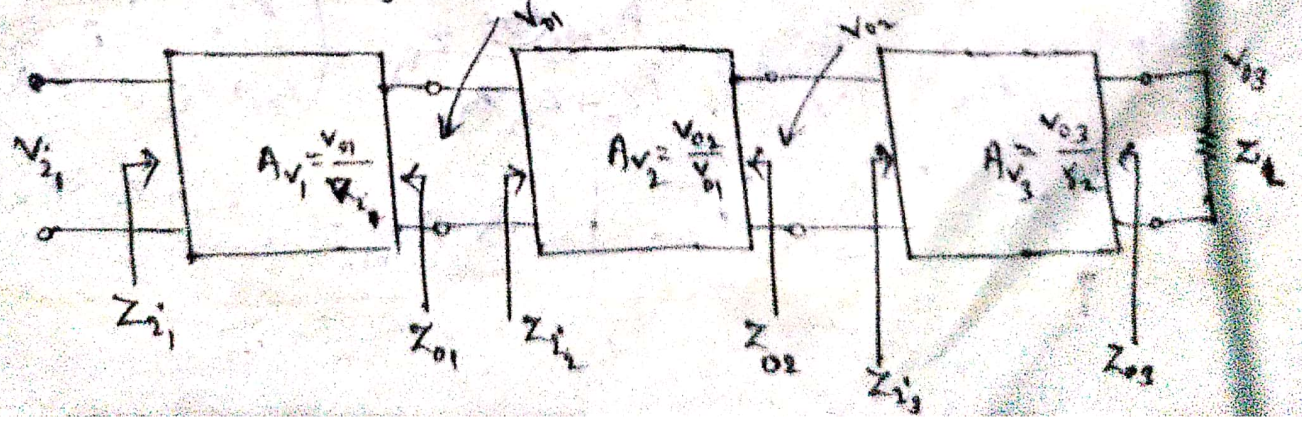
(1)

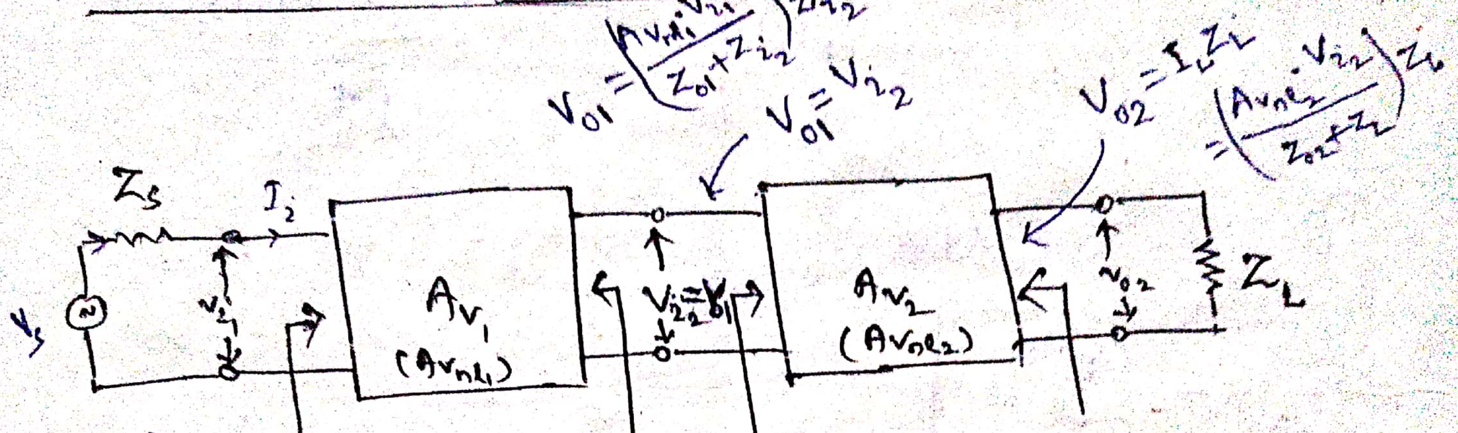
CASCADED SYSTEM

When two or more systems are connected in such a way that the input impedance of succeeding system acts a load to preceeding system as shown in fig-1 as below is called cascading.



