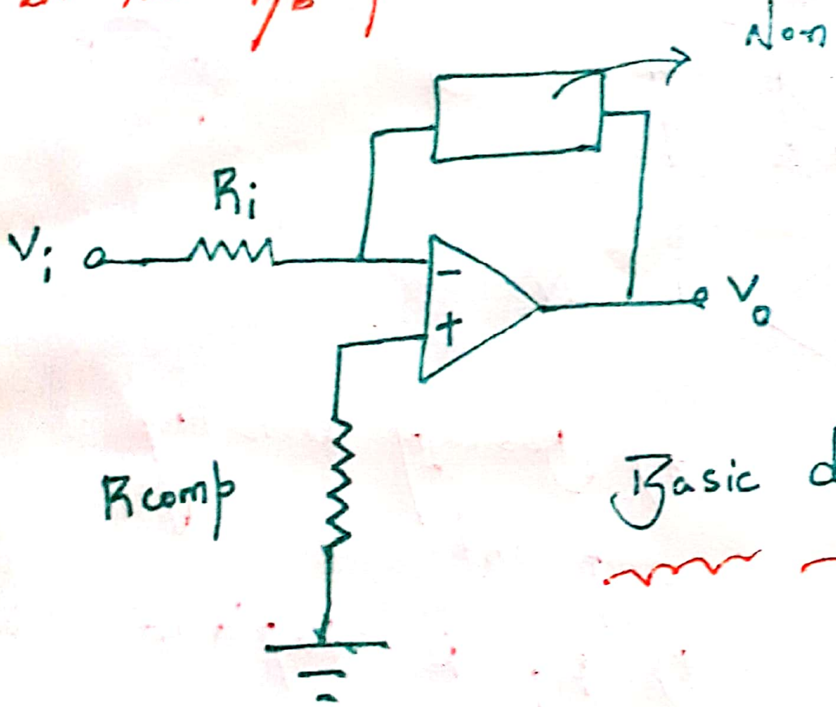
Logarithmic Amplifiers

*) L.Amp are formed by using non-linear devices such as Diodes, transistors, FET's e.t.c. in the f/b paths.



Basic diagram

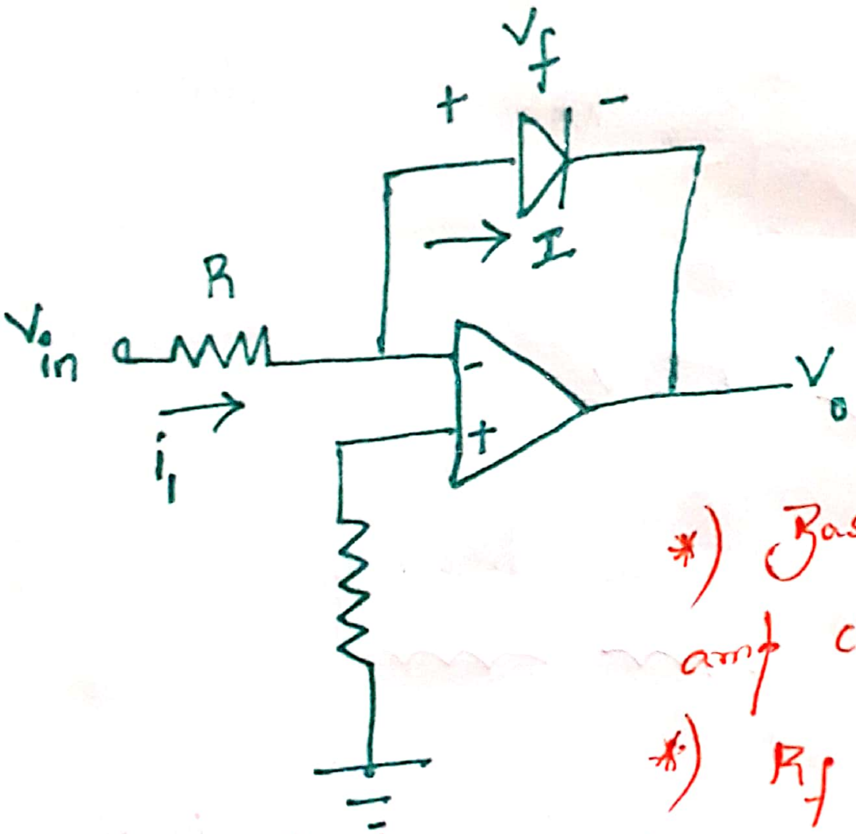
*) Log Amp → V_o which is proportional to the log of applied i/p vtg

$$\boxed{V_o \propto \ln(V_i)}$$

*) op-amp used in the log amp are LM 1458, LM 771, 714 & 741 are recommended.

