UNIT-4 >>CURRENT MIRROR AND OP-AMP DESIGN

CLASS>>II$_{ND}$ YEAR, IV SEM

SUBJECT-ANALOG CIRCUITS

PAPER-CODE>>BT-402

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TOPIC>>CLASS(A,B,AB,C)Linearity issues

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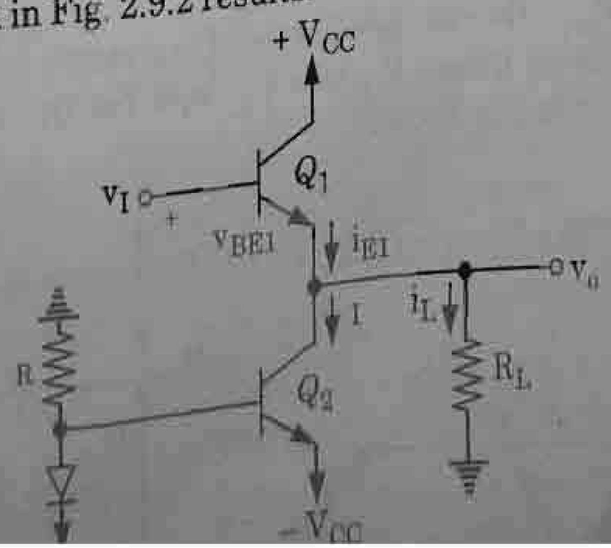
Linearity issues of Class A:-

1. An emitter follower (Class A) Q_1 biased with a constant current I supplied by transistor Q_2.
2. The emitter current $i_{E1} = I + i_L$, the bias current I must be greater than the largest negative load current; otherwise, Q_1 cuts off and class A operation will no longer be maintained.
3. The transfer characteristic of the emitter follower of Fig. 2.9.1 is described by

$$v_o = v_I - v_{BE1}$$

where v_{BE1} depends on the emitter current i_{E1} and thus on the load current i_L.

4. If we neglect the relatively small changes in v_{BE1}, the linear transfer curve shown in Fig. 2.9.2 results.



5. As indicated, the positive limit of the linear region is determined by the saturation of Q_1, thus

$$v_{o\,max} = V_{CC} - V_{CE1sat}$$

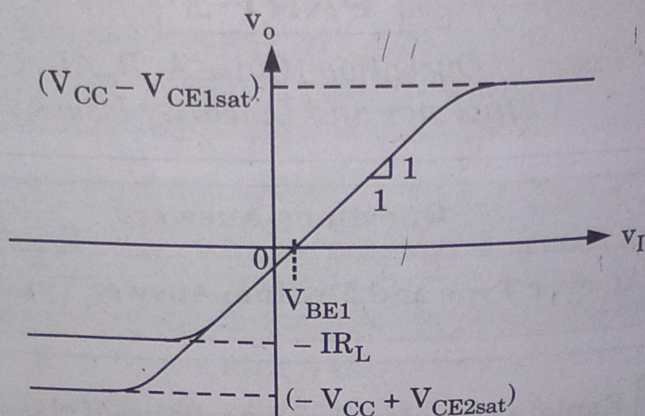


Fig. 2.9.2. Transfer characteristic of the emitter follower.

6. In the negative direction, depending on the values of I and R_L, the limit of the linear region is determined either by Q_1 turning off,

$$v_{o\,min} = -IR_L$$

or by Q_2 saturating,

$$v_{o\,min} = -V_{CC} + V_{CE2sat} \quad ...(2.9.1)$$

7. The absolutely lowest output voltage is that given by eq. (2.9.1) and is achieved provided the bias current I is greater than the magnitude of the corresponding load current,

$$I \geq \frac{|-V_{CC} + V_{CE2sat}|}{R_L}$$

Signal wavefor...

Linearity issues of class AB:-

1. A bias voltage V_{BB} is applied between the bases of Q_N and Q_P. For $v_I = 0$, $v_o = 0$, and a voltage $V_{BB}/2$ appears across the base-emitter junction of each of Q_N and Q_P.
2. Assuming matched devices,

$$i_N = i_P = I_Q = I_S e^{V_{BB}/2V_T} \quad \text{...(2.13.1)}$$

3. When v_I goes positive by a certain amount, the voltage at the base of Q_N increases by the same amount and the output becomes positive at an almost equal value,

$$v_o = v_I + \frac{V_{BB}}{2} - v_{BEN} \quad \text{...(2.13.2)}$$

4. The positive v_o causes a current i_L to flow through R_L, and thus i_N must increase i.e.,

$$i_N = i_P + i_L \quad \text{...(2.13.3)}$$

The increase in i_N will be accompanied by a corresponding increase in v_{BEN}.

5. Since the voltage between the two bases remains constant at V_{BB}, the increase in v_{BEN} will result in an equal decrease in v_{EBP} and hence in i_P. The relationship between i_N and i_P can be derived as follows.

$$v_{BEN} + v_{EBP} = V_{BB}$$

$$V_T \ln \frac{i_N}{I_S} + V_T \ln \frac{i_P}{I_S} = 2V_T \ln \frac{I_Q}{I_S}$$

$$i_N i_P = I_Q^2 \quad \text{...(2.13.4)}$$

6. Eq. (2.13.3) and (2.13.4) can be combined and we get

$$i_N^2 - i_L i_N - I_Q^2 = 0 \quad \text{...(2.13.5)}$$

7. For positive output voltages, the load current is supplied by Q_N, which acts as the output emitter follower. Meanwhile, Q_P will be conducting a current that decreases as v_o increases, for large v_o the current in Q_P can be ignored altogether.
8. For negative input voltages the opposite occurs, the load current will be supplied by Q_P, which acts as the output emitter follower, while Q_N conducts a current that gets smaller as v_I becomes more negative. Eq. (2.13.4), relating i_N and i_P, holds for negative inputs as well.
9. We conclude that the class *AB* stage operates in much the same manner as the class *B* circuit, with one important exception. For small v_I, both transistors, and as v_I is increased or decreased, one of the two transistors takes over the operation.
10. Since the transition is a smooth one, crossover distortion will be almost totally eliminated. Fig. 2.13.1 shows the transfer characteristic of the class *AB* stage.