S.Y. Diploma : Sem. III
[DE/EJ/ET/EN/EX/EQ/IE/IS/IC]

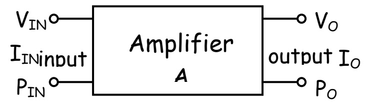
Applied Electronics

Time: 3 Hrs.] Prelim Question Paper Solution **[Marks : 70**

Q.1 Attempt any FIVE of the following : [10]

Q.1(a) Define amplifier with block diagram. [2]

Ans.: An electronic circuit which raises (i.e., increases) the level of input signal without distortion is known as amplifier.



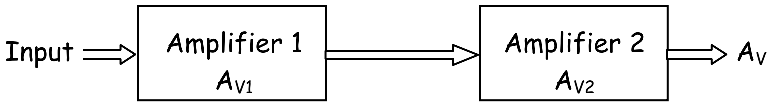
Q.1(b) State the need of multistage transistor amp [2]

Ans.: Need of Multistage amplifier

For most of the system a single transistor amplifier does not provide sufficient gain or will not have correct input or output impedance matching.

The solution is to combine multiple stages of amplification.

In multistage amplifier, voltage gain is product of individual voltage gain.

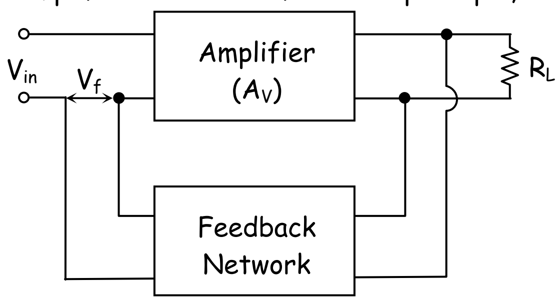


$$A_v = A_{V1} \times A_{V2}$$
$$A_V\,(dB) = 20 \log A_{V1} + 20 \log A_{V2}$$

Q.1(c) Define feedback. What are their types? [2]

Ans.: Feedback [2 marks]

Feedback is the process of injecting some energy from output and then return it back to the input. The amplifiers which use feedback principle, called feedback amplifier.



There are two types of feedback
(i) Positive Feedback (ii) Negative Feedback

Q.1(d) Define oscillator. [2]

Ans.: Introduction to Oscillators

- Oscillators are basically ac signal generators which you use in your laboratories. Oscillators generate alternating voltage of desired shape (sine, square, triangular etc), at desired frequency.
- The output voltage and frequency of an oscillator can be variable.
- The block diagram of a basic oscillator is shown in Figure.

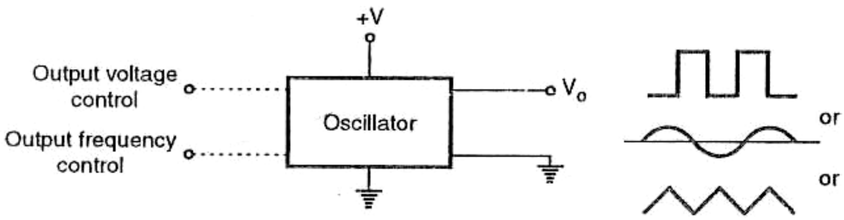
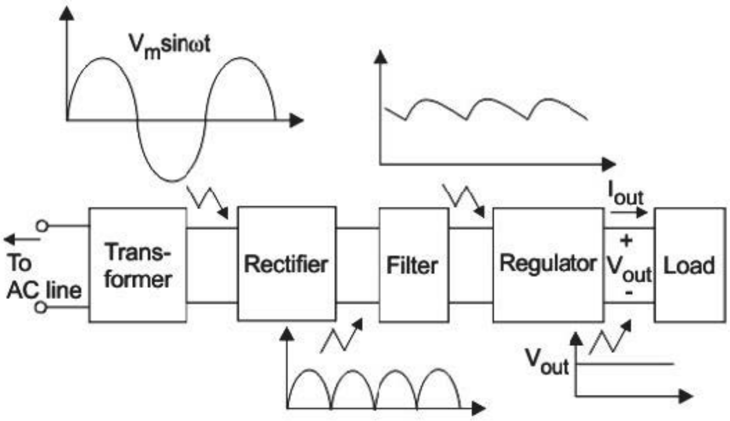


Fig. : Block diagram of an oscillator

Q.1(e) Draw block diagram of regulated dc voltage power supply. **[2]**

Ans.: **Functional block diagram of a regulated dc power supply**



Q.1(f) Define (i) Line Regulation (ii) Load regulation **[2]**

Ans.: **(i) Line Regulation**

It can be defined as ratio of change output voltage to change Input voltage.

$$\text{Line Regulation} = \frac{\text{Change in output voltages}}{\text{Change in input voltages}} = \frac{\Delta V_o}{\Delta V_i}$$

Ideally line regulation is zero.

