JAT-3.

1. The functional block diagram of IC 723 regulator is given be shown below

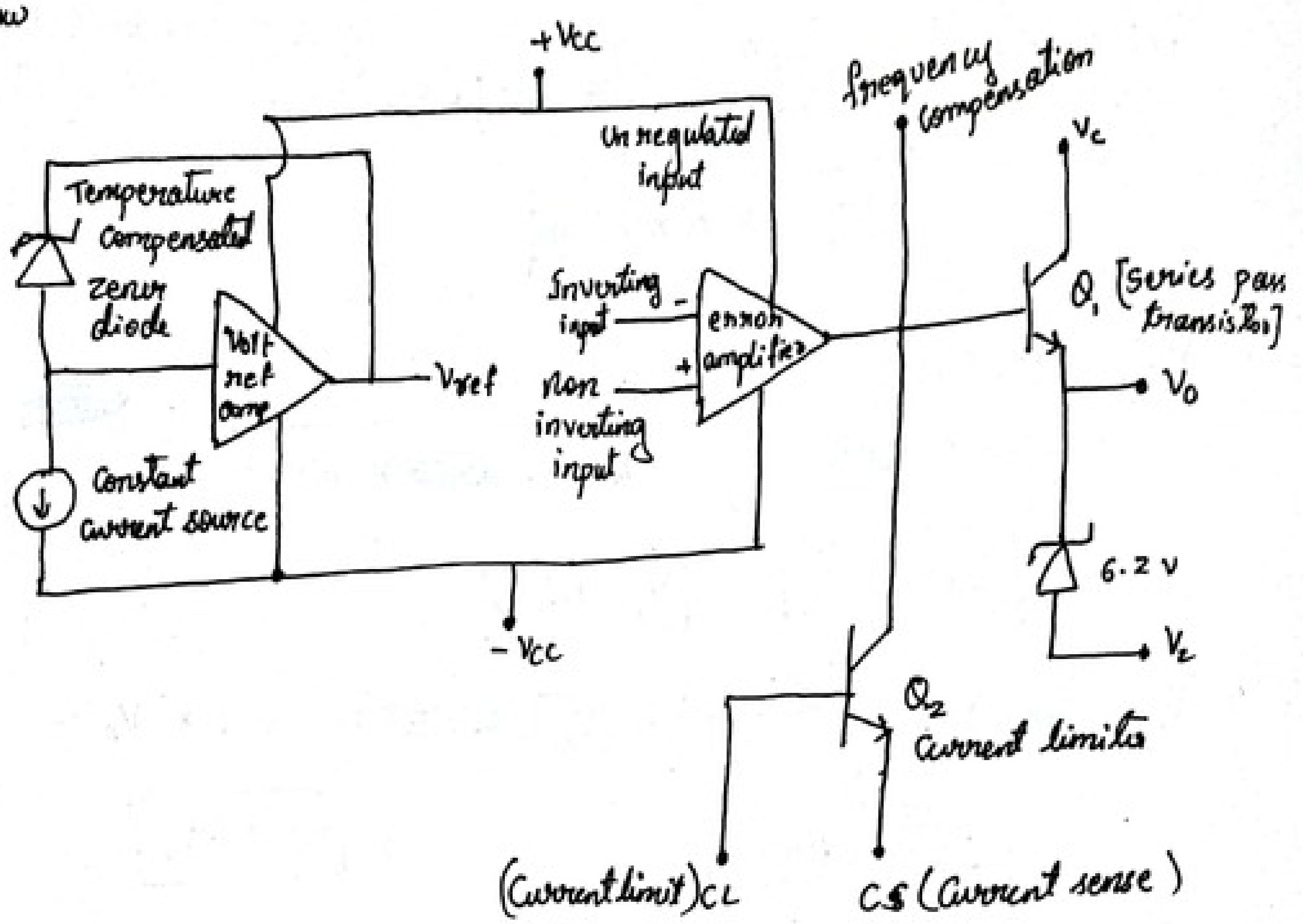
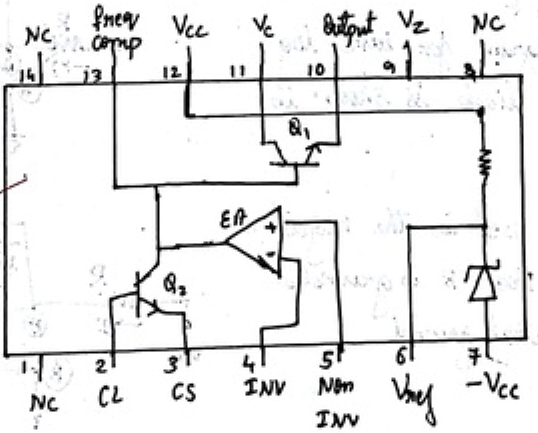


