EEE-2103: Electronic Devices and Circuits

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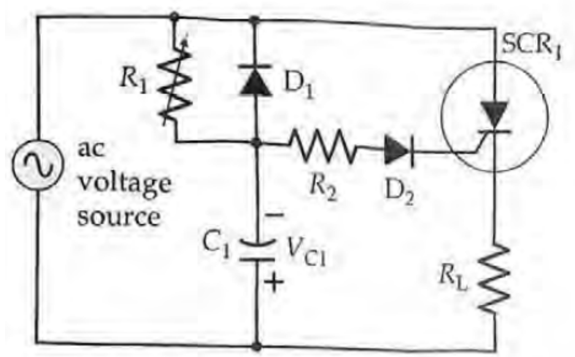
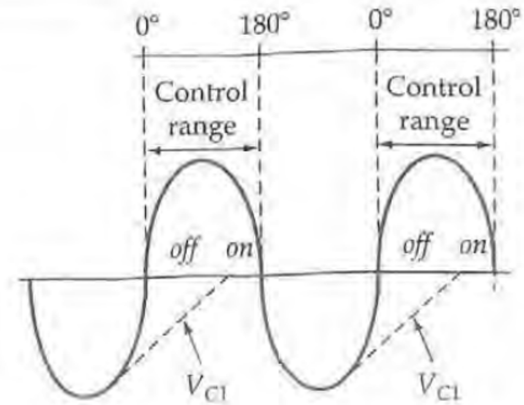
SCR Control Circuits

180^o phase control:
R_1 and C_1 determine triggering angle between 0^o ~ 180^o
R_2 restricts I_G.

-ve half-cycle →
C_1 is charged via D_1 to -ve peak.





After -ve peak →
D_1 and D_2 are reverse-biased
C_1 discharges via R_1

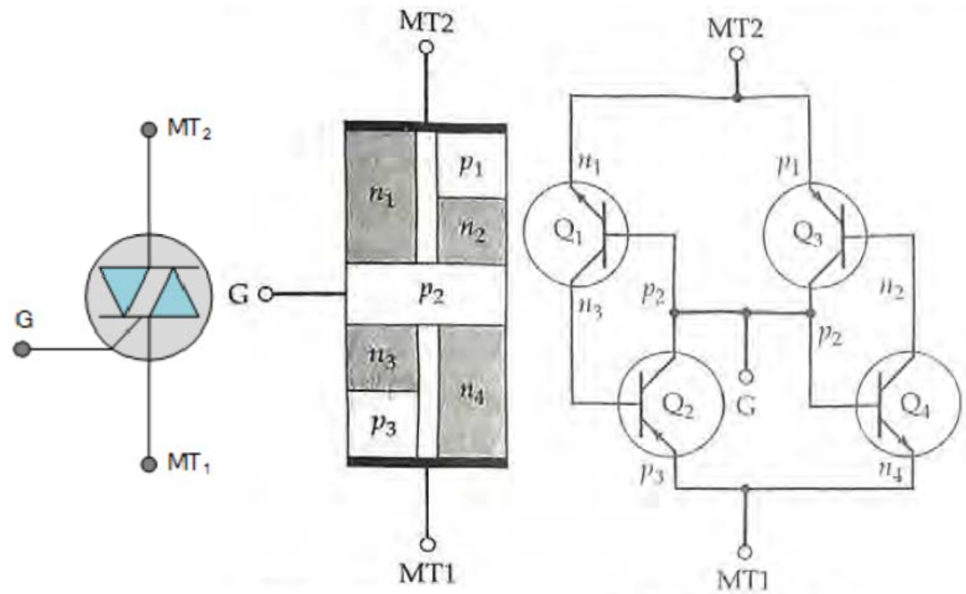
$R_1 = 0$ → SCR_1 switches on at 0^o.
$R_1 \approx \frac{0.75\,T}{C_1 \ln 6}$ → SCR_1 remains off till 180^o.