(ii) Load Regulation

It is defined as change in output voltage that will occur per unit change in load current.

$$\text{Load Regulation} = \frac{V_{NL} - V_{FL}}{\Delta I_L}$$

V_{NL} = No load voltage
V_{FL} = Full load voltage
I_L = Load current

Q.1(g) Classify power amplifiers. **[2]**

Ans.:

Classification of power amplifiers

A) According to frequency

1. Audio power amplifier (20 Hz ≤ f ≤ 20 kHz)
   (i) Public address amplifier
   (ii) Stereo amplifier
   (iii) Final audio stage in radio, T.V., Tape-recorder, C.D. player, etc.
2. R.F. (radio frequency) power amplifier
   (i) Radio (AM or FM) transmitter
   (ii) T.V. transmitter

B) According to selection of Q (quiescent) point

(i) Class A
(ii) Class B
(iii) Class C
(iv) Class AB

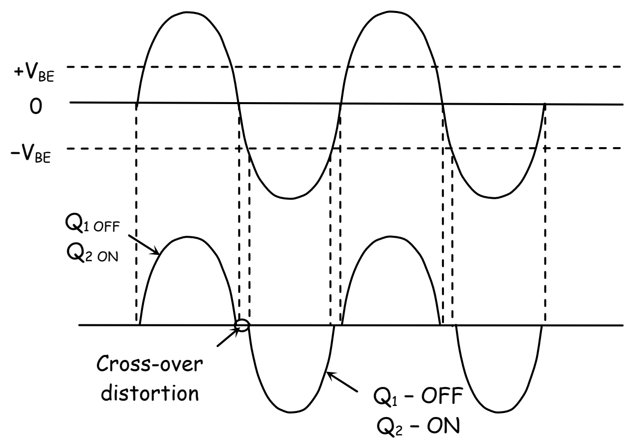
Q.2 Attempt any THREE of the following : **[12]**

Q.2 (a) Explain the term cross over distortion and state the method to overcome it. **[4]**

Ans.: In class B push-pull amplifier transistor's are biased at cut-off. It means a transistor does not conduct until the input signal exceeds 0.7 V for silicon and 0.3 V for germanium transistors.

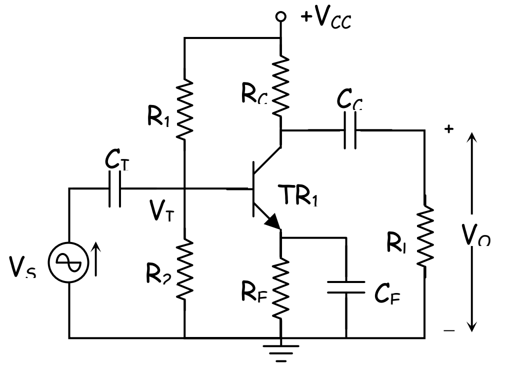
Because of this, there is a time interval between positive and negative alterations of input signal when neither transistor is conducting as shown in diagram. The resulting distortion in output signal is quite common and is called cross over distortion.

It may be avoided by applying slight forward bias to the base-emitter junction of both the transistors of amplifier circuit.

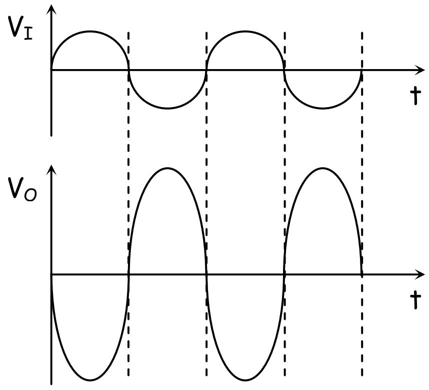


Q.2 (b) Draw single stage CE amp and explain the function of each component. **[4]**

Ans.: Block diagram :



Wave form :



1. $V_O > V_{IN}$ without distortion
2. V_O is 180° out of phase w.r.t. input voltage V_{IN}

Functions of each component :

(i) Resistors R_1 & R_2 : They are used as voltage divider biasing circuit to establish Q point in the centre of active region.

(ii) R_E : This emitter resistor also helps in selecting Q point. At the same time the negative feedback due to this resistor for D.C. voltage, stabilizes the operating point under D.C. condition.

(iii) C_{IN} : Input capacitor is used for following 2 reasons.
   (a) It blocks D.C. voltage at the base of transistor from reaching the function generator. If this is not prevented then function generator will get damaged.
   (b) It allows A.C. input signal from function generator to reach the base of the TR_1. This A.C. input signal is amplified by TR_1.

(iv) C_C : This is known as coupling capacitor at the output. It also does the same two functions viz.
   (a) To block D.C. voltage present at the collector of TR_1 from reaching the load resistor R_L.
   (b) It allows amplified A.C. output voltage to pass and reach load resistor R_L.

(v) C_E : It is known as emitter by–pass capacitor. At the emitter of TR_1 both D.C. and A.C. voltages are present. C_E blocks D.C. voltage but by–passes A.C. voltage. This removes negative feedback for the A.C. signal. The negative feedback reduces A_V. Since it is removed, A_V increases.

(vi) R_C : This collector resistor fixes the value of V_{CE}. Hence,
(a) It helps in establishing Q point in the centre of active region.
(b) $A_V \propto R_C$ Hence value of R_C decides the voltage gain A_V.