fig: Functional block diagram of IC 723.

- Temperature compensated zener diode, constant current source, reference amplifier forms the reference element.
- To get a fixed voltage from zener diode, the constant current source forces the zener to operate at a fixed point.
- Output is compared with this temperature compensated reference potential of the order of 7 volts. For this Vref. The non inverting input terminal of the error amplifier is connected

- This error amplifier is a high gain differential amplifier. It inverting input is connected to that either whole regulated output or a part of it from outside.
- Error amplifier controls the series pass transistor Q_1, whose ~~output current~~ ~~is~~ The series pass transistor is a small power ~~series~~ transistor having about 800mW dessipation.
- The transistor Q_2 acts as a current limiter in case of short circuit condition.
- The frequency compensation terminals is used to control the frequency respo of error amplifier.
- The simplified internal block diagram of IC 723 is

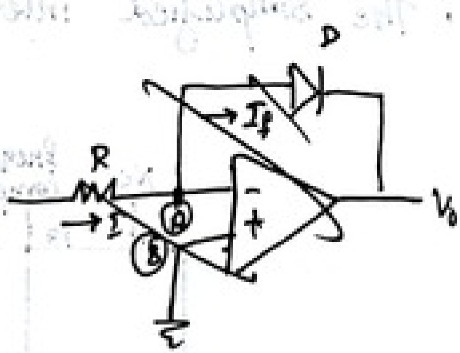


- Q_1 is series pass transistor
- EA is error amplifier
- Q_2 is current limit transistor

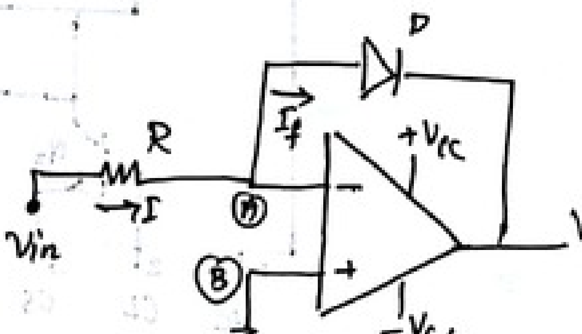
Features

- It is used to ~~capable~~ ~~of~~ producing regulated output voltage ranging from 2 to 37v and current at 150mA.
- It is used to have ~~having~~ current ≥ 150mA by use of a suitable NPN or PNP external series pass transistor.
- It has good load and line regulation
- It has high ripple rejection factor and low temperature drift.
- It can choose the power supply range.
- Wider applications in series, shunt, floating and switching regulators.

2. Basic log amplifier using diode.



- The circuit diagram for basic log amplifier using diode is shown in the figure



- The diode D is used in the negative feedback path. Node B is grounded hence due to virtual ground

$V_A = 0V$

- The current through resistor R is

$$I = \frac{V_{in} - V_A}{R} = \frac{V_{in}}{R} \quad —(1)$$

- Since, the opamp input currents is zero

$I = I_f \Rightarrow$ diode current.