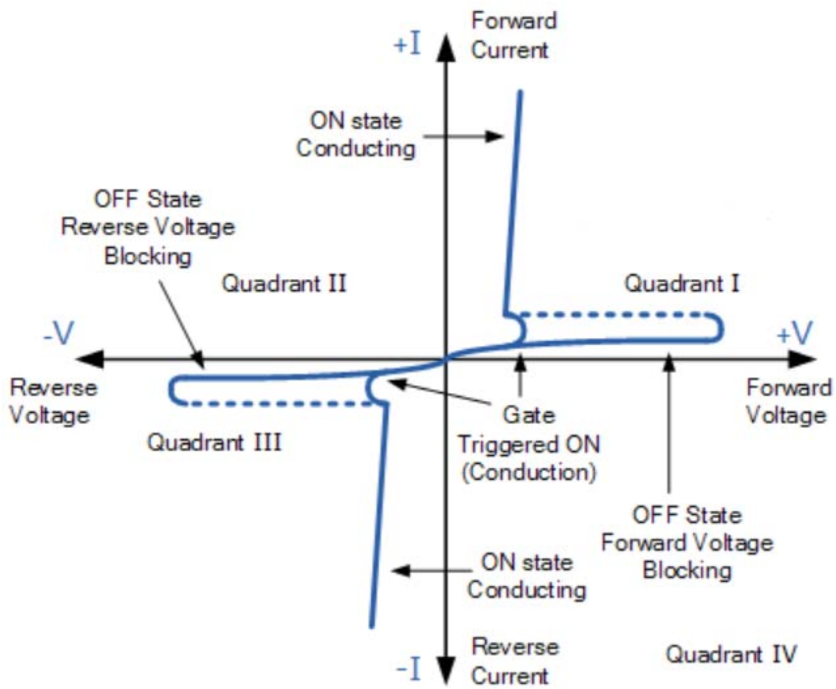
TRIAC and DIAC

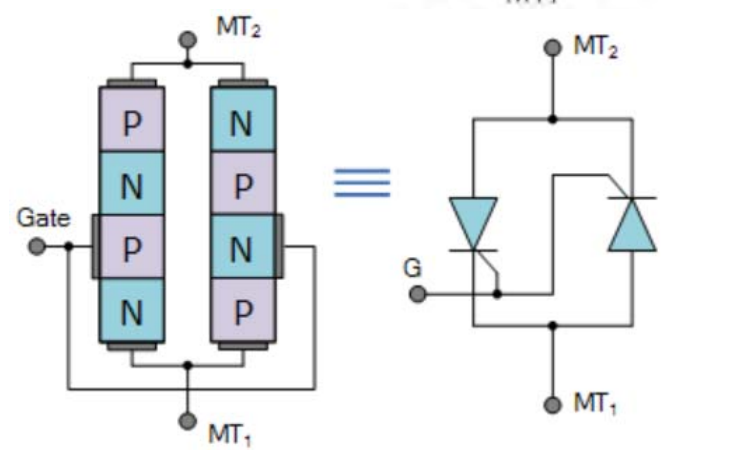
TRIAC operation and characteristics:

MT2 +ve → Q_3 and Q_4 can be triggered on
current flows from MT2 to MT1.

MT1 +ve → Q_1 and Q_2 can be triggered on
current flows from MT1 to MT2.