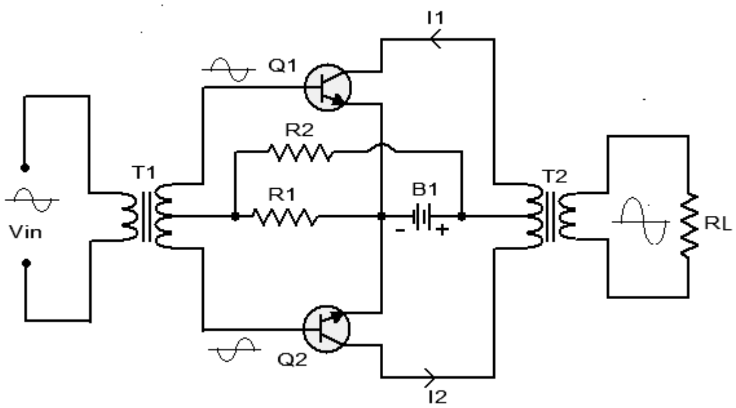
(vii) TR_1 : This transistor is used as an active device which actually does the amplification. $A_V \alpha \beta_{A.C.}$ Hence transistors having higher values of $\beta_{A.C.}$ are selected for increasing the voltage gain.

(viii) R_L : Load resistor R_L (or input resistance of next stage) should be selected properly to avoid loading (decreasing) of the output A.C. signal. The amplified output voltage is made available across R_L.

Q.2 (c) Compare class A, class B, class AB and class c amplifier. [4]
Ans.:

	Parameter	Class A	Class B	Class AB	Class C
(i)	Angle of conduction	360°	180°	More than 180°	Less than 180°
(ii)	Efficiency	25% can extend upto 50%	78.5%	78.5%	95%
(iii)	Position of operating point	At the centre of load line	On X-axis	Just above the X-axis	Below X-axis
(iv)	Power dissipation	Maximum	Less than A More than C	Less than A More than C	Minimum
(v)	Distortion	No distortion	More than A and AB	More than A less than B and C	Maximum distortion
(vi)	Application	Outdoor musical system	Used in Public address system, Stereo amplifier, tape recorder	In Hi fi system	Used in RF amplifier

Q.2 (d) Draw and explain class AB push-pull power amplifier. [4]
Ans.:



Class AB is another type of push pull amplifier which is almost similar to that of a Class A push pull amplifier and the only difference is that the value of biasing resistors R_1 and R_2 are so selected that the transistors are biased just at the cut in voltage (0.7 V). This reduces the time for which both transistors are simultaneously OFF (the time for which input signal is between (–0.7 V and +0.7 V) and so the cross over distortion gets reduced. Of the above said classes Class A has least distortion, then Class AB and then Class B. Any way Class AB configuration has reduced efficiency and wastes a reasonable amount of power during zero input condition. Class B has the highest efficiency (78.5%), then Class B (between 78.5 to 50%) and then Class A (50%).

A push pull amplifier can be made in Class A, Class B, Class AB or Class C configurations. The circuit diagram of a typical Class AB push pull amplifier is shown above. Q_1 and Q_2 are two identical transistor and their emitter terminals are connected together. R_1 and R_2 are meant for biasing the transistors. Collector terminals of the two transistor are connected to the respective ends of the primary of the output transformer T_2. Power supply is connected between the center tap of the T_2 primary and the emitter junction of the Q_1 and Q_2. Base terminal of each transistor is connected to the respective ends of the secondary of the input coupling transformer T_1. Input signal is applied to the primary of T1 and output load RL is connected across the secondary of T_2.Quiescent current of Q_2 and Q_1 flows in opposite directions through the corresponding halves of the primary of T_2 and as a result there will be no magnetic saturation. From the figure you can see the phase splited signals being applied to the base of each transistors. When Q_1 is driven positive using the first half of its input signal, the collector current of Q_1 increases. At the same time Q_2 is driven negative using the first half of its input signal and so the collector current of Q_2 decreases. From the figure you can understand that the collector currents of Q_1 and Q_2 i.e.; I_1 and I_2 flows in the same direction trough the corresponding halves of the T_2 primary. As a result an amplified version of the original input signal is induced in the T_2 secondary. It is clear that the current through the T_2 secondary is the difference between the two collector currents. Harmonics will be much less in the output due to cancellation and this is results in low distortion.

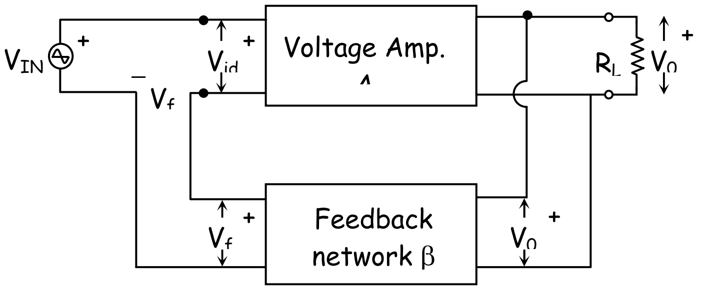
Q.3 Attempt any THREE of the following : [12]

Q.3(a) Draw block diagram of –ve feedback amplifier and define: [4]

(i) Open loop voltage gain A_v (ii) feedback factor β

(iii) closed loop or feedback voltage gain A_{fb}.