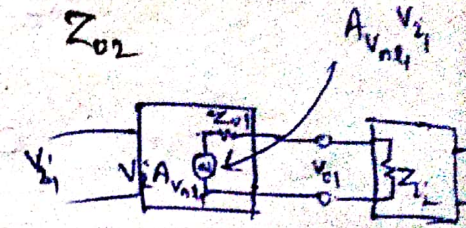
Cascaded system of effect of source impedance

(2)



$V_S = I_i(Z_S + Z_{i_1})$

$V_{i_1} = I_i Z_{i_1}$



The above figr. shows cascading of two systems with no-load gain A_{vnl_1} and A_{vnl_2} and loaded gain A_{v_1} and A_{v_2}.

Now,

$$A_{v_1} = \frac{V_{01}}{V_{i_1}} = \frac{A_{vnl_1} V_{i_1}}{(Z_{01}+Z_{i_2}) V_{i_1}} \cdot Z_{i_2} = \left(\frac{Z_{i_2}}{Z_{01}+Z_{i_2}}\right) A_{vnl_1}$$

$$\boxed{A_{v_1} = \left(\frac{Z_{i_2}}{Z_{01}+Z_{i_2}}\right) A_{vnl_1}} \Rightarrow A_{vnl_1} = \frac{(Z_{01}+Z_{i_2}) A_{v_1}}{Z_{i_2}} \quad \text{—(1)}$$

Similarly —

$$A_{v_2} = \frac{V_{o2}}{V_{i_2}} = \left(\frac{A_{vnl_2} \cdot \cancel{V_{i_2}}}{Z_{o2}+Z_L}\right) \cdot Z_L \cdot \frac{1}{\cancel{V_{i_2}}} = \left(\frac{Z_L}{Z_L+Z_{o2}}\right) A_{vnl_2}$$

$$\boxed{A_{v_2} = \left(\frac{Z_L}{Z_L+Z_{o2}}\right) A_{vnl_2}} \Rightarrow A_{vnl_2} = \frac{A_{v_2}(Z_L+Z_{o2})}{Z_L} \quad \text{— (ii)}$$

$$\therefore \boxed{A_{v_T} = A_{v_1} \cdot A_{v_2}} \Rightarrow A_{v_T} = \left(\frac{Z_{i_2}}{Z_{o1}+Z_{i_2}}\right)\left(\frac{Z_L}{Z_L+Z_{o2}}\right) A_{vnl_1} \cdot A_{vnl_2}$$

$$\Rightarrow \boxed{A_{v_T} = \left(\frac{Z_{i_2}}{Z_{i_2}+Z_{o1}}\right)\left(\frac{Z_L}{Z_L+Z_{o2}}\right) A_{vnl_1} \cdot A_{vnl_2}} = A_{v_1}\left(\frac{Z_L}{Z_L+Z_{o2}}\right) A_{vnl_2}$$

Now, when effect of source is considered.

$$A_{v_s} = \frac{V_{o2}}{V_s} = \frac{A_{vnl_2} V_{i_2}}{(Z_{o2}+Z_L)} \cdot Z_L \cdot \frac{1}{V_s} = \left(\frac{Z_L}{Z_L+Z_{o2}}\right) \frac{V_{i_2}}{V_s} \cdot A_{vnl_2}$$

$$= \left\{\left(\frac{Z_L}{Z_L+Z_{o2}}\right) A_{vnl_2}\right\} \cdot \frac{A_{vnl_1} \cdot V_{i_1}}{Z_{o1}+Z_{i_2}} \cdot Z_{i_2} \cdot \frac{1}{V_s}$$