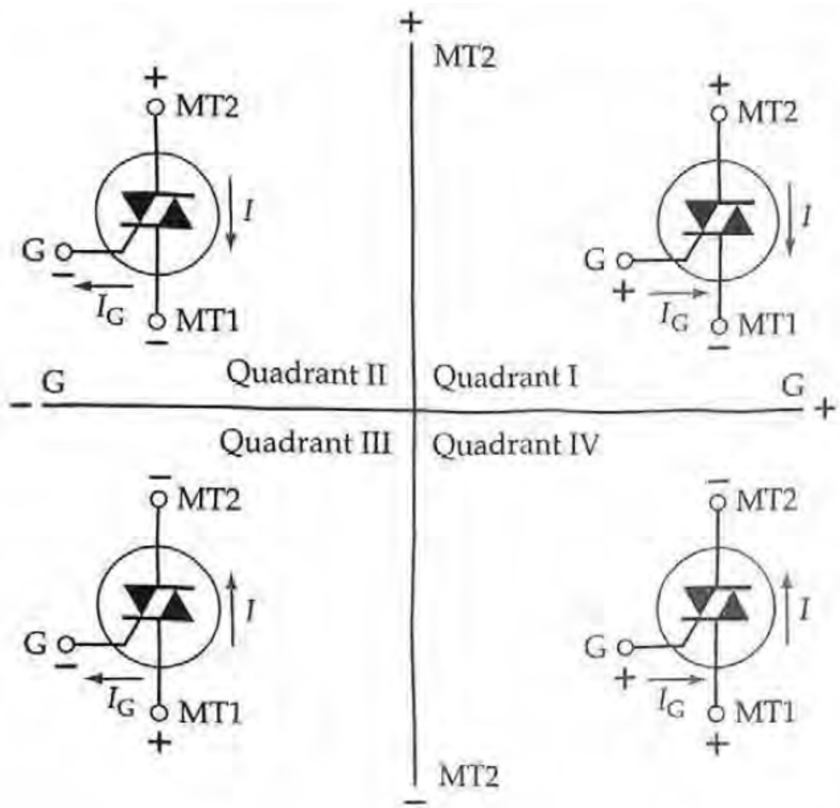


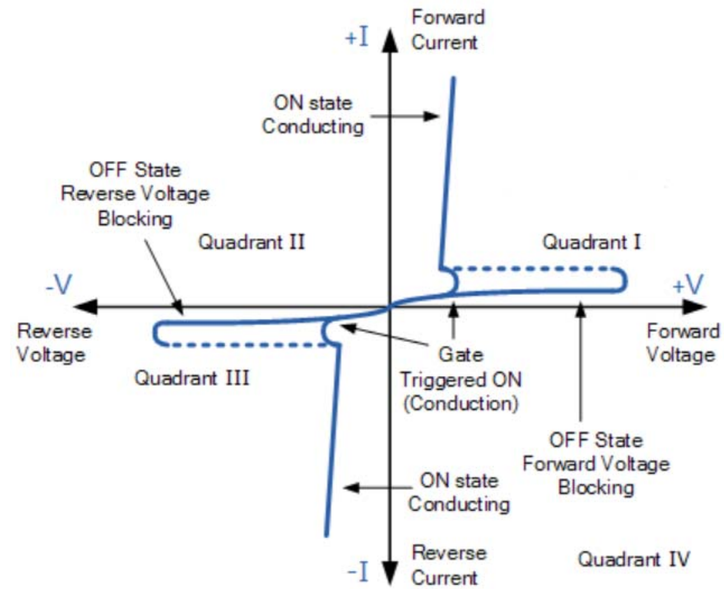


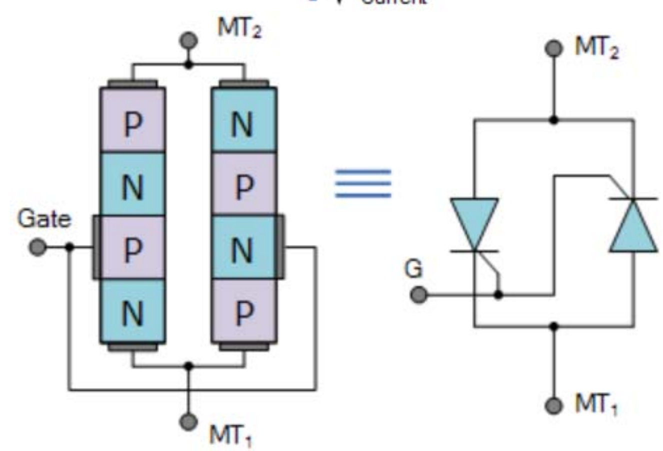


TRIAC and DIAC

TRIAC triggering:



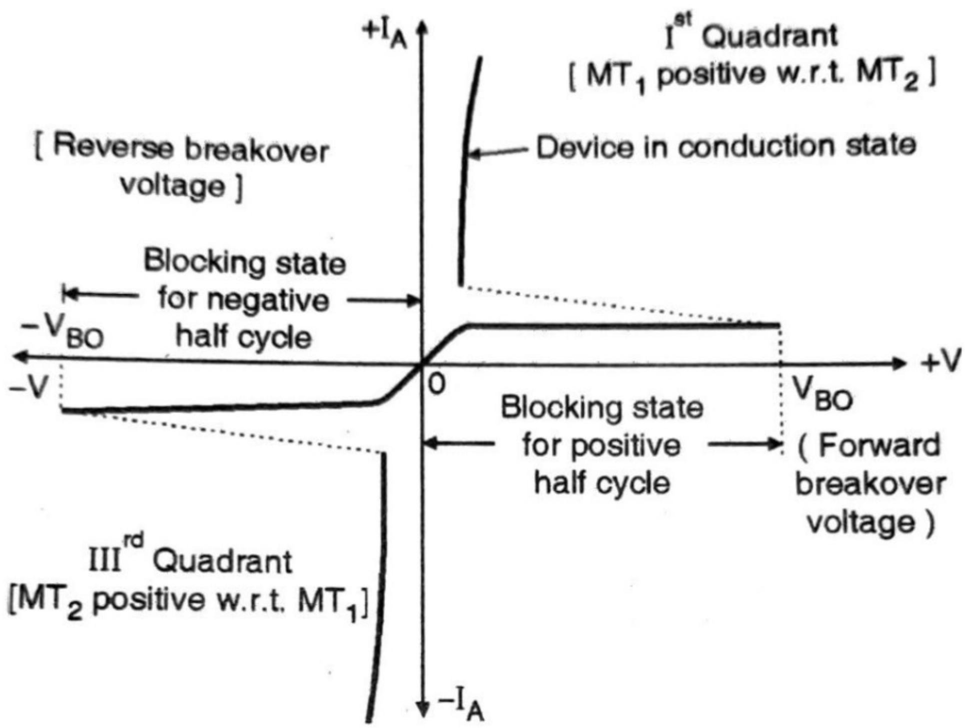


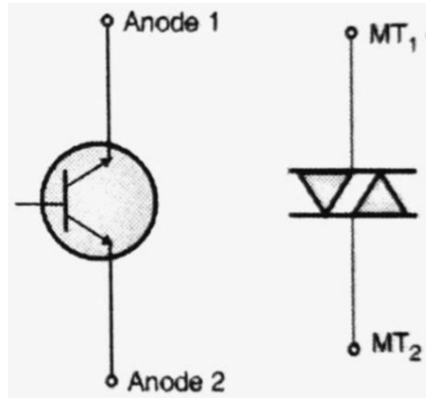


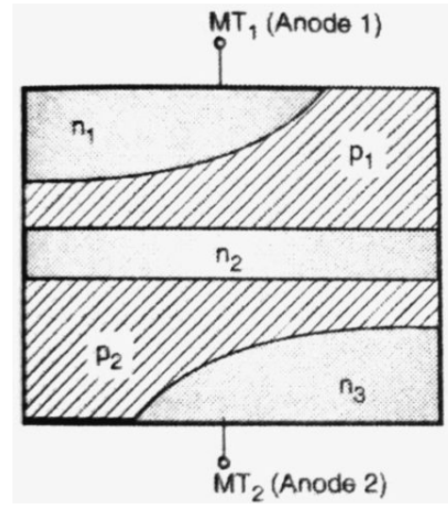
TRIAC and DIAC

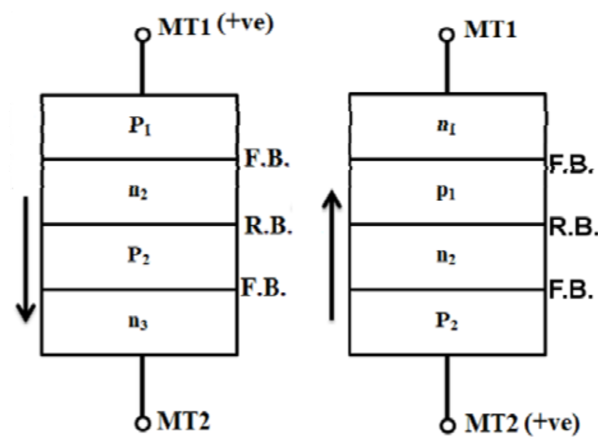
DIAC:

Low-current TRIAC without gate terminal.









