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MD IFTAKHAR KABIR SAKUR

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COURSE TITLE: Micro Electronics

COURSE TEACHER:

Abu Zafar Md. Imran

Lecturer
Electronic and Telecommunication Engineering

| Feedback Amplifier |

08.08.21

7:51 p.m

CCE-2303 (Micro Electronics)

E201037 SAKUR

Feedback Amplifier:-

In the process of feedback, a part of output is sampled and fed back to the ~~output~~ input of the amplifier.

In Input we have two signals:

(i) Input signal

(ii) part of the output which is fed back to the input.

∴ • Both these signals may be in phase or out of phase.

→ when input signal and part of output signal are in phase, the feedback is called positive feedback.

→ On the other hand, when they are in out of phase, the feedback is called negative feedback.

⊛ Use of positive feedback results in oscillations and hence not used in amplifier.

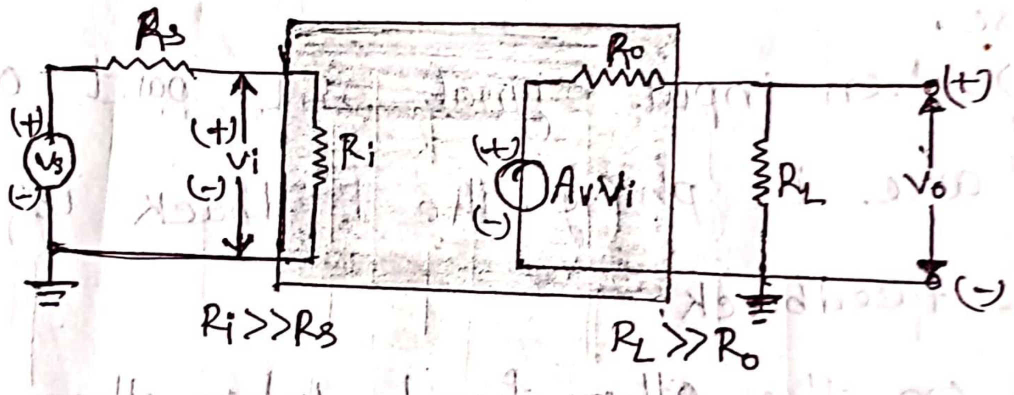
3.2] Classification OF Amplifiers :-

The classification of amplifiers based on the magnitudes of the input and output impedances of an amplifier relative to the source and load impedances, respectively.

The amplifiers can be classified into four broad catagories :-

(i) voltage (ii) current (iii) transconductance and (iv) transresistance amplifiers.

(i) Voltage Amplifier :- → Figure :- Thevenin's



=) If the amplifier input resistance R_i is large compared with the source resistance R_s then $V_i = V_s$. If the external load resistance R_L is large compared with the output Resistance R_o of the amplifier, then

$V_o = A_V \cdot V_i = A_V \cdot V_s$. (Such amplifier circuit provides a voltage output proportional to the voltage input and the proportionality factor does not depend on the magnitudes (मात्रा) of the source and load resistances. Hence, this amplifier is called voltage amplifier.) An ideal voltage amplifier must have infinite input Resistance (R_i) and zero Output Resistance (R_o). For practical voltage amplifier we must have $R_i >> R_s$ and $R_L >> R_o$

(2) Current Amplifier:

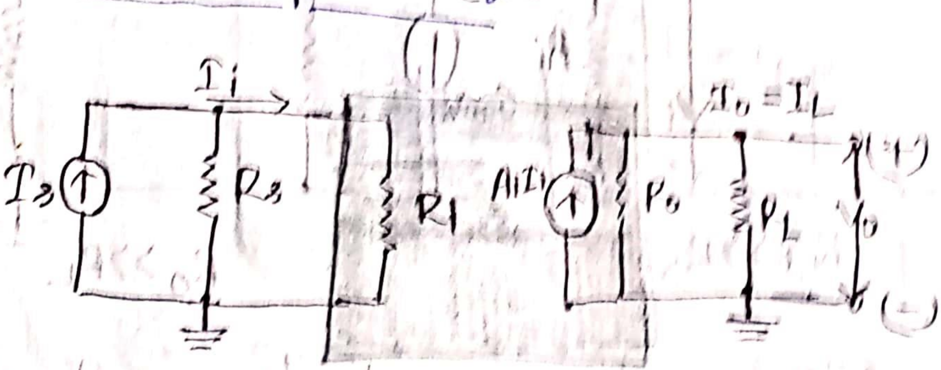


Figure: Norton's equivalent circuits of a current amplifier.