$$= A_{v_2} \cdot \left\{\frac{A_{vnl_1} Z_{i_2}}{Z_{i_2}+Z_{o1}}\right\} \cdot \frac{V_{i_1}}{V_s} \quad [\text{from eq (1)}]$$

$$= A_{v_2} \cdot A_{v_1} \frac{\cancel{I_1}(Z_{i_1})}{\cancel{I_1}(Z_{i_1}+Z_s)} = A_{v_1} \cdot A_{v_2}\left(\frac{Z_{i_1}}{Z_{i_1}+Z_s}\right)$$

$$\Rightarrow \boxed{A_{v_s} = A_{v_T} \cdot \left(\frac{Z_{i_1}}{Z_{i_1}+Z_s}\right)}$$

$V_{i_1} = I_1 Z_{i_1}$

$V_s = I_1 (Z_{i_1}+Z_s)$

Current gain is given by —

$$A_{i_T} = -A_{v_T}\left(\frac{Z_{i_1}}{Z_L}\right)$$

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CASCODE CONNECTION

When two transistors are connected in different configuration, then thus obtained connection is termed as cascode connection. The fig-1 and fig-2 represents cascode connection where leading transistor is in CE configuration and following transistor is in CB configuration.

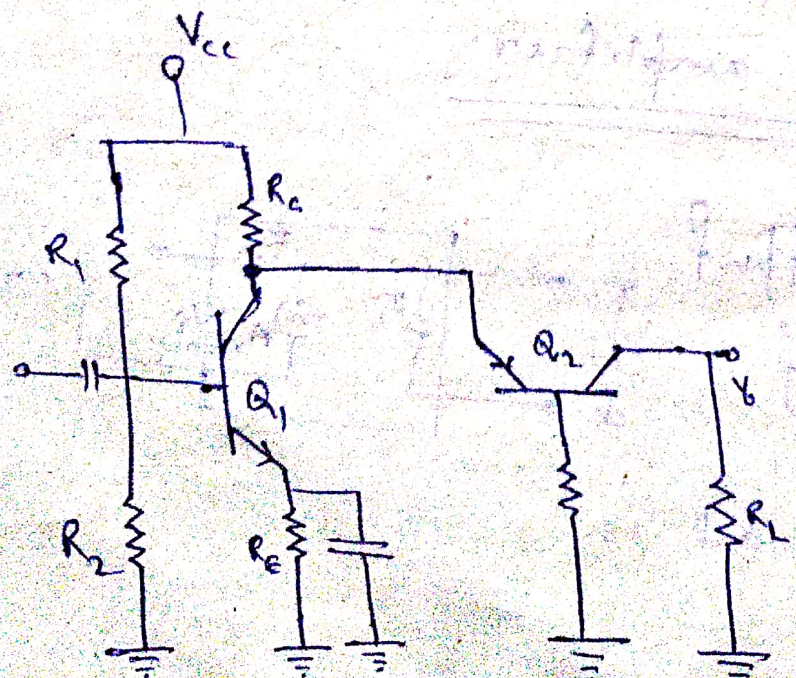


Fig-1.

