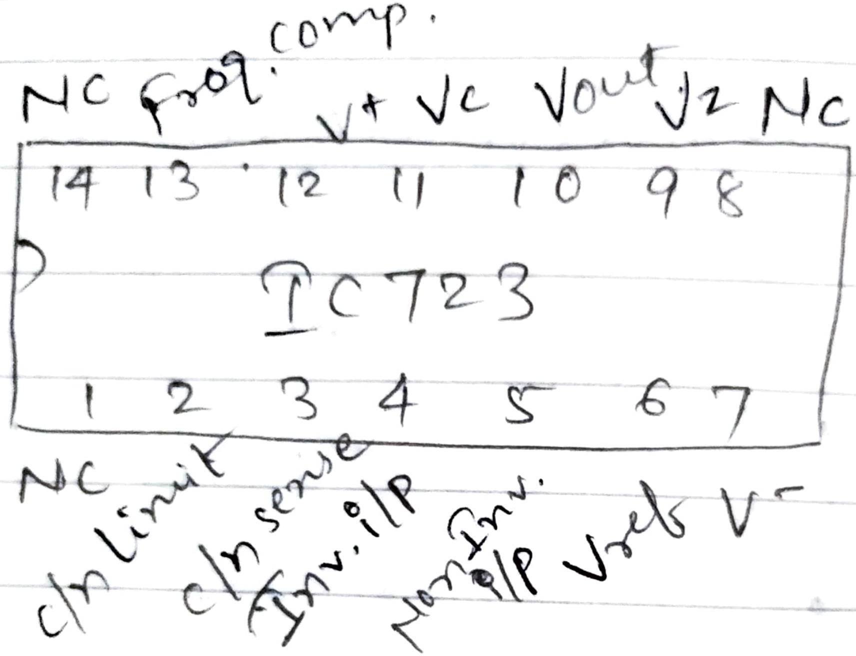
IC regulator 723



The three terminal regulators have foll. limita"

→ Not short circuit protection

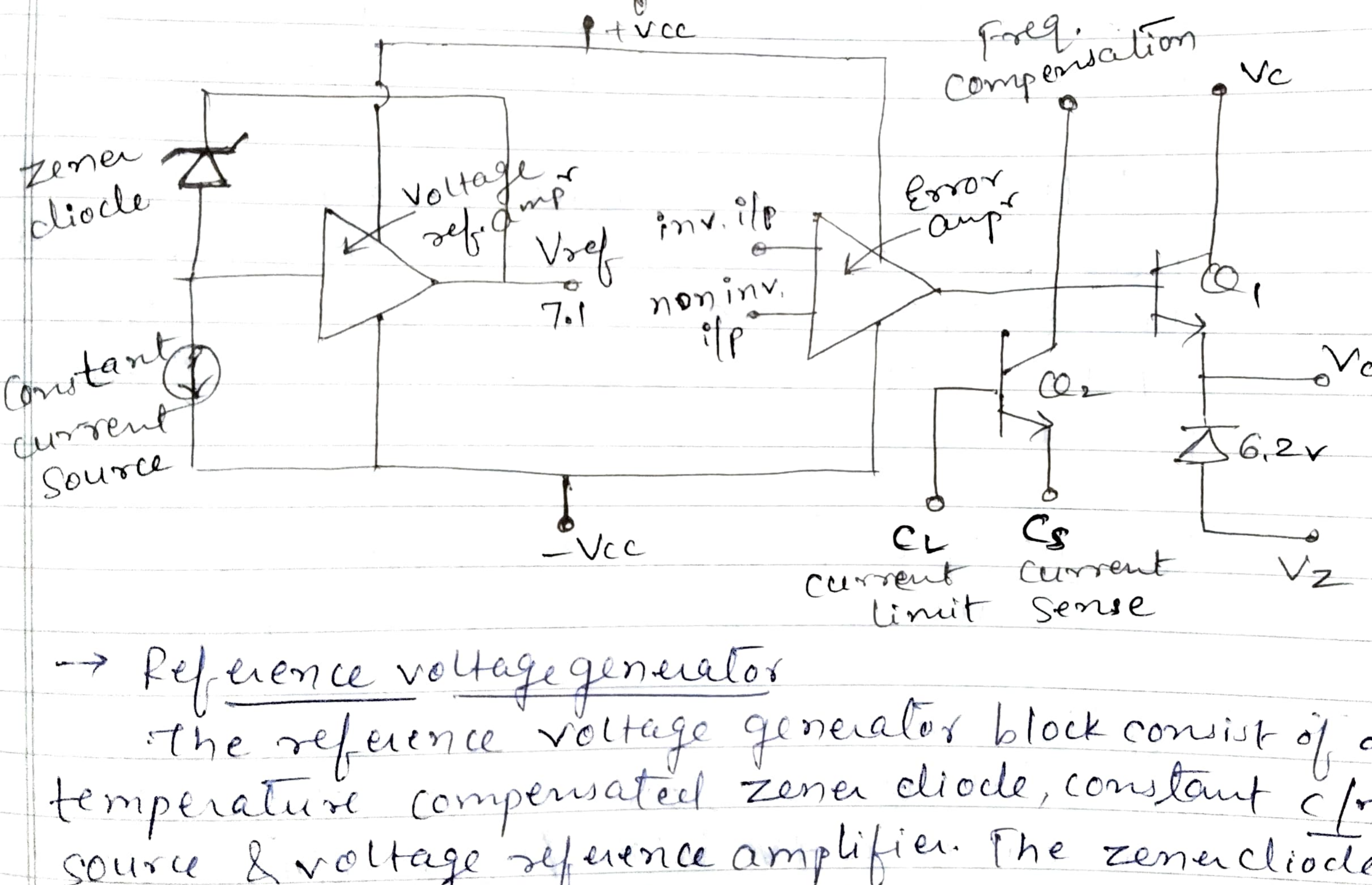
→ o/p voltage (+ve or -ve) is fixed.