- I_f is the current through the diode and the voltage across the diode is $V_A - V_0$ i.e. $-V_0$
- The diode equation is given by $I_f = I_0[e^{V/\eta V_T} - 1]$
- The expression for V can be written as

$$V = \eta V_T \ln\left[\frac{I_f}{I_0}\right]$$

- $\because I_f = I = \frac{V_{in}}{R}$ and $V = -V_0$ (diode voltage across diode)

Therefore, $$-V_0 = \eta V_T \ln\left[\frac{V_{in}}{I_0 R}\right]$$

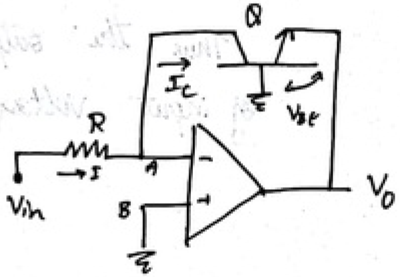
$$V_0 = -\eta V_T \ln\left[\frac{V_{in}}{I_0 R}\right]$$

- $I_0 R$ is a dc voltage so let $V_{ref} = I_0 R$

$$\Rightarrow \boxed{V_0 = -\eta V_T \ln\left(\frac{V_{in}}{V_{ref}}\right)}$$

Thus the output voltage V_0 is proportional to the logarithm of input voltage V_{in}

- Basic log amplifier using transistor:



- The circuit diagram for basic log amplifier using transistor is shown in the figure
- Node B is grounded hence, due to virtual ground $V_A = 0V$
- $I = \frac{V_{in} - V_A}{R} = \frac{V_{in}}{R}$ —(1) the current through resistor R.

Since opamp input currents are zero,

$I = I_C$ i.e., collector current.

- $V_{CB} = 0_V$ because the collector is at ground voltage and base is ground
- Thus the equation of collector current becomes

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

- From output side, $V_0 + V_{BE} = 0$

$$\Rightarrow \boxed{V_0 = -V_{BE}}$$

- & we have $I = I_C = \frac{V_{in}}{R}$

∴ eqn (2) becomes

$$-V_0 = V_T \ln\left[\frac{V_{in}}{I_S R}\right]$$

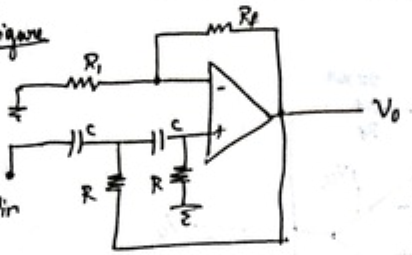
$$V_0 = -V_T \ln\left[\frac{V_{in}}{I_S R}\right]$$

let $I_S R = V_{ref}$

$$\therefore \boxed{V_0 = -V_T \ln\left[\frac{V_{in}}{V_{ref}}\right]}$$

Thus the output voltage V_0 is proportional to ~~input~~ logarithm of input voltage V_{in}.

3a. figure



The circuit diagram for second order high pass active filter is shown in the figure

Given:

- $A = 1.5, \quad f_L = 10\,KHz$
- $1 + \frac{R_f}{R_1} = A = 1.5$

$\therefore \frac{R_f}{R_1} = 0.5 \Rightarrow R_f = 0.5\,R_1 \rightarrow \boxed{R_1 = 2R_f}$

- Let $\boxed{R_1 = 10\,K\Omega}$

$\therefore R_f = 2 \times 10k = 20\,K\Omega$

$\boxed{R_f \cong 22\,K\Omega}$ standard.