Ans.: Block diagram of –ve feedback amplifier



Definitions

(i) Open loop voltage gain (A_v)

$Av = \frac{V_0}{V_{id}}$. It is defined as the ratio of output voltage V_0 to the effective input V_{id} at the input terminals of the amplifier.

(ii) Feedback factor (β) : $\beta = \frac{V_f}{V_0}$

It is defined as the ratio of voltage fed back to the input terminals of the feedback amplifier (V_f) to the output voltage of the amplifier (V_0).

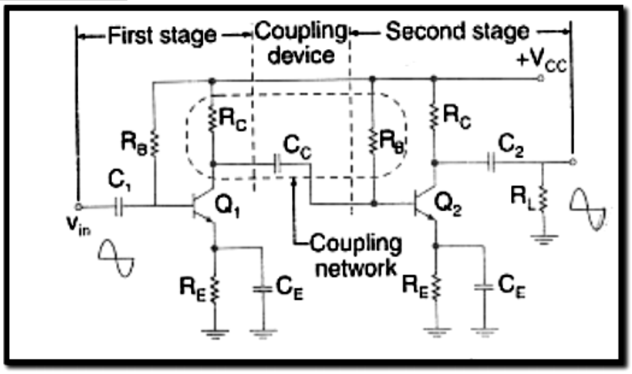
(iii) Closed loop or feedback voltage gain

$A_{fb} = \frac{V_0}{V_{IN}}$. It is defined as the ratio of output voltage v_0 of the feedback amplifier to the input voltage V_{IN} given from the signal generator.

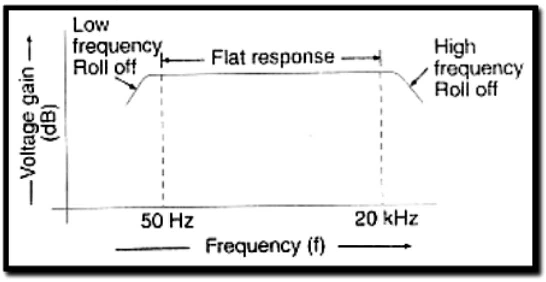
Q.3(b) Draw neat circuit of two stage RC coupled amplifier and also draw it's frequency response. [4]

Ans.:

Circuit Diagram:

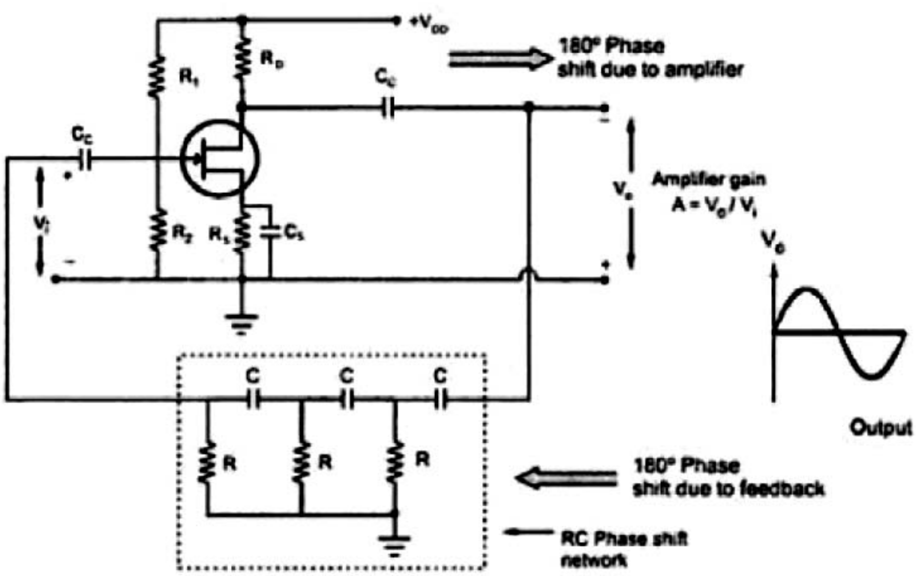


Frequency Response:



Q.3(c) Draw labeled circuit of RC phase shift oscillator. State the formula for frequency of oscillation. [4]

Ans.:

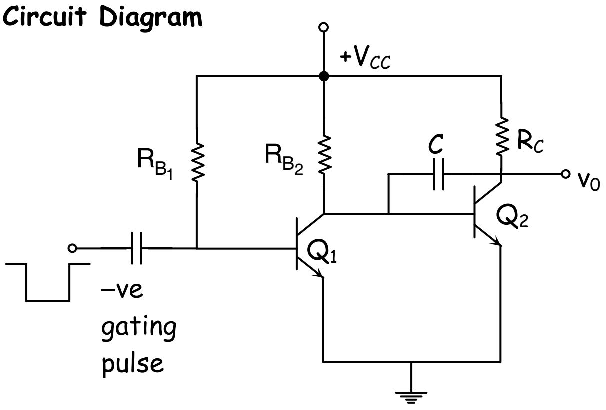


Formula for frequency of oscillation is given by,

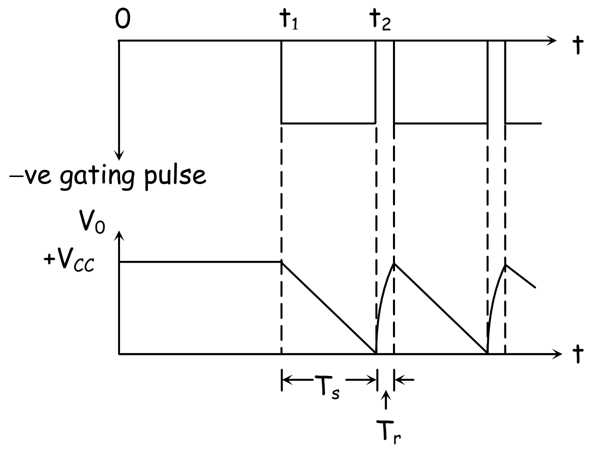
$$f = \frac{1}{2\pi CR\sqrt{6}}$$

Q.3(d) Draw and explain miller sweep circuit. **[4]**

Ans.: **(i) Circuit Diagram**



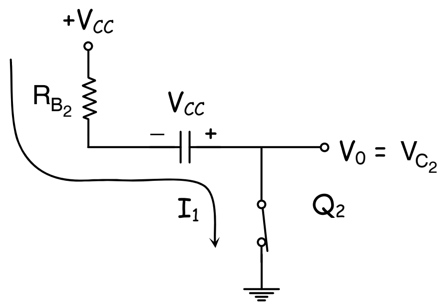
(ii) Waveforms



Working

At t = 0, –ve gating pulse is not given to the base of Q_1. Values of R_{B_1} and R_{B_2} are so selected that Q_1 goes into saturation $V_{C_1} = 0.2V = V_{B_2}$. But this base voltage is not sufficient for Q_2 to become ON. Since Q_2 is off, $v_{C_2} = V_0 = +V_{CC}$. Thus capacitor is charged to a voltage of $+V_{CC}$ with right plate +ve. $V_0 = +V_{CC}$ and is a horizontal line as shown in output waveform.

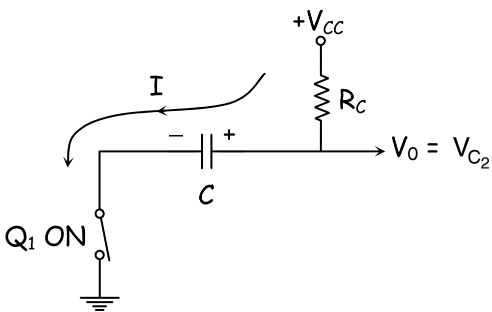
At t = t_1 and a –ve going gating pulse is given to the base of Q_1. Due to this it goes into cut–off and $V_{C_1} = V_{B_2} = +V_{CC}$. Transistor Q_2 now starts conducting and its $V_{C_2} = V_0$ starts decreasing. In this case charged capacitor starts discharging because of opposite charging current I_1 as shown.



Here discharging time constant = $R_{B_2} \times C$.

The capacitor is connected between collector and base of Q_2. Hence v_{C_2} is communicated to base of Q_2 immediately. The value of R_{B_2} is very high hence discharging current I_1 is almost constant. Due to this capacitor discharge linearly and $V_C = V_0$ starts decreasing linearly w.r.t. time as shown in the output waveform.

When $V_0 = V_{C_2} = 0$ the –ve gating pulse is removed at t = t_2. Now once again Q_1 goes into saturation and Q_2 goes into cut–off. The capacitor now charges due to I_2 as shown below. The charging time constant in this case is $R_C \times C$. Since R_C is small 'C' charges very quickly and $V_0 = V_{C_2} = +V_{CC}$.



(i) In the above circuit time constant for T_s is $R_{B_2} \times C$ and time constant for T_r is $R_C \times C$. Since $R_{B_2} >> R_C$ we get $T_s \times T_r$

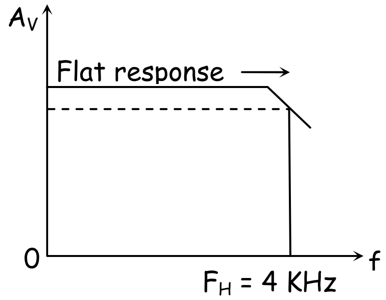
(ii) The output voltage is a linear –ve going ramp voltage for the time period of T_s.

Q.4 Attempt any THREE of the following : [12]

Q.4 (a) Calculate bandwidth of direct coupled amplifier having frequency response with upper 3dB cut of frequency as 4kHz. Sketch the frequency response. [4]

Ans.: **Given data**

- Amplifier → Directly coupled amplifier
- Frequency response
- B.W. = $f_H - f_L$
  = 4 KHz – 0
  B.W. = 4 KHz