These limitations are overcome in IC 723 regulator.

→ Features of IC723

→ It works as voltage regulator at o/p ranging from 2 to 37v at current up to 150mA.
→ It can be used at load current greater than 150mA.
→ I/p & o/p short circuit protection is provided.
→ It has good line & load regulation (0.03%)
→ It provides a choice of supply voltage.

→ Block diagram of IC723



→ Reference voltage generator

The reference voltage generator block consist of a temperature compensated zener diode, constant c/n source & voltage reference amplifier. The zener diode is used to generate fixed reference voltage internally. The constant c/n source will make ~~dio~~ zener diode to operate at fixed point. The internally generated reference voltage is 7.15v & it is applied to non Inv Terminal of error amplifier.

[v/g → voltage, c/n → current]

→ Error Amplifier → The error amplifier is high gain differential amplifier, with two i/ps inverting & noninverting. Non Inv. terminal is connected to the full regulated o/p voltage or part of regulated o/p voltage.

→ Series pass ~~[illegible]~~ transistor (Q_1) → The 'Q_1' is internal series pass transistor which is driven by error amplifier. This Transistor acts as a variable resistor & regulates the o/p voltage. The Q_1 is a small transistor which is capable of dissipating power up to 800mW. Max voltage is up to 36V & max c/n is up to 150mA.

→ C/n limiter (Q_2) → Internal transistor Q_2 is used for the sake of current sensing & current limiting. The transistor Q_2 is normal off. It turns ON only when load current exceeds predetermined limit.

→ Frequency Compensation → It is used to decide the frequency response of error amplifier.

→ Application

→ It can be used as low voltage high c/n regulator.