- Let $\boxed{C = 0.01\,\mu F}$

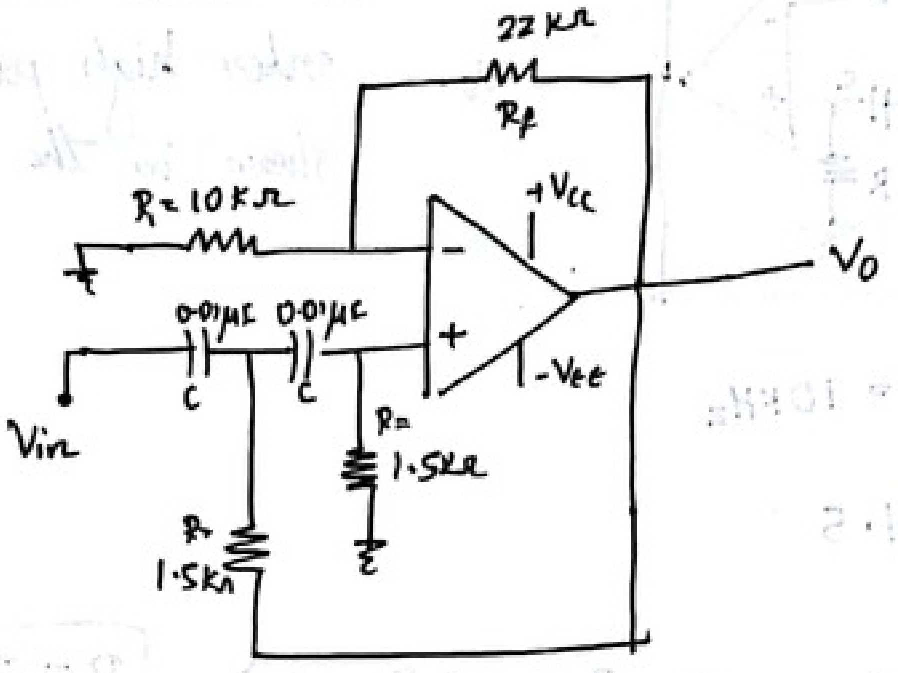
then $f = \frac{1}{2\pi RC} \Rightarrow R = \frac{1}{2\pi f C}$

$R = \frac{1}{2\pi \times 10 \times 10^3 \times 0.01 \times 10^{-6}} = ~~795.77~~$

$R = 1591.54\,\Omega$

$\Rightarrow \boxed{R \cong 1.5\,K\Omega}$

The designed circuit is

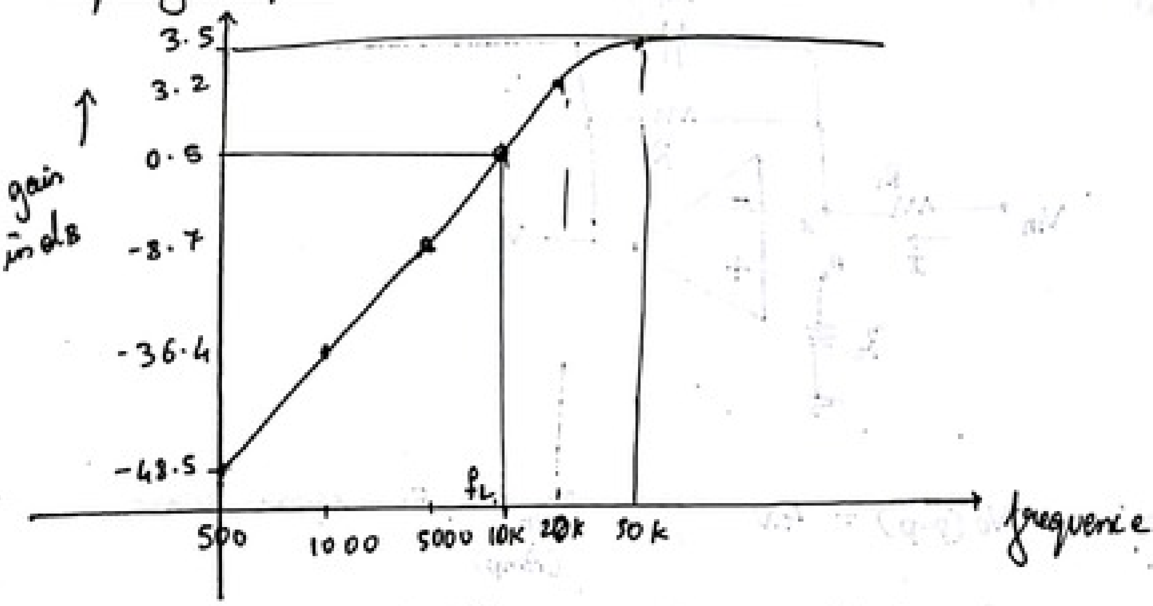


• We have $\left|\frac{V_o}{V_{in}}\right| = \frac{A_{CL}}{\sqrt{1+\left(\frac{f_L}{f}\right)^4}} = \frac{1.5}{\sqrt{1+\left(\frac{10\times10^3}{f}\right)^4}}$

