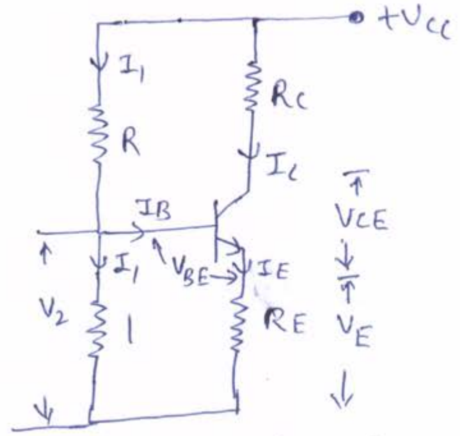
(iii) Above Knee Voltage, $I_C = \beta I_B$

Output resistance :- Output impedance is given by ratio of change in collector-emitter voltage (ΔV_{CE}) to the change in collector current (ΔI_C) at constant I_B

$$Z_o = \left.\frac{\Delta V_{CE}}{\Delta I_C}\right|_{\text{Constant } I_B.}$$

(18)

Q 8 (b)



In this method two resistors R_1 and R_2 are connected as shown in figure above and provide biasing. The emitter resistance provide (R_E) stabilisation. The name "Voltage divider" comes from the voltage dividing circuit formed by R_1 and R_2. The voltage drop across R_2 forward biased the base emitter junction. This causes base current and hence collector current flow in the zero signal conditions.

Suppose that the current flowing through resistance is I_1 as base current is very small, therefore, current through R_2 is also I_1

$$\therefore \quad I_1 = \frac{V_{CC}}{R_1 + R_2}$$

or Voltage across Resistance R_2 is

$$V_2 = \left(\frac{V_{CC}}{R_1 + R_2}\right) R_2$$

Applying KVL in base circuit

$$V_2 = V_{BE} + V_E$$

$$V_2 = V_{BE} + I_E R_E$$

$$\text{or } I_E = \frac{V_2 - V_{BE}}{R_E}$$

Since $I_E \simeq I_C$

$$I_C = \frac{V_2 - V_{BE}}{R_E}$$

And Applying KVL to the collector side.

$$V_{CC} = I_C R_C + V_{CE} + I_E R_E$$

$$= I_C R_C + V_{CE} + I_C R_E \quad (\text{as } I_E \simeq I_C)$$

$$= I_C (R_C + R_E) + V_{CE}$$

Or $V_{CE} = V_{CC} - I_C (R_C + R_E)$

Note that excellent stabilisation is provided by R_E, and the stability factor of the circuit is unity provide maximum possible thermal stability.

— X — X — X — X —

Q 9(a) It is note that the transistor can work as amplifier only if proper associated circuitry is used with it. The varius circuit elements and their function are explained below.

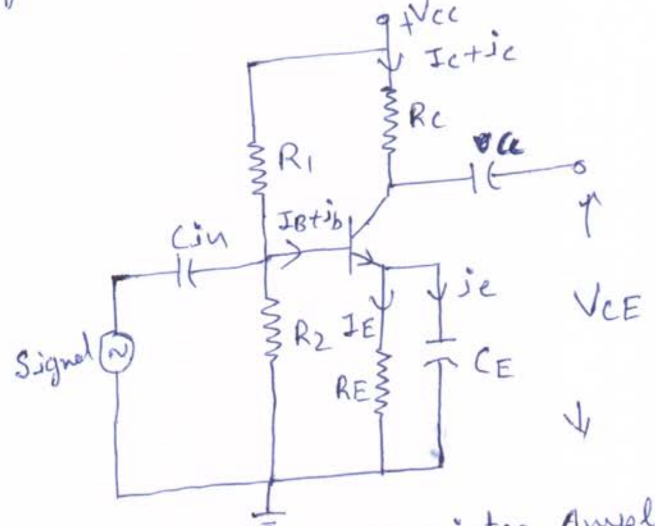
(i) Biasing circuit:- The resistance R_1, R_2 & R_E form the biasing and stabilisation circuit. The biasing circuit must establish a proper opearing point.