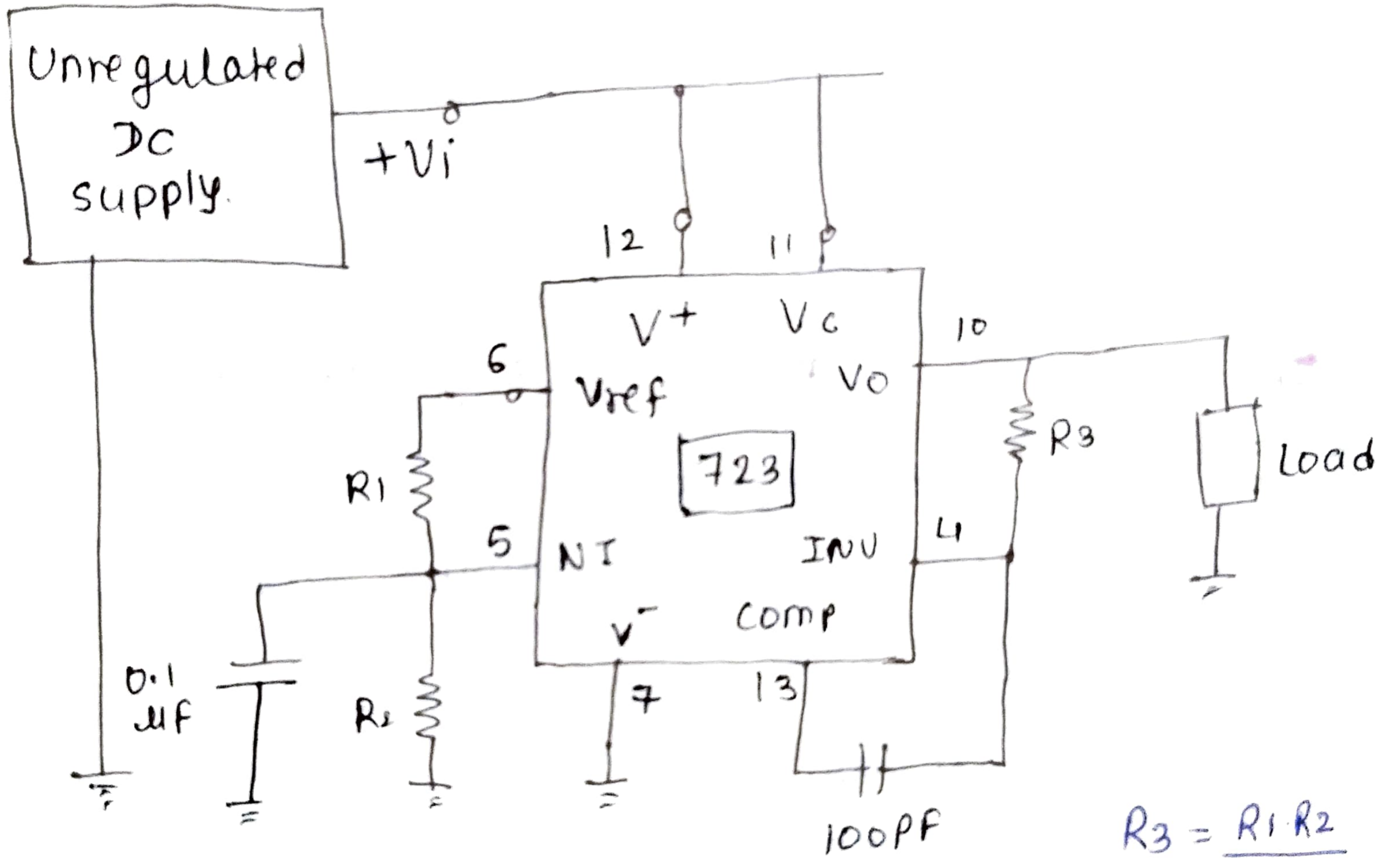
→ Can be used as +ve high v/g low c/n regulator.

→ —"— high —"—

→ Can be used as -ve voltage regulator.

→ Can be used as low voltage or high voltage regulator with short circuit protection.

1) Low vtg. Regulator using IC 723: [LVLC]



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

- used to regulate vtg. ranging from. 2V to 7V (<150mA)
- O/P vtg is directly fed back to the INV I/P terminal. The non-inverting I/P NI is obtained from potential divider R_1 & R_2.