⇒

frequency f (Hz)	$\left\|\frac{V_o}{V_{in}}\right\|$	$\left\|\frac{V_o}{V_{in}}\right\|$ in dB $= 20\log_{10}\left\|\frac{V_o}{V_{in}}\right\|$
500	3.74×10^{-3}	−48.54
1000	0.01499	−36.48
5000	0.3638	−8.7827
10 000	1.0606	0.511
20 000	1.4552	3.258
50 000	1.4988	3.514

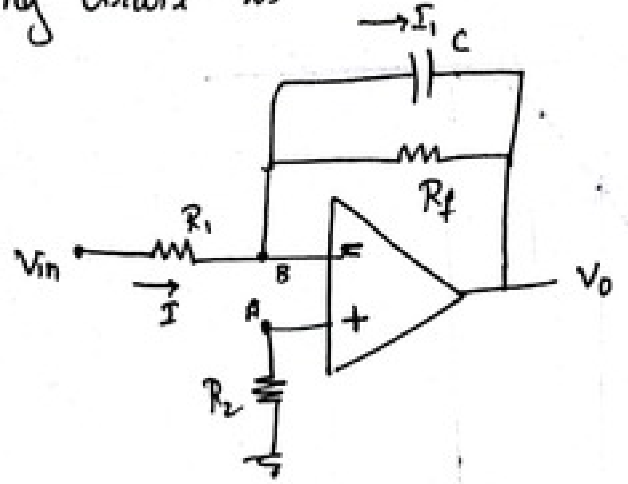
Frequency response



3b Advantages of active filters over passive filters are as follows

- All the elements along with opamp can be used as integrated circuit which helps in reduction of size and weight.
- ~~In large quantities, a Opamp~~ cost ~~are~~ lower than its
- Inductors are not used in active filters, hence the modern active filters are more economical
- ~~Due to availability of modern IC's, Opamp~~
- Opamp has high input impedance and low output impedence hence the active filters ~~can~~ will not have loading effect of load or source.
- Opamp are used to realized various class of function like Butterworth, Thomson, etc
- In large quantities, the cost of the active filters is much lower than its equivalent passive network.
- The design ~~is~~ procedure is simpler compared to passive filters.

5. Integrating circuit is



- Given : $V_0 (p\text{-}p) = 4V$, $V_{i/p\,(Amp)} = 5V$ square wave

$f = 500\,Hz$. , $I_{B(max)} = 500\,nA$

- $I_f = \dfrac{V_{in}}{R_1}$ & $I_e = 100\, I_{B(max)} = 50\,\mu A$

$\Rightarrow R_1 = \dfrac{V_{in}}{I_e} = \dfrac{V_{in}}{100 \times I_{B(max)}}$

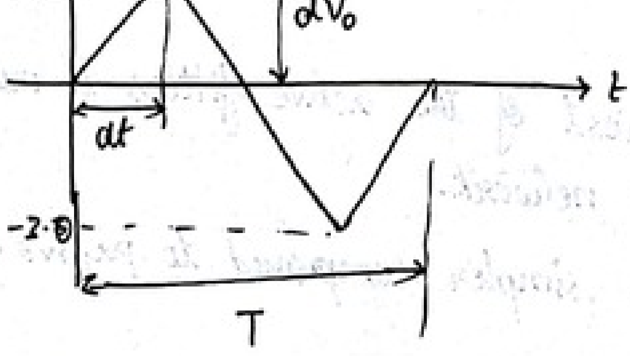
$R_1 = \dfrac{5}{100 \times 500 \times 10^{-9}} = 100\,K\Omega$