Becoz that amp gives high performance.

Realization of log amp by using diode:



*) Basically inverting amp ckt.

*) R_f is Replaced by a diode.

*) current across the diode is

$$I = I_s\left[e^{\frac{V_f}{\eta V_T}} - 1\right]$$

V_f → vtg across the diode

I → forward current of the PN junction diode

I_s → Reverse saturation " " " "

V_T → thermal vtg

η → Ideality factor
Ge → 2 Si → 1

*) If we restrict the operating range of the diode such that $V_f > \eta V_T$ then neglecting 1

Equ becomes $I = I_s \, e^{V_f/\eta V_T}$

taking log on B.S

$$\ln . I = \ln . I_s + \frac{V_f}{\eta V_T}$$

$$\ln I - \ln I_s = \frac{V_f}{\eta V_T}$$

$$V_f = \eta V_T (\ln I - \ln I_s)$$

Due to virtual Ground concept

$$V_0 = -V_f$$

$$= -\eta V_T (\ln I - \ln I_s)$$

where I is current flowing through the diode and the same current through R. Bcoz the current entering into the op-amp i/p terminal is negligible (zero i/p I)

Hence I is given by $\boxed{I = \frac{V_i}{R}}$

Substitute in above Equ

$$V_0 = -V_f$$

$$V_0 = -\eta V_T \left(\ln \frac{V_{in}}{R} - \ln I_s \right)$$

$$V_0 \propto \ln (V_i)$$

log amp depends on 2 temp factors

1) scalling factor ηV_T

2) offset term $\ln I_s$

$\therefore$ log amp is very sensitive to temp.

Applications

*) Analog computation x, $\log_{10} x$, $\sinh x$, $\tanh x$, mul, div e.t.c.

*) compression of all analog signals.

*) used for power extraction, square root calculation

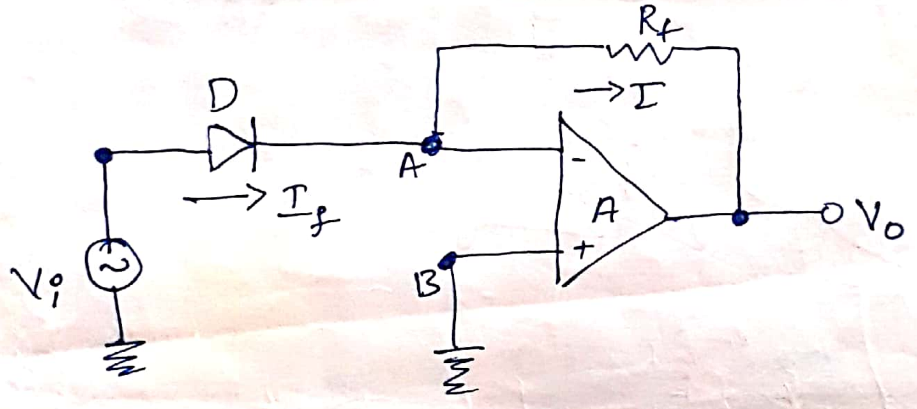
Drawback $I_s \rightarrow$ changes the temp.

in fact it double for every $10°C$ rise in temp.

~~Anti log amp~~ Anti-log Amp

By interchanging the positions of the diode/Transistor and resistor as compared to logarithmic amplifier circuit, the antilog amplifier can be obtained.

Realization of Antilogarithmic Amplifier using diode:—



→ The diode is connected to the inverting terminal of the op-amp. The node-B is grounded and hence node-A is at virtual ground.

Hence $V_B = 0$

→ The current flowing through the diode is I_f and voltage across the diode is V_i itself, as A is at virtual ground

Hence the expression for the forward current "I_f" through the diode is given by

$$I_f = I_s e^{(V_i / \eta V_T)} \quad \text{--- } (1)$$

Assuming the input current inside the op-amp to be zero, i.e the current I must be same as I_f

$$I = I_f = \frac{V_A - V_0}{R_f}$$

$(\because V_A = 0)$

$$= \frac{0 - V_0}{R_f}$$

$$I_f = I \quad \text{--- } (2)$$

$$I = \frac{-V_0}{R_f}$$

If $I = I_f$ then

$$I_s e^{(V_i / \eta V_T)} = \frac{-V_0}{R_f}$$

$$V_0 = - I_s R_f e^{(V_i / \eta V_T)}$$

Product I_s & R_f assumed to be V_{ref} so

$$\boxed{V_0 = -V_{ref} e^{(V_i / \eta V_T)}}$$

Thus the output voltage is proportional to the Exponential function of "V_i" & then circuit works as an anti log amplifier.