$\therefore V_{NI} = V_{ref} \times \frac{R_2}{R_1 + R_2}$

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

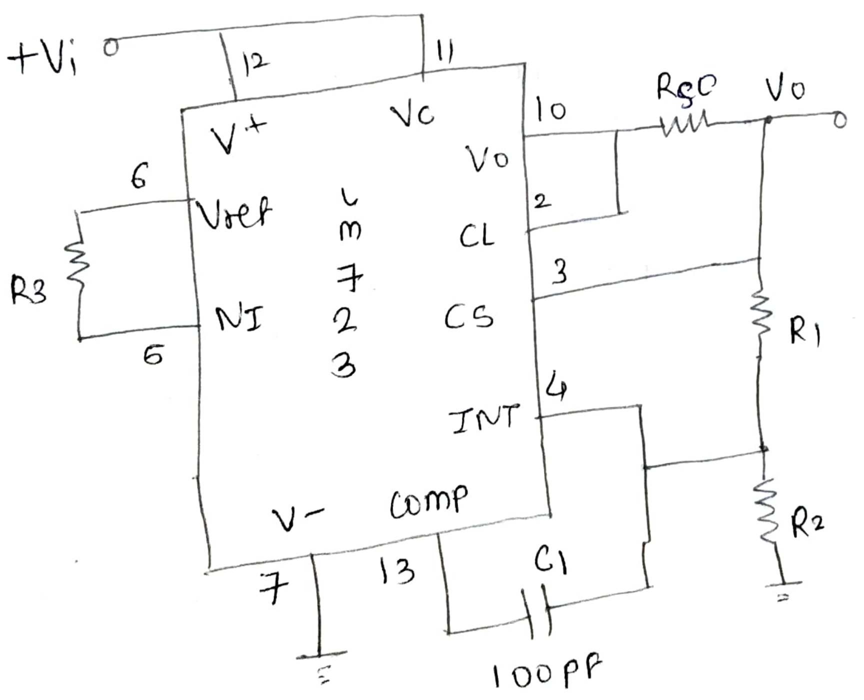
The error ampr amplifies the diffⁿ & it drives the pass transistor Q_1. Depending on the error signal, the pass transistor Q_1 acting as control element, minimises the difference betⁿ the NI & INV I/Ps of error ampr.

$$\therefore V_o = V_{ref} \times \frac{R_2}{R_1 + R_2} = 7.15 \times \frac{R_2}{R_1 + R_2}.$$

$V_o \downarrow, V_{INV} \downarrow$
$V_{error} \uparrow, I_L \uparrow$
$V_o \uparrow$.

Now assuming that the O/P vtg. is low, the INV terminal I/P goes down, making O/P of error ampr more +ve. This drives the NPN pass transistor further into conduction. Hence higher current is driven into the load, thereby causing the O/P vtg to increase. This compensates for drop in O/P vtg.
- similarly rise in load vtg gets regulated.

High voltage Regulator Circuit using IC 723:- HVLC.



$R_3 = R_1 \parallel R_2$

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

- IC 723 can be used for designing a high vtg. regulator for O/P vtg. ranging from 7V to 37V.
- NI terminal is connected to Vref thr' R_3.
- INV terminal connected to the jun^c of resistors R_1 & R_2 connected with the O/P V_o.
- R_3 → selected = $R_1 \parallel R_2$.
- error ampr - acts as non-inv amp^r with gain of