=> If amplifier input resistance $R_i \to 0$, then $I_i = I_s$. If amplifier output resistance $R_o \to \infty$

then $I_L = A_i I_i$. Such amplifier provides a current output proportional to the signal current and the proportionality factor is independent of source and load resistances. This amplifier is called current amplifier.

An ideal current amplifier must have zero input resistance R_i and infinite output resistance R_o. Current amplifier must have $R_i << R_s$ and $R_o >> R_L$.

④ Transconductance Amplifier:-

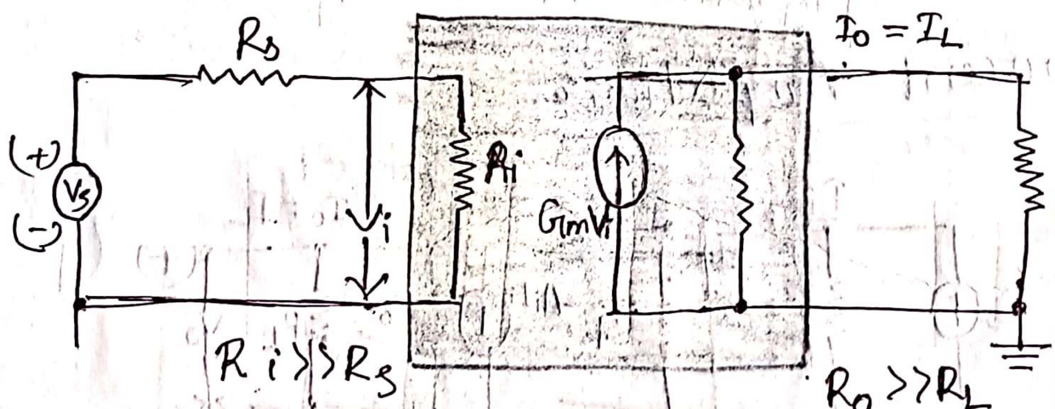


Figure: Transconductance Amplifier

2) Thevenin's equivalent in its input circuit and Norton's equivalent in its output circuit makes transconductance amplifier.

In this amplifier, an output current is proportional to the input signal voltage and the proportionality factor is independenct of the magnitudes of the source and load resistances.

Ideally, this amplifier must have an infinite input Resistance R_i and infinite output Resistance R_o.

For practical transconductance amplifier we must have $R_i >> R_s$ and $R_o >> R_L$.

4) Transresistance Amplifier:-

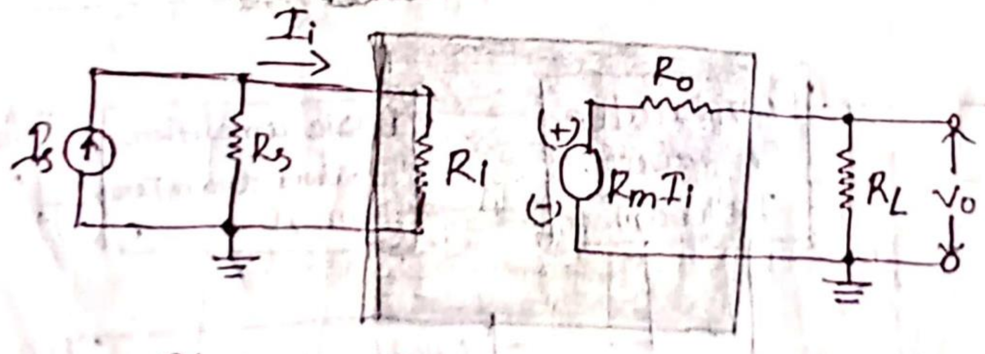


Figure:- Transresistance Amplifier

⇒ A resistance amplifier with a Norton's equivalent in its input circuit. And a Thevenin's equivalent in its output circuit.