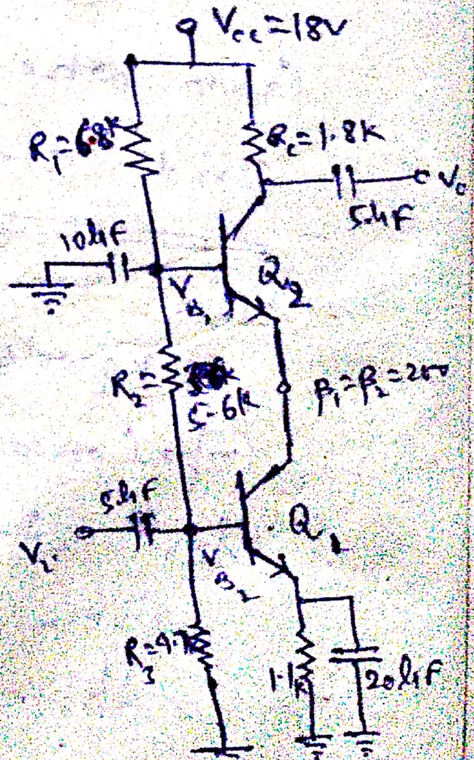


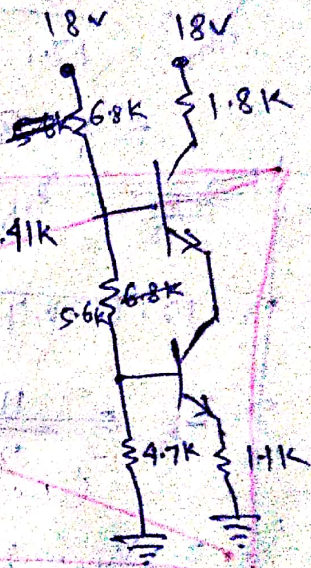
Fig-2

(5) D.C biasing analysis of cascode amplifier in fig-2

It is clear that, input signal is applied to transistor Q_2 and base of Q_1 is grounded and output is taken betn collector of Q_1 and ground. Hence, fig-2 consist of Q_1 ~~leading~~ leading by Q_2.

For d.c biasing analysis —

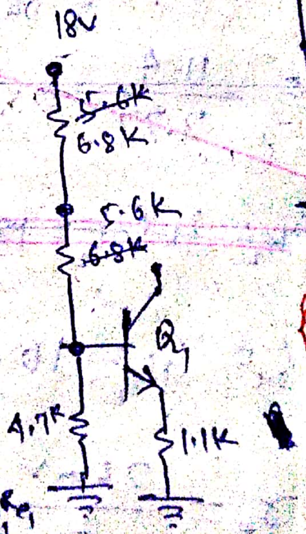
For, Q_1 —



$$R_{Th_1} = \boxed{\frac{5.6\times 10.5}{17.1} = 3.766} = \frac{12.4\times 4.7}{17.1} = 3.41k$$

$$V_{Th_1} = \frac{18}{17.1}\times 4.7$$

$$= 4.947 \text{ volt}$$



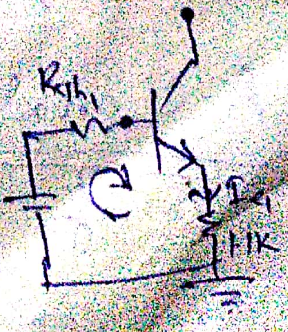
For Tr. Q_1, $\{(6.8+5.6)||4.7\}\Omega$

Applying KVL to Q_1

$$V_{Th_1} = I_b R_{Th_1} + 0.7 + I_{e_1} R_1$$

$$\text{or } 4.947 - 0.7 = I_{b_1} R_{Th_1} + (\beta+1) I_{b_1} R_{e_1}$$

$$\text{or, } I_{b_1} = \frac{4.247}{R_{Th_1} + (\beta+1) R_{e_1}}$$



$$I_{b_1} = \frac{4.294}{3.41 + 201\times 1.1} = 0.018942\,mA$$

$$I_{e_1} = (\beta+1) I_{b_1} = 3.80\,mA$$

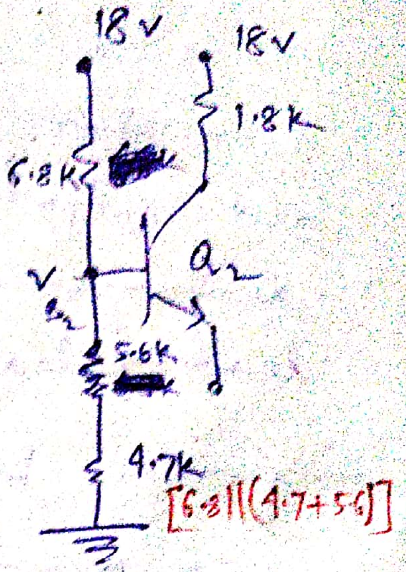
$$V_{B_1} = V_{Th_1} - I_b R_{Th_1} = 4.947 - 0.018942\times 3.41 = 4.88 \approx 4.9 \text{ volt}$$

$$I_{c_1} \simeq I_{e_1} = 3.8\,mA$$

(6) from cascode connection — (Trans, Q_2)