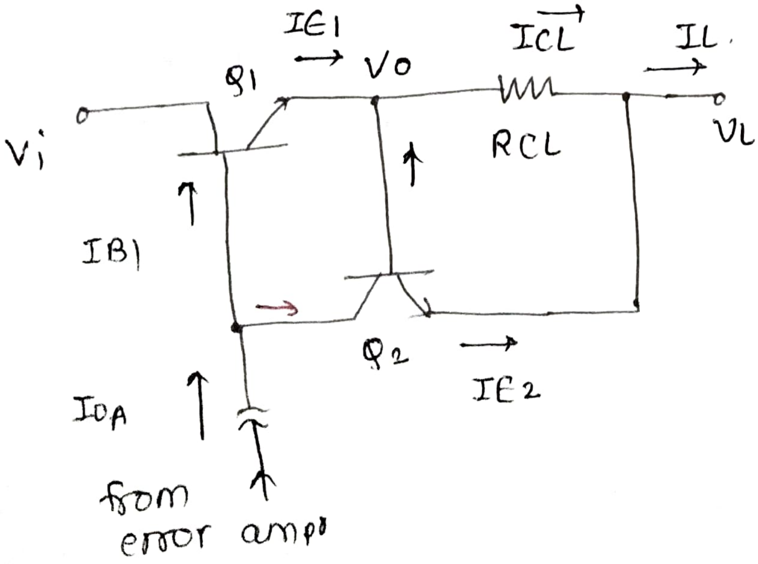
$$A_v = 1 + \frac{R_1}{R_2}.$$

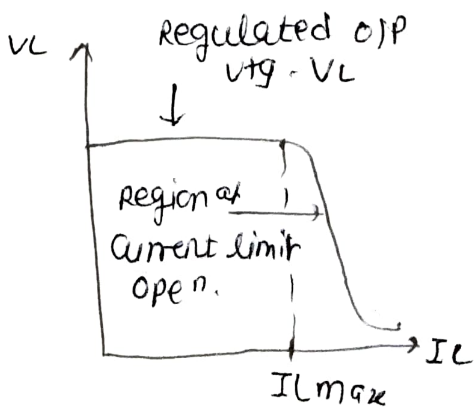
$$\therefore V_o = V_{ref}\left[1 + \frac{R_1}{R_2}\right] = 7.15\left[1 + \frac{R_1}{R_2}\right].$$

Current limiting circuits :-

Current limit protection :-

- Disadv of IC 723 → 1. no internal thermal protection
  2. " " S.C. protection.
- ∴ current limit protection is necessary in regulator IC. to provide protection against S.C condition a/c load.





O/P chara.

- This ckt prevents the IL from ↑ beyond a safe value.

- working:-

series pass element Q1 [part of regulator Ic] → connected in series with RCL

Vtg a/c RCL ← (current limiting resi.)

↓

Bias Q2 & turn it ON

Let IL (max) ← max current of ckt.

Vo = const ← for any value of ICL upto IL max.

⇓ (normal condn).

$V_{CL} = I_{CL} \times R_{CL}$ (In normal condn) ⇒ could not turn ON Q2 (∵ bias < 0.7) ⇒ ∴ Q1 supplies current for load at const. O/P VL.

⇓

VCL ↑ → turn ON Q2 → IL > IL(max) → extra current diverted away from base of Q1 ⇒ ↓ Iemitter of Q1

⇓

IL ↓.

- similarly, when IL ↓, Vtg a/c RCL ↓, Q2 OFF & Q1 ON to pass IL.

- O/P charg :-

Q2 supplies an additional small amount of current to the load, when the current limiting takes place.

Refer pg. 379 of L.I.C by S. Salivahanan

Example: Assume that $V_L = 20V$ for limiting max current of 0.5A.

1. RCL = ? for limiting max current of 0.5A.
2. RCL = ? find Vo when RL = 100Ω
3. comment on the operation of the ckt. for RL = 10Ω.

Ex 2: Design a +12V reg. using LM 723 with current limiting value of 50 mA.