$\boxed{R_1 = 100\,K\Omega}$

- $R_f \geq 20\, R_1$

$R_f = 2000\,K\Omega$

$\boxed{R_f = 2M\Omega}$

- 

- $f = 500\ Hz$

$$\therefore T = \frac{1}{f} = \frac{1}{500} = 2\times10^{-3}$$

$$\boxed{T = 2\times10^{-3} s}$$

- $$dt = \frac{T}{4} = \frac{2\times10^{-3}}{4} = 5\times10^{-4} s$$

- $$dV_o = \frac{V_{o\,peak-peak}}{2} = \frac{4}{2} = 2.5V$$

$$\therefore \boxed{dV_o = 2V}$$

- The capacitance $C = I_1 \cdot \frac{dt}{dV_o}$

here $I_1 = I = 50\mu A$

$$\therefore C = 50\times10^{-6} \times \frac{5\times10^{-4}}{2}$$

$R_2 \simeq R_1$

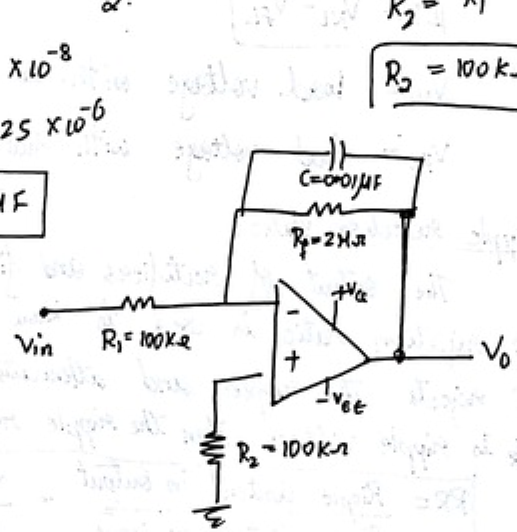
$$\boxed{R_2 = 100k\Omega}$$

$$C = 1.25\times10^{-8}$$

$$C = 0.0125\times10^{-6}$$

$$\boxed{C = 0.01\mu F}$$

$\therefore$ Circuit is



6a. i) Line regulation

It is also called as source regulation and it is denoted by SR.
Line regulation is defined as the changes in the regulated load voltage with specified range of line voltage typically 230V ± 10%.
Mathematically it is given as

$$SR = V_{HL} - V_{LL}$$

where V_{HL} = load voltage with high line voltage
V_{LL} = load voltage with low line voltage

ii) Load Regulation:

Load regulation is the changes in the regulated output voltage when the load current is varied from minimum (no load) to maximum (full load)
It is denoted as LR and mathematically expressed as.

$$LR = V_{NL} - V_{FL}$$

V_{NL} = load voltage with no load current
V_{FL} = load voltage with full load current

iii) Ripple rejection ratio:

The output of rectifiers and filters consists of ripples. The ripple rejection ratio is used to know how effectively the regulator output rejects the ripples and attenuates it from input to output.
If V_R is ripple voltage then the ripple rejection ratio is given by

$$RR = \frac{\text{Ripple Content in Output}}{\text{Ripple Content in input}} = \frac{V_R(out)}{V_R(in)}$$

iv) Thermal stability: (S_T)

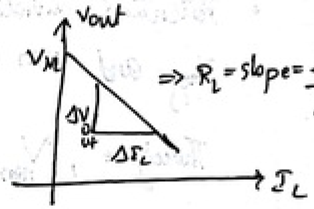
The thermal stability of a power supply is determined by the temperature coefficients of various temperature effective semiconductor devices.

Mathematically its given by,

$$S_T = \frac{\Delta V_{out}}{\Delta T} \Big|_{V_{in} \text{ and } I_L \text{ Constant}}$$

v) Output Resistance

The slope of the load regulation characteristic is known as the output resistance



$\Rightarrow R_L = \text{slope} = \frac{\Delta V_{out}}{\Delta I_L}$

Mathematically its given by.

$$R_{out} = \frac{\Delta V_{out}}{\Delta I_L} \Big|_{V_{in} \text{ and temperature constant}}$$

6b) Low voltage regulator.