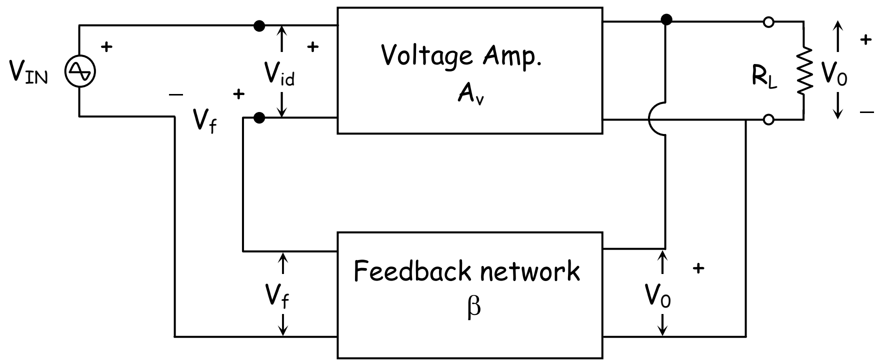
Q.4 (b) Calculate output frequency of RC phase shift oscillator if $R_1 = R_2 = R_3 = 2k\Omega$ and $C_1 = C_2 = C_3 = 0.1$ frequency. [4]

Ans.: $f = \dfrac{1}{2\pi\sqrt{6}\ RC} = \dfrac{1}{2\pi\sqrt{6}\times 2\times 10^3 \times 0.1\times 10^{-6}}$

$= \dfrac{1}{2\pi\sqrt{6}\times 0.2\times 10^{-3}} = \dfrac{1000}{2\pi\sqrt{6}\times 0.2} = \dfrac{1000}{3.078} = 324.88$ Hz

Q.4 (c) Derive an expression for the closed loop gain of –ve feedback amplifier. [4]

Ans.:



Applying K.V.L. at the input of the amplifier

We get

Σ All voltages = 0 $\quad \therefore +V_{IN} - v_{id} - v_f = 0$

$\therefore \quad V_{IN} - V_f = v_{id}$. By definition of feedback factor

$\beta = \dfrac{V_f}{V_0}$ hence $V_f = \beta v_0$. Putting this value in above equation we get

$V_{IN} - \beta\, v_0 = v_{id}$ ... (1)

By definition of open loop voltage gain $Av = \dfrac{v_0}{v_{id}}$

$\therefore \quad v_0 = A_v v_{id}$ from equation (1)

$v_0 = A_v (V_{IN} - \beta v_0) = A_v\, v_{IN} - A_v\beta v_0$

$\therefore \quad V_0 + A_v\, \beta\, v_0 = A_v\, v_{IN} \qquad \therefore \quad V_0\,(1 + A_v\, \beta) = A_v\, v_{IN}$

$\therefore \quad \dfrac{v_0}{V_{IN}} = \dfrac{A_V}{1 + A_V\beta}$ But by definition $\dfrac{v_0}{V_{IN}} = A_{fb} =$ closed loop voltage gain.

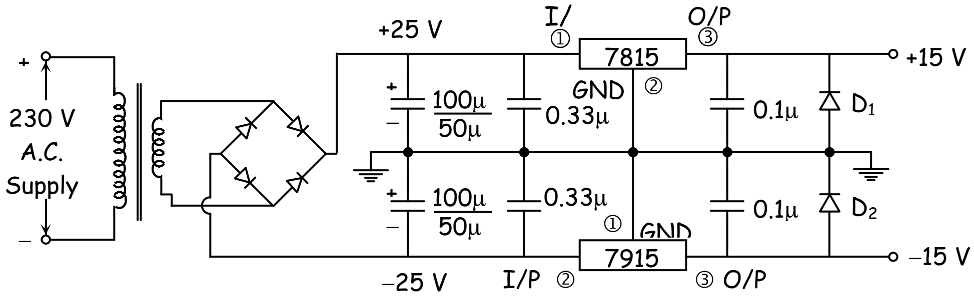
Hence $A_{fb} = \dfrac{A_v}{1 + A_v\beta}$

In the above expression denominator > 1.

Hence $A_{fb} < A_v$ i.e. voltage gain of the amplifier reduces when –ve feedback is used.

Q.4 (d) Draw ±15V dual regulated power supply. **[4]**

Ans.: Circuit diagram of dual ± 15V regulated power supply.

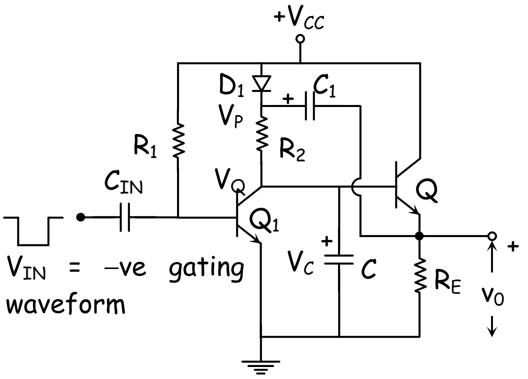


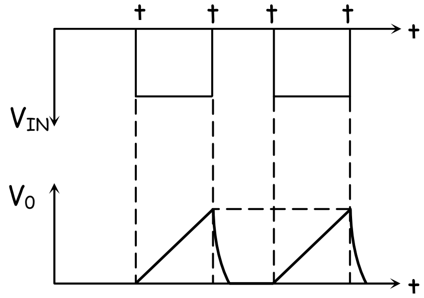
Diodes D_1 and D_2 are connected at the output and are working as protection circuit.