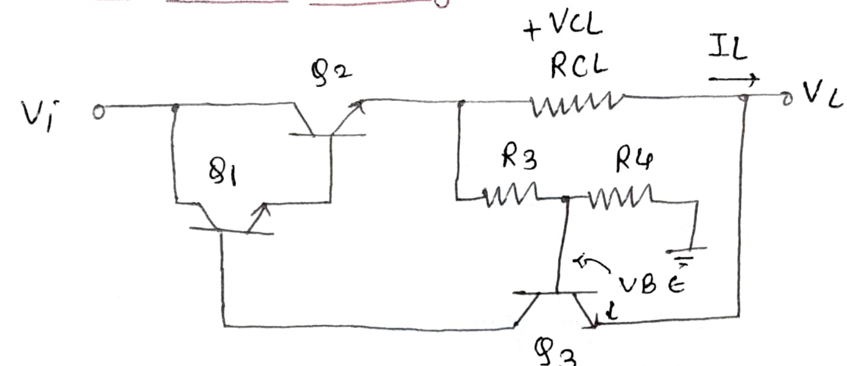
Soln:- $V_o = V_{ref}\left[1 + \frac{R_1}{R_2}\right]$.

Let $R_2 = 10\,K\Omega$, find R_1

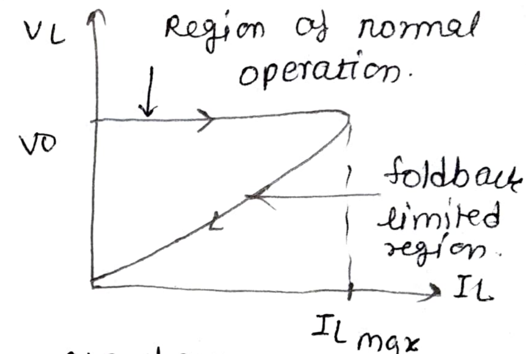
$$R_1 = \left[\frac{V_o}{V_{ref}}\right] \cdot R_2 - R_2$$

$$= \left(\frac{12}{7.15}\right) 10 \times 10^{-3} - 10 \times 10^{3} = 6.78\,K\Omega.$$

* foldback current limiting :-



ckt



O/P chara

In simple current limiting ckt,

- I_{Lmax} was present such that → P_D never $> V_L I_{L(max)}$
  & RCL was accordingly chosen.
  ⇓ Hence
  Regulator is under utilised. } ⇒ In such conditions
  ⇓
  → Current foldback method provides full protection to device + allows higher currents to the load.

— ↓ IL & VL when $I_{L(max)}$ is reached. ⇐

working :- As load resi ↓ beyond certain min. value
⇓
VL & IL ↓
& when Load resi → S.C
VL = IL = 0.

Adv → a) protect load from over-current operation.
b) protects regulator itself.

The base of Q_3 is connected to the vtg. divider formed by R_3 & R_4.

Applying KVL around loop, we get.

$V_{BE} = V_{CL} - V_{R3}$.

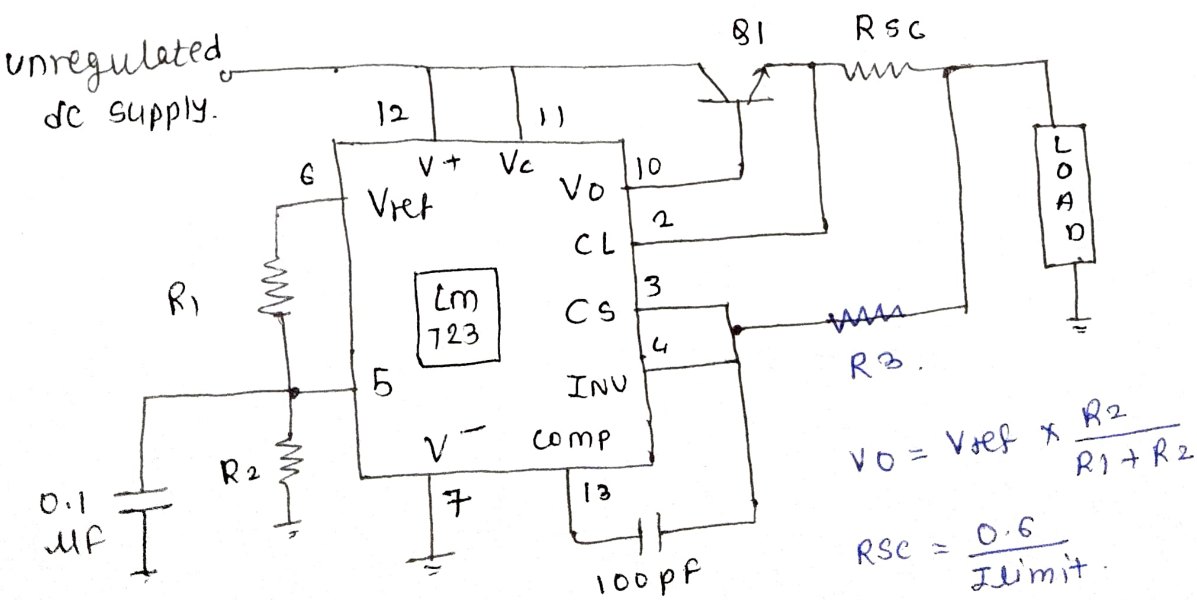
The current limit transistor Q_3 starts conducting only when its base to emitter vtg. V_{BE} is approx. 0.7V.