The low voltage regulator has its output voltage varying from 2v to 7v.

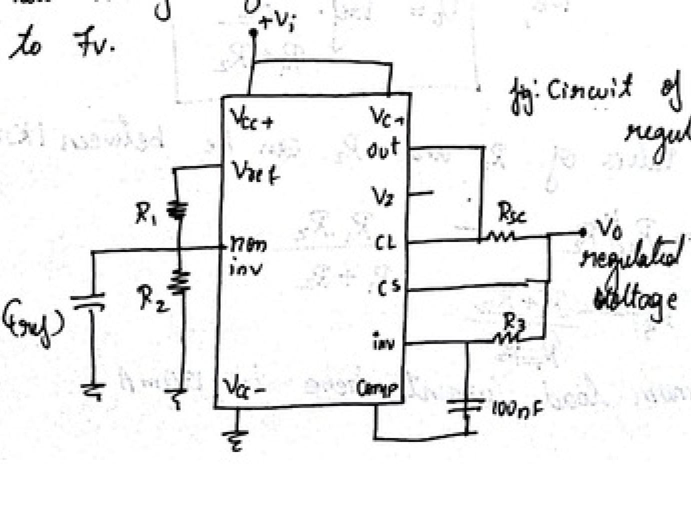


fig: Circuit of low voltage regulator.

- Resistance R_{sc} is connected between CL and CS pins. The current limiting transistor remains non conductive until the drop across R_{sc} is 0.6v (drop across BE). The value of R_{sc} can be found out by following equation

$$R_{sc} = \frac{V_{sense}}{I_{limit}} = \frac{0.6}{I_{limit}}$$

- I_{limit} can be from 1.2 to 1.5 times the maximum load current.
- Potential divider made up of R_1 and R_2 is connected between V_{ref} and non inverting terminal of the error amplifier

Therefore, $V_{non\ inv} = V_{ref} \cdot \frac{R_2}{R_1 + R_2}$

- The ~~power~~ series pass transistor works as voltage ~~to~~ follower

therefore $V_0 = V_{non.inv}$

i.e., $$V_0 = V_{ref} \cdot \frac{R_2}{R_1 + R_2}$$

- The values of R_1 and R_2 can be between 1KΩ to 10KΩ
- $R_3 = R_1 // R_2 = \frac{R_1 R_2}{R_1 + R_2}$

~~$R_3 = \frac{R_1 + R_2}{R_1 R_2}$~~

- Maximum load current here is 150mA

7b. Basic - anti logarithmic amplifier

The circuit diagram for basic anti-logarithmic amplifier using transistor is shown in the figure below

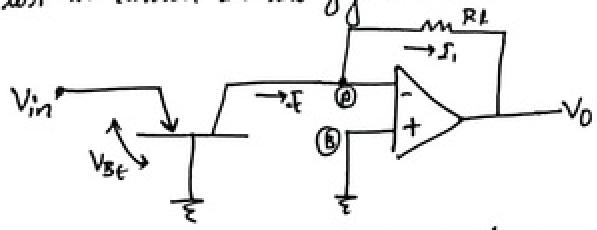


fig: circuit of anti log amplifier

- Node B is at grounded, therefore due to virtual ground.

$V_A = 0V$

- The current across R_f is

$$I_1 = \frac{V_A - V_0}{R_f} = \frac{-V_0}{R_f} \Rightarrow \text{I}.$$

- A $V_{CB} = 0V$ because collector is at virtual ground and base is ~~at~~ also grounded.
- From figure, the voltage across transistor is V_{BE} and its equal to input voltage Vin
- $V_{in} = V_{BE}$.
- The collector current equation is

$$I_C = I_S e^{V_{BE}/V_T}$$

- here $I_C = I_1$ because opamp input current is zero

$$\therefore I_1 = I = \frac{-V_0}{R_f} = I_S e^{V_{in}/V_T} \Rightarrow \boxed{V_0 = -R_f I_S e^{V_{in}/V_T}}$$