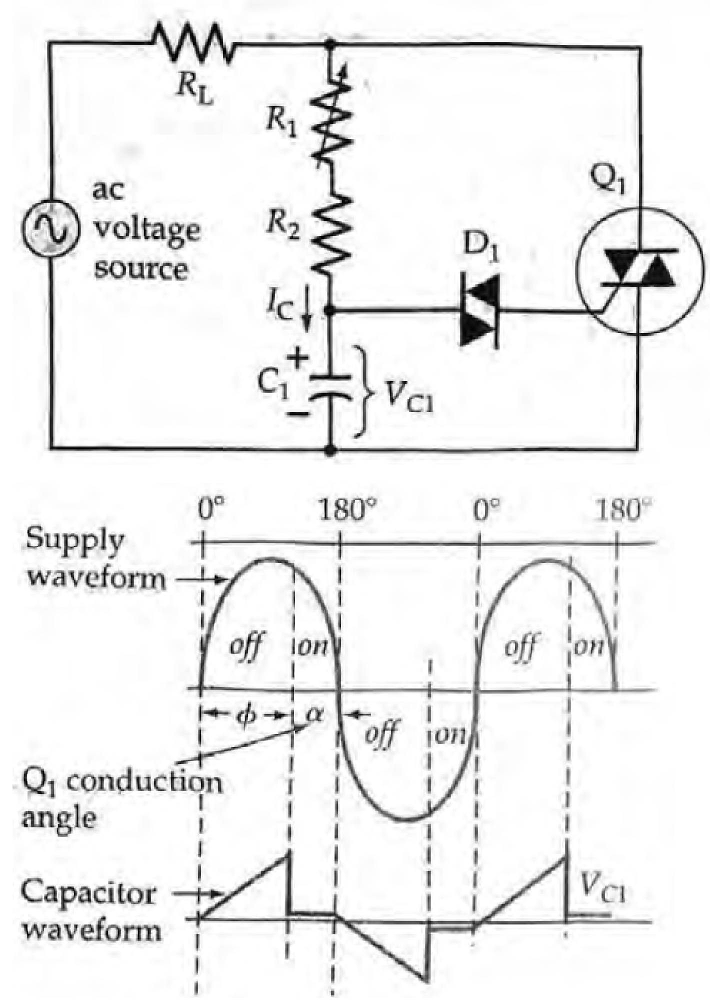
TRIAC and DIAC

<u>TRIAC phase-control circuit:</u>
Q_1 is off at beginning of +ve half-cycle.
C_1 is charged via R_1 and R_2.
V_{C1} = D_1 switching voltage
Q_1 gate triggering voltage

C_1 discharges through D_1 and Q_1 →
discharge current falls below D_1 holding current.
Q_1 switches off at end of +ve half-cycle.

Process is repeated during –ve half-cycle.

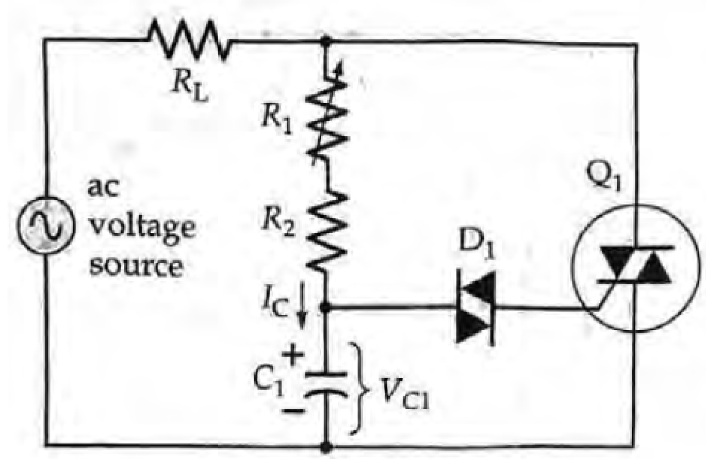
Q_1 conduction angle is controlled by R_1.