i.e $V_{CL} > 0.7V$.

i.e $V_{BE} = V_{CL} - V_{R3} = 0.7$

- current limit starts occuring.
- $R_L \downarrow$, load vtg. drop. & $V_{R3} \downarrow$.
- V_{CL} should $\downarrow$ to maintain V_{BE} of Q_3 at 0.7V
- Q_3 starts conducting, $\rightarrow$ Q_1 turn off & $I_L \downarrow$.
- V_{R3} further $\downarrow \rightarrow \uparrow$ conduction of Q_3 & $\downarrow$ conduction of Q_1. $\rightarrow I_L \downarrow$.
- process continues until $V_O = 0$ & $I_L = min$.
- If R_L = nominal operating value, the ckt. resumes its normal regulation action.

* High current low vtg. regulator :- (LVHC)



$V_O = V_{ref} \times \frac{R_2}{R_1 + R_2}$

$R_{SC} = \frac{0.6}{I_{limit}}$.

P.D of Q_1 = $(V_{i(max)} - V_{O(min)}) \times I_{L max}$.

- max current obtainable from 723 is 140 mA.
- for ↑ current, boost pass transistor Q_1 can be added to the regulator.
- collector of Q_1 is connected to unregulated P.S.
- O/P V_o of reg. drives base of Q_1.

$$\therefore \; I_o = \beta_{\text{Boost transistor}} \times I_{o(723)}.$$

- Darlington transistor pair can also be used in place of Q_1 as the pass transistor for obtaining much higher values of load currents.

EX: Design a continuously adjustable P.S. for range of 2V to 5V with a current limit of 1 A using LM 723.

→ $V_o = V_{ref} \cdot \dfrac{R_2}{R_1 + R_2}$ (Adj vtg. reg. for high current).

To produce $I_L = 1A$, Q_1 is req.

for vtg. adj → R_1 is replaced with series of R_{1a}, R_{1b}.

- Here min & max values of R_1 will be R_{1b} & $R_{1a} + R_{1b}$ resp.

Then 3 resi are in series will form vtg. divider.

$$\therefore \; \frac{R_1 + R_2}{R_2} = \frac{V_{ref}}{V_o}.$$

for max. vtg. of 5V,

$$\frac{R_{1b} + R_2}{R_2} = \frac{V_{ref}}{V_o} = \frac{7.15}{5} = 1.43$$

$$\therefore \; R_{1b} = 0.43 \, R_2.$$

for min vtg. of 2V

$$\frac{R_{1a} + R_{1b} + R_2}{R_2} = \frac{V_{ref}}{V_o} = \frac{7.15}{2} = 3.575$$

substitute $R_{1b} = 0.43 R_2$ in above eq^n.