In this amplifier an output voltage is proportional to the input signal current and the proportionality factor is independent on the source and load resistances.

Ideally, this amplifier must have zero input resistance R_i and zero output resistance R_o. For practical transistance amplifier we must have $R_i << R_s$ and $R_o << R_L$.

Feedback Concept

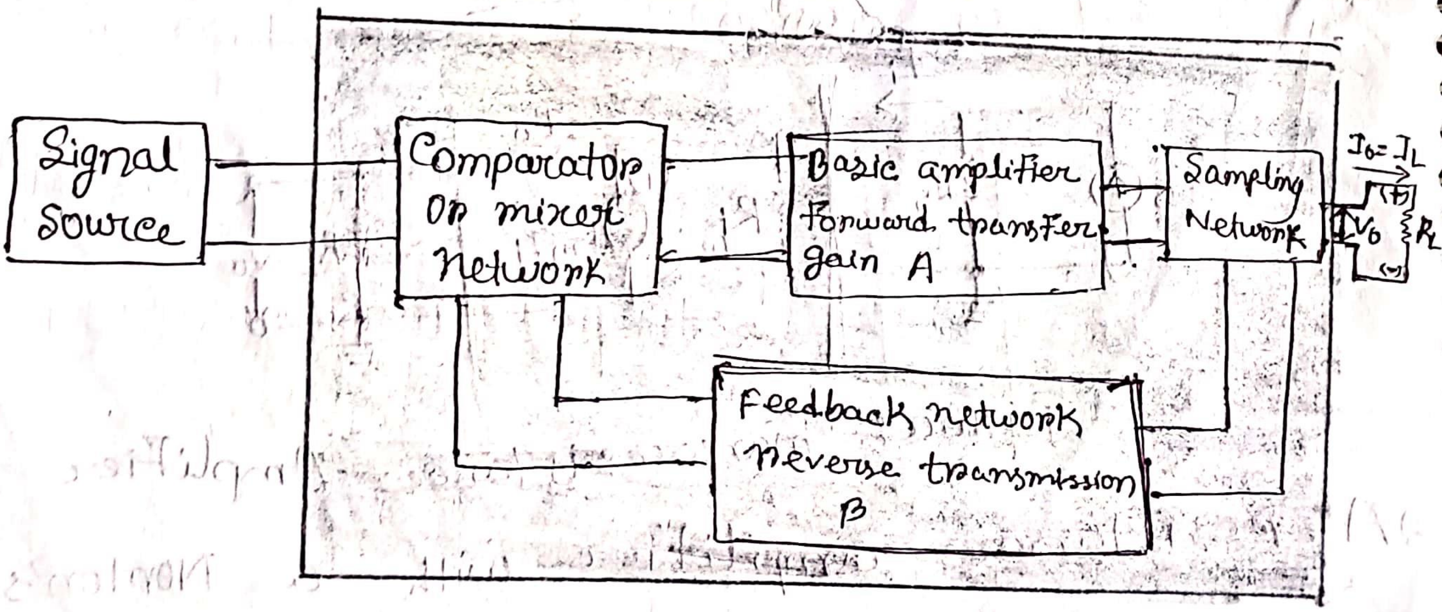


Figure:- Typical feedback connection around a basic amplifier.

Feedback connection has three networks:-

(1) Sampling Network. (নমুনা নেটওয়ার্ক)