TRIAC and DIAC

Problem-42:

Estimate the smallest conduction angle for Q_1 for the circuit in Fig. 42. The supply is 115 V, 60 Hz, and the components are R_1 = 25 kΩ, R_2 = 2.7 kΩ and C_1 = 3 μF. The D_1 breakover voltage is 8 V and V_G = 0.8 V for Q_1.



At Q_1 switch-on, $V_{C1} = V_{D1} + V_G = 8 + 0.8 = 8.8$ V

Average charging voltage,

$$E = 0.636 \times V_{ac(pk)} = 0.636 \times 1.414 \times 115 \approx 103 \text{ V}$$

Average charging current,

$$I_C \approx \frac{E}{R_1+R_2} = \frac{103}{25\times10^3+2.7\times10^3} \approx 3.7 \text{ mA}$$

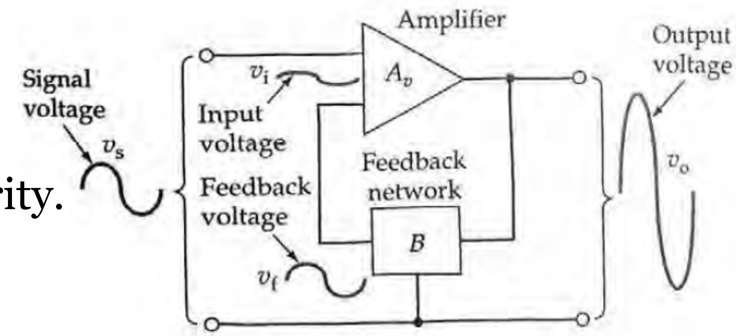
Charging time, $t \approx \frac{C_1 V_{C1}}{I_C} = \frac{3\times10^{-6}\times8.8}{3.7\times10^{-3}} \approx 7.1$ ms

$$T = 1/f = 1/60 = 16.7 \text{ ms}$$

Q_1 switch-on point, $\phi \approx \frac{t\times360^0}{T} = \frac{7.1\times10^{-3}\times360}{16.7\times10^{-3}} = 153^0$

Conduction angle, $\alpha = 180^0 - \phi = 180^0 - 153^0 = 27^0$

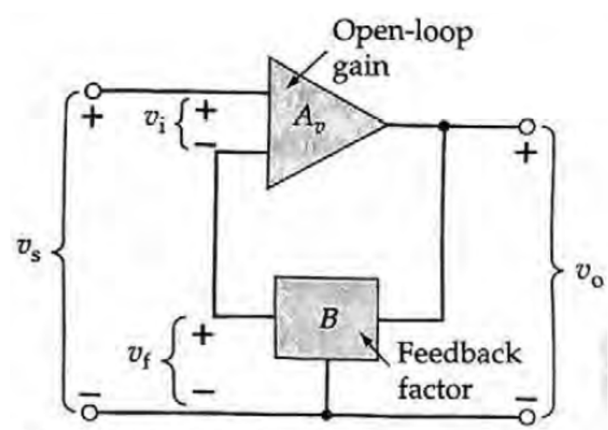
Series Voltage Negative Feedback



Series negative feedback:

Small portion of V_{out} is fed back to input.
Feedback voltage is in series with signal voltage.
Polarity of feedback voltage is opposite to signal voltage polarity.

$v_i = v_s - v_f$
Overall voltage gain v_o/v_i is reduced.
Stability of voltage gain is improved.



Voltage gain:

Open-loop gain, $A_v = v_o/v_i$
Feedback factor, $B = v_f/v_o$
Input voltage, $v_i = v_s - v_f = v_s - Bv_o$
Output voltage, $v_o = A_v v_i = A_v(v_s - Bv_o) = A_v v_s - A_v B v_o$