Q.5 Attempt any TWO of the following : **[12]**

Q.5 (a) Draw and explain Bootstrap sweep circuit. **[4]**

Ans.: **(i) Circuit Diagram :** **(ii) Waveforms :**





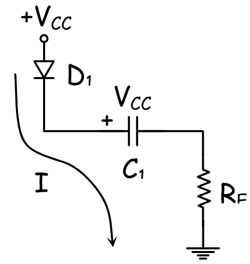
$C_1 \gg C$

$Q_1 \Rightarrow$ Switch

$Q_2 \Rightarrow$ Emitter follower

Working

At t = 0, –ve gating input voltage V_{IN} is absent. The values of R_1 and R_2 are so selected that Q_1 is driven into saturation and acts as a closed switch across C. The capacitor is prevented from charging hence $V_c = V_Q = 0$. This voltage is given to the base of Q_2 which is acting as emitter follower. Q_2 remains off and hence $V_{E_2} = V_0 = 0$ till –ve gating pulse is given.



During this time current I_1 flows in the circuit as shown. This current charges C_1 to $+V_{CC}$ with the polarity in very short time because it is charging through ($r_f + R_E$) where R_f = forward resistance of diode which is very small and value of R_E is also small. Now anode and cathode voltage of D_1 are both at the same voltage of $+V_{CC}$ volts and hence it is reverse biased due to which I_1 stops flowing immediately when C_1 is fully charged to $+V_{CC}$ volts. Due to reverse biased diode D_1, supply voltage of $+V_{CC}$ is not connected to collector of Q_1.

Now at t = t_1, $-V_{IN}$ is given to the base of Q_1. Its magnitude is so selected that Q_1 is driven into cut–off region. It acts as open switch and allows capacitor 'C' to charge, by the voltage of $+V_{CC}$ across C_1 which now acts as a d.c. battery, through resistor R_2. Due to this $V_C = V_Q$ starts increasing. Since Q_2 is acting as emitter follows $V_{E_2} = v_0$ follows this base voltage and starts increasing by same voltage (ΔV) and hence $v_0 = V_{E_2} = V_C$. This rising voltage of ΔV is immediately communicated by C_1 to the top of resistor R_2. Hence V_p also increases by same amount and becomes $V_P = V_{CC} + \Delta V$. Since $C_1 \gg C$ charged capacitor C_1 does not discharge much.

Now $V_P - V_Q = (V_{CC} + \Delta V) - \Delta V = +V_{CC}$ i.e. voltage drop across charging resistor R_2 remains constant and equal to $+V_{CC}$ all the time. Hence charging current supplied by R_2 remains constant and is equal to $\frac{+V_{CC}}{R_2}$ all the time. Due to this 'C' is charged by constant current and hence $V_C = V_0$ increases linearly w.r.t. time during the time period from t_1 to t_2.

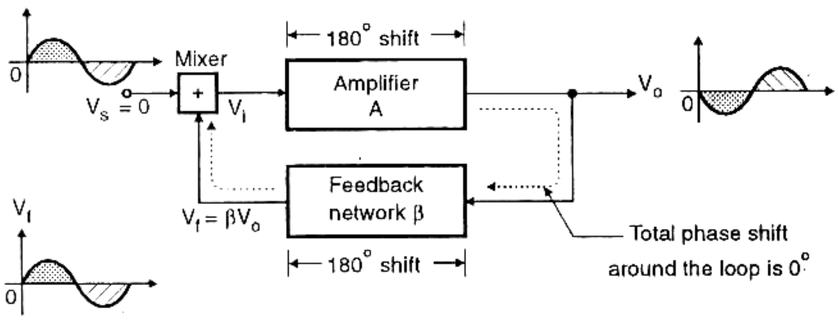
At $t = t_2$, $-V_{IN}$ is removed and hence Q_1 goes into saturation and Q_2 goes into cut off and $V_0 = 0$ volts. Now if V_{IN} is continuously repeated all the waveforms repeats themselves.

Q.5 (b) Explain Barkhausen's criteria in detail. [4]

Ans.: Barkhausen Criteria

- The Barkausen criteria should be satisfied by an amplifier with positive feedback to ensure the sustained oscillations.
- For an oscillator circuit, there is no input signal "V_s", hence the feedback signal V_f itself should be sufficient to maintain the oscillations.
- Refer to figure to understand the Barkhausen criteria.
- From figure the expression for output voltage V_o is,

  $V_o = A\ V_i$ ... (1)



- But V_i is the sum of V_s and V_f

  $\therefore \quad V_i = V_s + V_f$ ... (2)

  Note that we have added V_s and V_f because in positive feedback v_s and V_f will be in phase with be in phase with each other am hence will get added.
- The expression for feedback voltage is,

  $V_f = \beta V_o$ ... (3)

  Substitute the value of V_o from Equation (1) into Equation (3) to get,

  $V_f = \beta\ A\ V_i$ ... (4)
- Substitute this equation into Equation (2) to get,

  $V_i = V_s + A\ \beta V_i$

  $\therefore \quad (1 - A\beta)V_i = V_s$ ... (5)
- For an oscillator the input voltage V_s is absent i.e. $V_s = 0$ and the feedback signal V_f is supposed to maintain the oscillations. Therefore substitute $V_s = 0$ into Equation (5) to get,

  $V_i(1 - A\ \beta) = 0$

  or $\quad A\ \beta = 1$ ... (6)

  [This condition must be satisfied in order to obtain sustained oscillations. Alongwith this condition, the condition for the positive feedback which states that the phase shift between V_s and V_f must be zero, should also be satisfied.]
- With an inverting amplifier introducing a 180° phase shift between V_i and V_o, the feedback network must introduce another 180° phase shift to ensure that V_i and V_f are in phase.
- These two conditions which are required to be satisfied to operate the circuit as an oscillator are called as the "Barkhausen criterion" for sustained oscillations.