(ii) Input Capacitance :- An electrolytic capacitor C_{in} ($\simeq 10\mu F$) is used to couple the signal to the base of the transistor. If it is not used, the source resistance of signal will come across R_2 and thus change the bias. The capacitor C_{in} allows only a.c. signal to flow but isolate the signal source from R_2.

(iii) Emitter by pass capacitor :- An emitter bypass capacitor C_E ($\simeq 100\mu F$) is used in parallel with R_E

(20)

to provide a low reactance path to the amplified ac signal.



Single stage transistor Amplifier

(iv) Coupling capacitor :- The coupling capacitor C_c ($\simeq$ 10μF) couples one stage of amplifier to the next stage. If it is not used, biased condition of the next stage will be change due to the shunting effect of R_c.

Various current in the circuit are

(i) Base current :- When no signal is applied only d.c. base current flows, when ac is applied base current i_b also flows, hence total base current is given by

$$i_B = I_B + i_b.$$

(ii) Collector current :- When no signal is applied only d.c. I_c is flowing, when signal is applied, ac current i_c also flows. Thus total current is

$$i_C = I_c + i_c$$

(iii) Emitter current:-

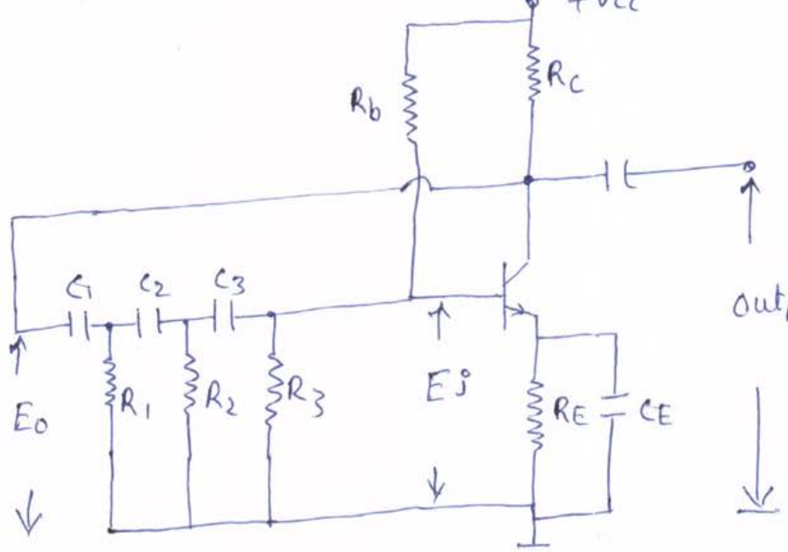
When no signal is applied, a d.c. emitter current I_E flows, when signal applied, i_e also flows, hence total current is

$$i_E = I_E + i_e$$

Also we know that

$$I_E = I_B + I_C$$
$$i_e = i_b + i_c$$

Q9b Figure shows circuit of BJT phase shift oscillator.



It consists of a single stage transistor amplifier and a RC phase shift network. The phase shift network consist of three sections R_1C_1, R_2C_2, and R_3C_3. At some particular frequency f_0, the phase shift in each RC section is 60° so that the total phase shift produced by the RC network is 180°. The frequency of oscillation is given by

$$f_0 = \frac{1}{2\pi RC\sqrt{6}}$$

where $R_1 = R_2 = R_3 = R$

and $C_1 = C_2 = C_3 = C$

Working :- When the circuit is on, it produces the frequency of oscillation given in above formula. The output E_0 of the amplifier is fed back to RC network. This network produces a phase shift of 180° and a voltage E_i appears at its output which is applied to the transistor amplifier.

Advantages :- (i) does not require transformer or inductor

(ii) Use to produce very low frequencies.

(iii) The circuit provide good frequency stability.

Disadvantage :-

(i) It is difficult for circuit to start oscillations.

(ii) The circuit gives small output

—x—x—x—

Text Books

1. V.N. Mittle & Arvind Mittal, `Basic Electrical Engineering`, Tata Mc Graw-Hill Publishing Company Limited, 2nd Edition

2. Electronic Devices and Circuits, Fourth Edition, David A Bell, PHI - 2006