$\therefore R_{1a} = 2.145 R_2$

choose std value of $R_{1a} = 10K$.

$$\therefore R_2 = \frac{R_{1a}}{2.145} = \frac{10 \times 10^3}{2.145} = 4.66\ K$$

$$\boxed{R_2 = 4.66\ K}$$

Similarly, $R_{1b} = 0.43 R_2 = 0.43 \times 4.66 \times 10^3 = 2K\Omega$

for choosing a suitable current sense Resi R_{SC},

$$I_{limit} = \frac{V_{sense}}{R_{SC}}$$

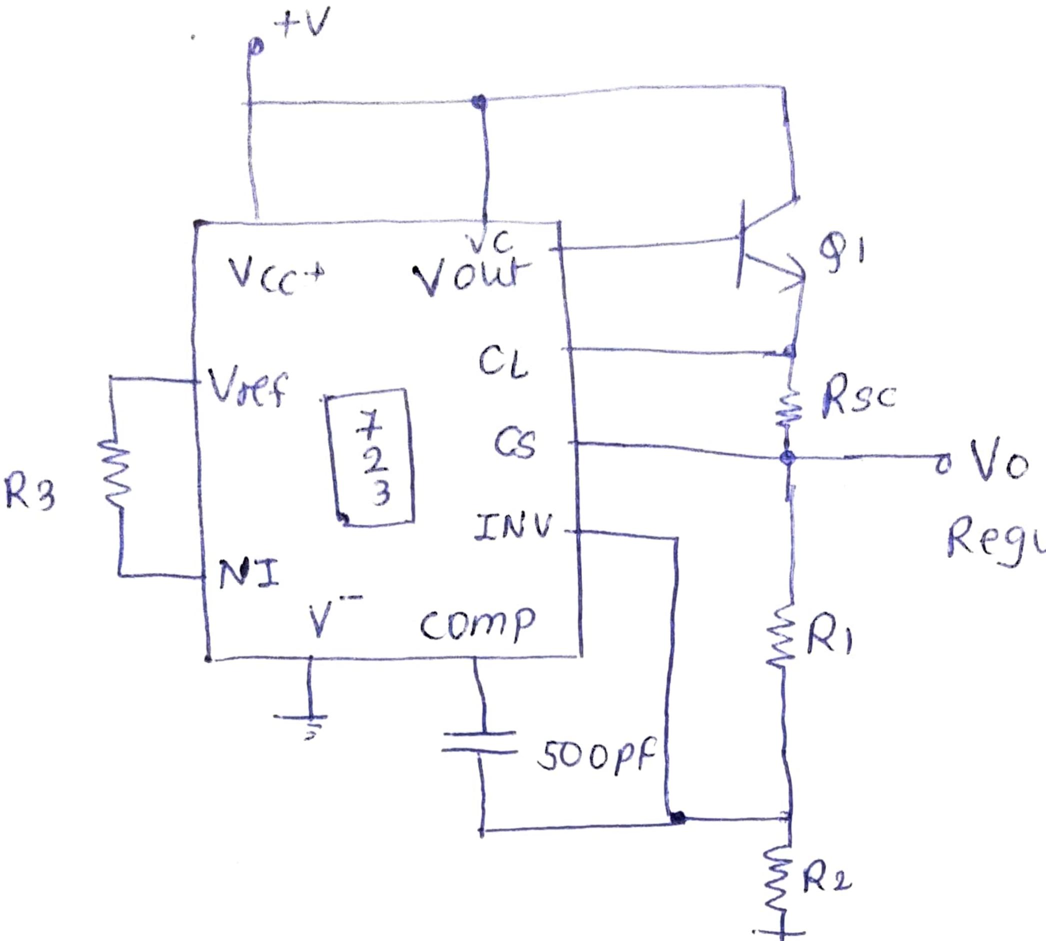
$$\therefore R_{SC} = \frac{V_{sense}}{I_{limit}} = 0.65\Omega$$

for min. temp. drift, R_3 is included as given by

$$R_3 = R_1 \parallel R_2 = 6K \parallel 4.66K$$

$$= 2.62\ K\Omega.$$

4] High voltage High current Regulator: — Vo = 7V to 37V > 150 mA



Regulated o/p.

$$V_o = V_{ref}\left(\frac{R_1+R_2}{R_2}\right).$$

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

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