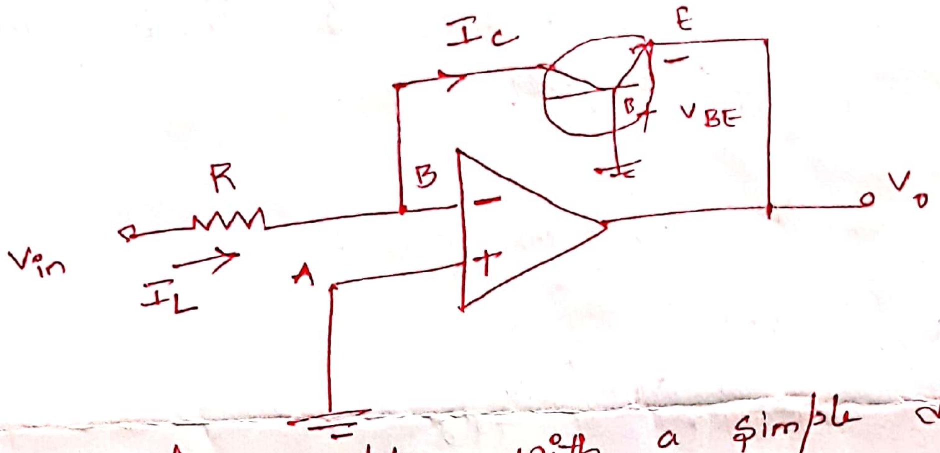
Dis adv anti log amp :-

1) V_o dependent on I_s and V_T

2) All these are functions of temp. Hence as temp changes these parameters I_s and V_T also changes and cause serious errors ~~at~~ the o/p.

3) ∴ It is necessary to design a temp compensated anti log amp.

Log amp by using Transistor



A practical problem with a simple diode is the internal resistance of any s.c material. This (R) is also subject to change with temp and it may actually cause some internal heating in some app. To reduce this problem a diode may be replaced by a transistor.

description

The base is connected to ground and the collector of the (t) is effectively connected to the ground. This is because pt B & A are at the same potential according to v.g. pt A is connected to pt B is potential (v.g).

The collector base junction is short circuited and the (t) is equivalent to only the base - emitter junction (i.e) it is equivalent to a diode. Hence this config... is also called as transdiode config.

The collector current I_c will be equal to I_E. since it is known that the relationship b/w the current & V/g of a pn junction diode given

$$I_c = I_E = I_s \left[e^{V_f/\eta V_T} - 1\right]$$

→ I_s → emitter saturation current

→ $V_f = V_{BE}$

→ $I_c = I_s \left[e^{V_{BE}/\eta V_T} - 1\right]$

$$e^{V_{BE}/\eta V_T} >> 1$$

$$\frac{I_c}{I_s} = e^{V_{BE}/\eta V_T} \quad \text{— (1)}$$

natural log on B.S

$$\ln\left[\frac{I_c}{I_s}\right] = \frac{V_{BE}}{\eta V_T}$$

$$V_{BE} = \eta V_T \ln\left[\frac{I_c}{I_s}\right] \quad \text{— (2)}$$

But $V_0 = -V_{BE}$

By substituting above equ.

$$= -\eta V_T \ln\left(\frac{I_c}{I_s}\right) \quad \text{— (3)}$$

node B is a v.g

$V_B = 0$

$$i_L = \frac{V_1 - V_B}{R}$$

$$= V_1/R \quad \text{— (4)}$$

6

If the op-amp i/p current is zero

$i_L = I_c =$ collector current —— (5)

$I_c = V_i/R$ —— (6)

substituting equ (6) in (3)

$V_0 = -\eta V_T \ln\left[V_i/I_S R\right]$ —— (7)

Let

$V_{ref} = R I_S$

$V_0 = -\eta V_T \ln\left[V_i/V_{ref}\right]$ —— (8)

V_0 is $\propto$ to the natural log of V_i