$I_{e_2} = I_{c_1} = 3.8\,mA$

For transistor Q_2 —



$R_{Th_2} = \dfrac{6.8 \times 10.3}{17.1} = 4.1k$

$V_{Th_2} = \dfrac{18}{17.1} \times 10.3$

$= 10.8$

~~$V_{Th_2} = I_b R_{Th_2} + 0.7$~~

~~$12.1 - 0.7 = I_{b_2} R_{Th_2}$~~

~~$I_{b_2} = \dfrac{11.4}{3.77} = 0.003024\,mA$~~

~~$V_{B_2} = V_{Th_2} - I_b R_{Th_2} = 12.1$~~

$\therefore V_{B_2} = V_{dc} = V_{Th_2} = 10.8$ volt.

Now, $r_{e_1} = \dfrac{26\,mV}{I_{e_1}} = \dfrac{26}{3.8} = 6.8\,\Omega$

$r_{e_2} = \dfrac{26\,mV}{I_{e_2}} = \dfrac{26}{I_{c_1}} = \dfrac{26}{3.8} = 6.8\,\Omega$

A.C analysis

For a.c analysis, all d.c components are considered as effectless or assumed to be removed.

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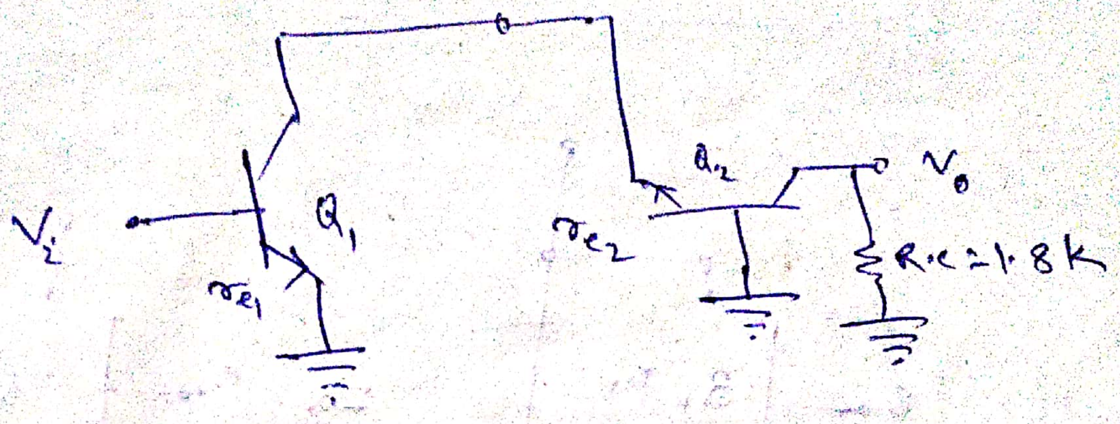

Here, loading of Q_1 is dynamic resistance r_{e_2} of Q_2.

$$\therefore A_{V_{nl_1}} = -\frac{R_c}{r_e} = -\frac{r_{e_2}}{r_{e_1}} = -1 \quad [-ve \text{ for CE}]$$

Again,

Loading of Q_2 is $R_c = 1.8k$.

$$\therefore A_{v_{nl_2}} = +\frac{R_c}{r_{e_2}} \quad [+ve \text{ for CB}]$$

$$= \frac{1.8 \times 10^3}{6.8} = 264.7$$

$\therefore$ Over-all no load gain,

$$\boxed{A_{V_{T(nl)}} = A_{v_{nl_1}} \cdot A_{v_{nl_2}} = -264.7} \text{ Ans.}$$

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