$v_o(1 + A_v B) = A_v v_s$

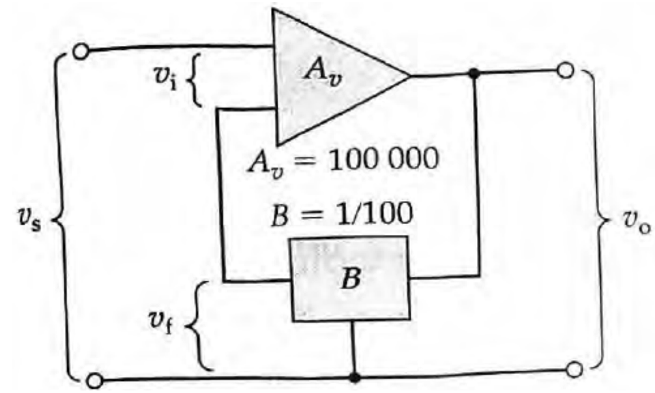
Closed-loop gain, $A_{CL} = \frac{v_o}{v_s} = \frac{A_v}{1+A_v B} \approx 1/B$ $\quad$ $[A_v B >>1]$

Open-loop gain, A_v >> Closed-loop gain, A_{CL}

Series Voltage Negative Feedback

Problem-43:

Calculate the closed-loop gain for the negative feedback amplifier shown in Fig. 43. Also calculate the closed-loop gain when the open-loop gain is changed by ±50%.



When $A_v = 100000$:

$$A_{CL} = \frac{A_v}{1+A_vB} = \frac{100000}{1+(100000/100)} = 99.9$$

When $A_v = 150000$:

$$A_{CL} = \frac{A_v}{1+A_vB} = \frac{150000}{1+(150000/100)} = 99.93$$

When $A_v = 50000$:

$$A_{CL} = \frac{A_v}{1+A_vB} = \frac{50000}{1+(50000/100)} = 99.8$$

Series Voltage Negative Feedback

Input impedance:

Input impedance without feedback, $Z_b = v_i/i_i$

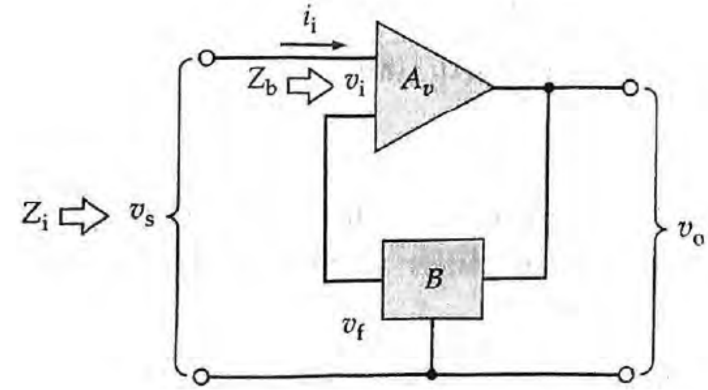
Input impedance with negative feedback,

$$Z_i = \frac{v_s}{i_i} = \frac{v_s \times Z_b}{v_i}$$

$v_i = v_s - v_f = v_s - Bv_o = v_s - A_v B v_i$

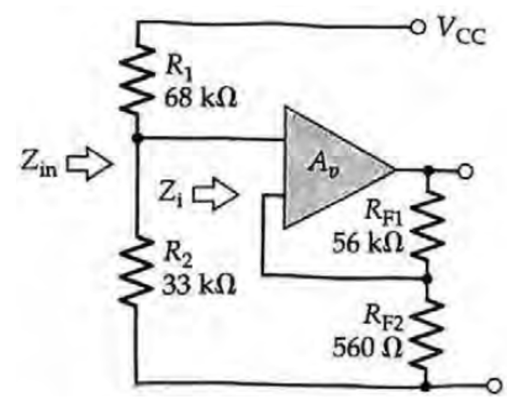
$v_i(1 + A_v B) = v_s$

$Z_i = (1 + A_v B) Z_b$



Problem-44:

The input impedance of the amplifier in Fig. 44 is 1 kΩ when negative feedback is not used, and the open-loop voltage gain is 100000. Calculate the circuit input impedance with negative feedback.



$B = v_f/v_o = \frac{R_{F2}}{R_{F1}+R_{F2}} = \frac{560}{560+56\times10^3} = 1/101$

$Z_i = (1 + A_v B) Z_b = \left[1 + 100000\frac{1}{101}\right] \times 1 \times 10^3 = 991$ kΩ

$Z_{in} = Z_i || R_1 || R_2 = 991||68||33 = 21.7$ kΩ