Q.5 (c) Complementary symmetry push-pall amplifier is operated using ± 10V and deliver power to load RL = 5Ω calculate: **[4]**
(i) Max power output
(ii) Power rating of transistor
(iii) DC input at max power output

Ans.: $V_{CC} = \pm 10$ V $\qquad R_L = 5\ \Omega$

(i) Maximum power output

$$P_{O\,(max)} = \frac{V_{CC}^2}{2R_L} = \frac{(10)^2}{2\times 5} = 10\ W$$

(ii) Power rating of transistor

$$V_m = \frac{2}{\pi}V_{CC} = \frac{2}{\pi}\times 10 = 6.36\ V$$

Total collector power rating in two transistors.

$$P_{C\,(dc)} = P_{in\,(dc)} - P_{o\,(ac)}$$

$$= V_{CC}\left(\frac{2V_m}{\pi R_L}\right) - \left(\frac{V_m^2}{2R_L}\right)$$

$$= 10\left(\frac{2\times 6.36}{\pi\times 5}\right) - \left(\frac{6.36}{2\times 5}\right)^2$$

$$= 4.052\ W$$

Power rating of each transistor $\frac{P_{C(dc)}}{2} = \frac{4.052}{2} = 2.026\ W$

(iii) D.C. input at maximum power output [2 marks]

$$P_{in(dc)\,max} = V_{CC}\times\frac{2V_{CC}}{\pi R_L} = 10\left(\frac{2\times 10}{\pi\times 5}\right) = 12.73\ W$$

Q.6 Attempt any TWO of the following : **[12]**

Q.6 (a) In amplifier has a gain 'A' at 300 without feedback output impedance is 1kΩ. If negative feedback with feedback factor of 0.03 is introduced in the circuit then calculate the gain with feedback and output impedance at this feedback amplifier. **[6]**

Ans.: **Given data :**

$A_V = 300$ (without feedback)

$\beta = 0.03$

$R_O = 1\ k\Omega$

$$A_{Vf} = \frac{A_V}{1+\beta.A_V} = \frac{300}{1+(0.03)(300)}$$

$A_{Vf} = 30$

(i) For voltage series and voltage shunt feedback connection.

$$R_{Of} = \frac{R_O}{1+\beta.A_V}$$

$$= \frac{1\times 10^3}{1+(0.03)(300)}$$

$R_{Of} = 100\ \Omega$

(ii) For current series and current shunt connection.

$R_{Of} = R_O\,(1 + \beta.A_V)$

$= 1\times 10^3\,[1 + (0.03)\,(300)]$

$= 1\times 10^3\times 10$

$R_{Of} = 10\ k\Omega$

Q.6 (b) State advantages and disadvantages at negative feedback. **[6]**

Ans.: Advantages

(i) Bandwidth of the amplifier increases $(B.W.)_{new} = (1 + A_v\beta)(B.W.)_{old}$

(ii) (Amplitude, frequency, phase harmonic) distortion of the amplifier reduces.

$$D_{0\,(new)} = \frac{D_{old}}{(1+A_v\beta)}$$

(iii) Noise signal in the output reduces.

$$N_{0(new)} = \frac{N_{0(old)}}{1+A_v\beta}$$

(iv) Stability of the amplifier improves due to which voltage gain becomes independent of transistor parameters and hence it remains almost constant.

(v) (a) R_{IN} for voltage amplifier should be high.

(b) R_0 of voltage amplifier should be low.

By using voltage series –ve feedback amplifier, R_{IN} increases and R_0 decreases.

$$R_{IN_{(new)}} = (1 + A_v\beta)\, R_{IN}(old)$$

$$R_{O(new)} = \frac{R_{0(old)}}{1+A_v\beta}$$

Disadvantages

The only disadvantage is that voltage gain of the amplifier decreases

$$A_{fb} = \frac{A_v}{1+A_v\beta}$$

But if more voltage gain is required then multistage amplifiers with –ve feedback can be used.

Q.6 (c) State the effect of low load regulation factor and higher load regulation factor on power supply. Also state the significance at how line regulation factor. **[6]**

Ans.:

- If load regulation is defined as the ratio of change in output voltage that will occur per unit change in load current.
- If load regulation factor is low then it indicates change in output voltage due to change in load current is less.
- If the load regulation factor is high then change in output voltage is more due to change in output current.
- **Significance of low load regulation factor**
  (i) Low load regulation factor indicates output voltages changes less due to change in load current i.e. it maintains output voltage constant.
  (ii) Ideally load regulation should be zero which indicates there is no change in output voltage due to change in load current. Practically, load regulation is low.

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