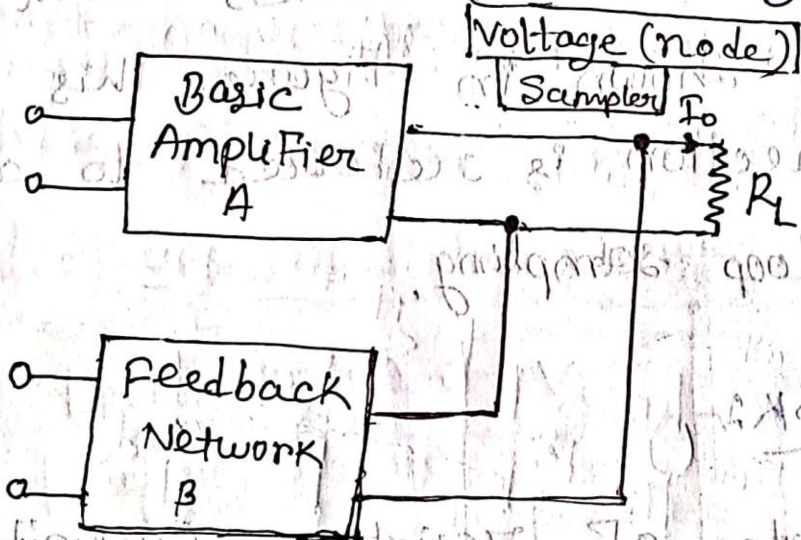
(2) Feedback Network. (প্রতিক্রিয়া নেটওয়ার্ক)

(3) Mixer Network (মিশ্র নেটওয়ার্ক)

1 Sampling Network:-

There are two ways to sample the output, according to the sampling parameter.

(i) Voltage or Node Sampling:-



Shunt:-
A resistor having a very low resistance connected in parallel with other resistor is caused shunt.
The shunt is used in the galvanometer for measuring the large current.

Fig:- Voltage or Node Sampling

=) The output voltage is sampled by connecting the feedback network in shunt across the output. This connection is referred to ~~as~~ as, voltage or node sampling.

(b) Current or loop Sampling :-

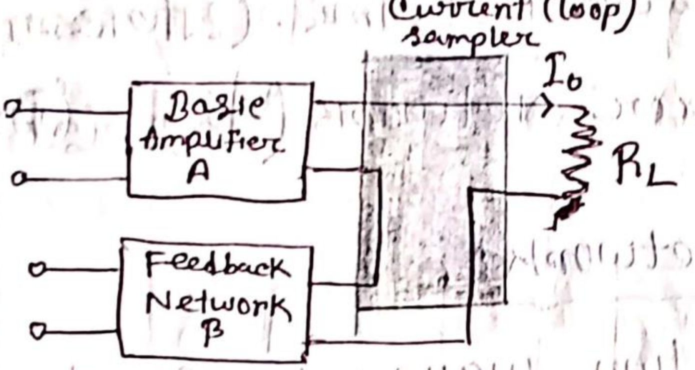


Fig:- Current or loop sampling

=) The output current is sampled (नमूना) by Connecting the Feedback network in series with the output as shown in Figure. This type of connection is referred to as Current or Loop sampling.

2] Feedback Network:-

It may consists of resistors, Capacitors and inductors. Most often it is simply a resistive Configuration.

It provides reduced ~~provides~~ portion of the output as feedback signal to ~~the~~ the input mixer network.

It is given as,

$$V_f = \beta V_o$$

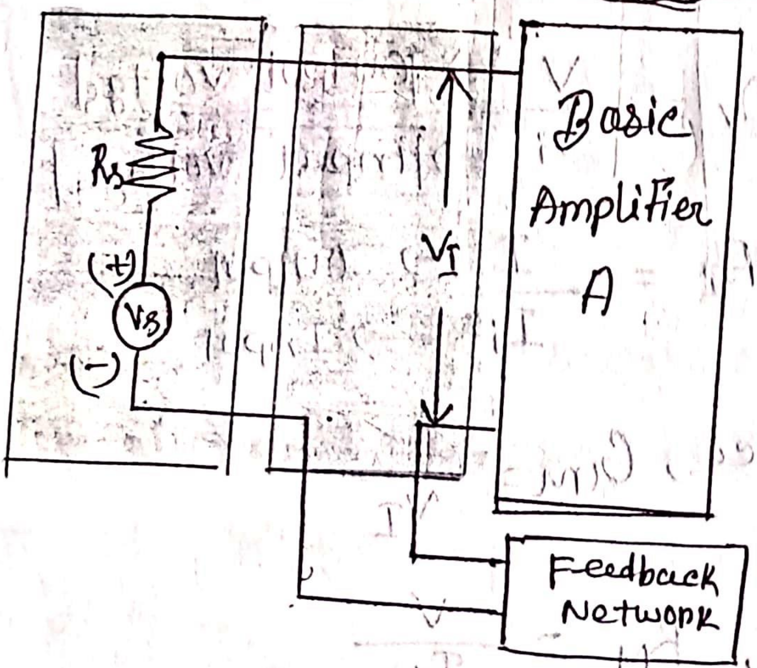
Here, β is a Feedback Factor or Feedback ratio. ~~The~~ which always lies between 0 & 1.

Another β symbol which represent current gain in common ~~emmi~~ emitter amplifier, which is greater than 1. These two β are not same.

3 Mixer Network:-

There are two ~~Ki~~ types of mixer network.

1| Series Input Connection:-



(a) Series Mixing

6.2) Shunt Mixing :-

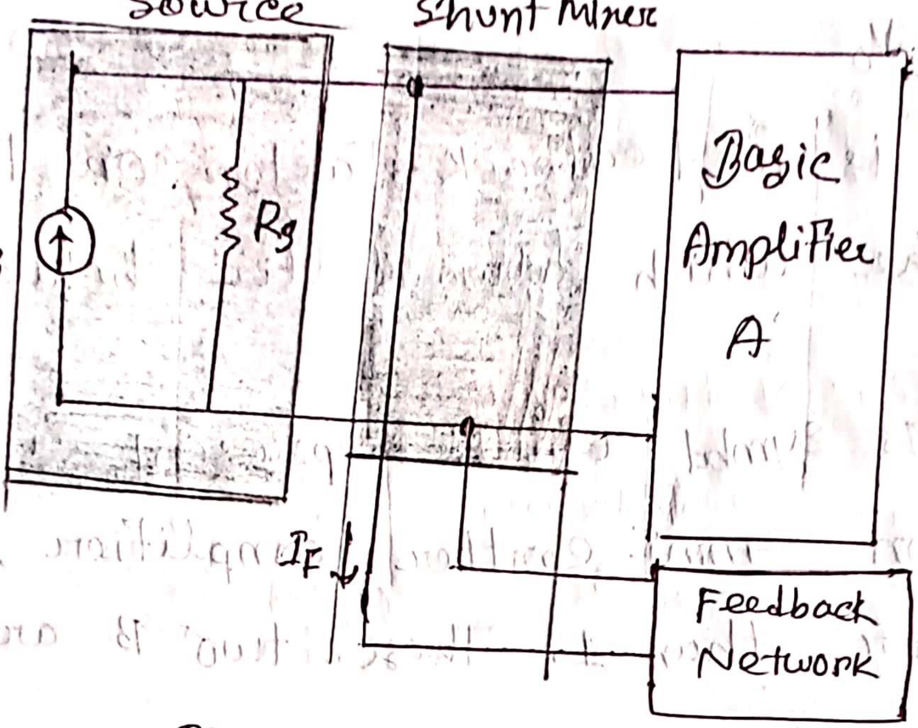


Fig:- Shunt Mixing

Transfer Ratio or gains (without Feedback)

A = The ratio of the output signal to the input signal of the basic amplifier

① Voltage gain, $A_V = \frac{V}{V_i}$ → Output voltage / Input voltage

② Current gain, $A_I = \frac{I}{I_i}$ → Output / Input

③ Transconductance, $G_M = \frac{I}{V_I}$

④ Transresistance, $R_M = \frac{V}{I_i}$

With Feedback:-

① A_{VF} = (Voltage gain with Feedback)

$$= \frac{V_o}{V_s} \begin{matrix} \rightarrow \text{Voltage output} \\ \rightarrow \text{signal voltage} \end{matrix}$$

② Current gain with Feedback, $A_{IF} = \frac{I_o}{I_s}$ (I_o → output, I_s → signal)

③ Transconductance with Feedback, $G_{MF} = \frac{I_o}{V_s}$

④ Transresistance with Feedback, $R_{MF} = \frac{V_o}{I_s}$

Negative Feedback Amplifier

When part of output signal and input signal are in out of phase the feedback is called negative feedback.

The schematic diagram shown figure represents negative feedback because the feedback signal is fed back to the input of the amplifier out of phase with input signal of the amplifier.

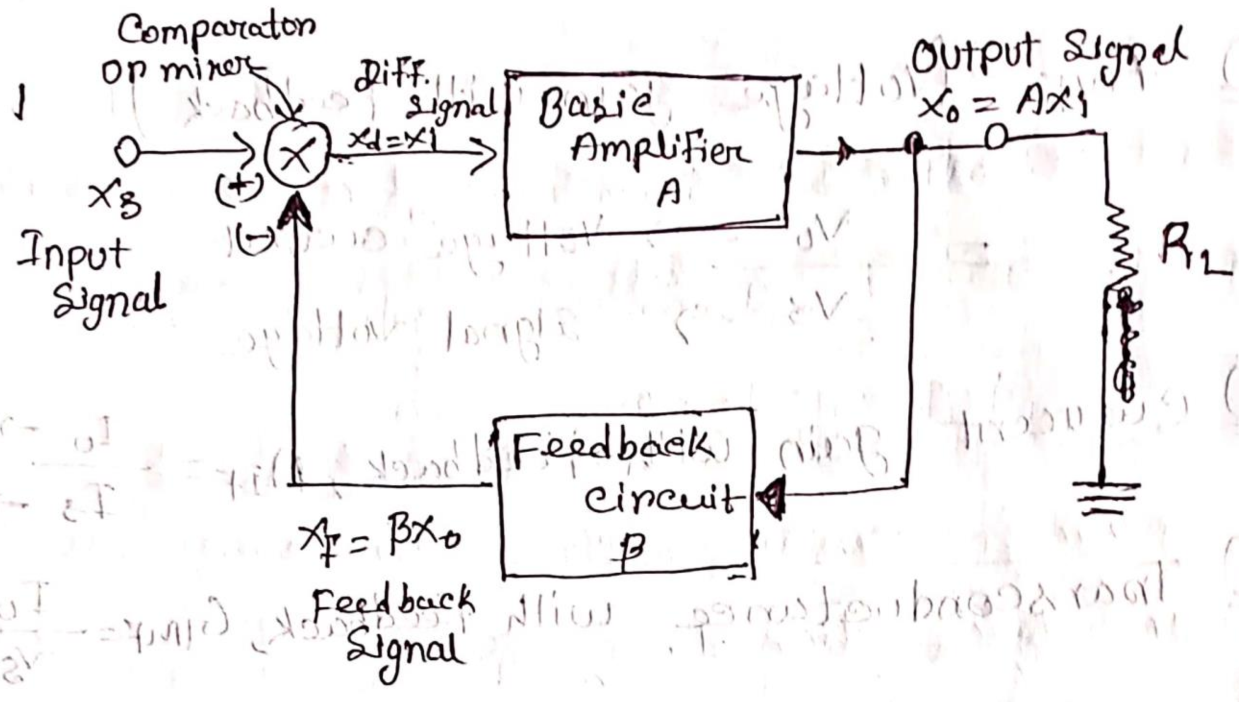


Fig:- Schematic Representation of negative Feedback amplifier.

Ways of introducing negative Feedback in Amplifiers:-

(a)

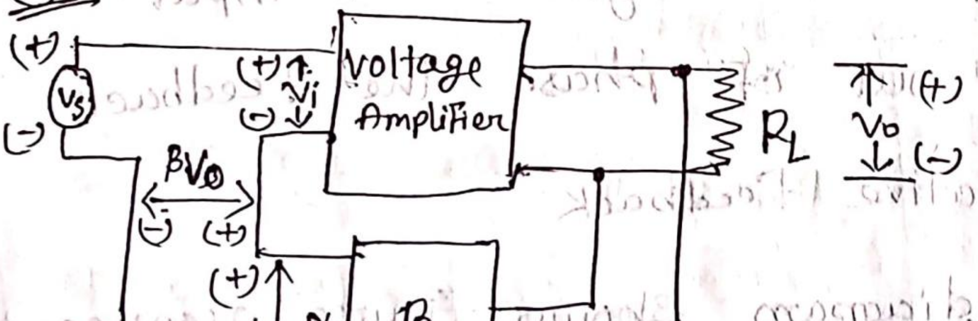


Fig:- Voltage amplifier with voltage series Feedback.

(b)

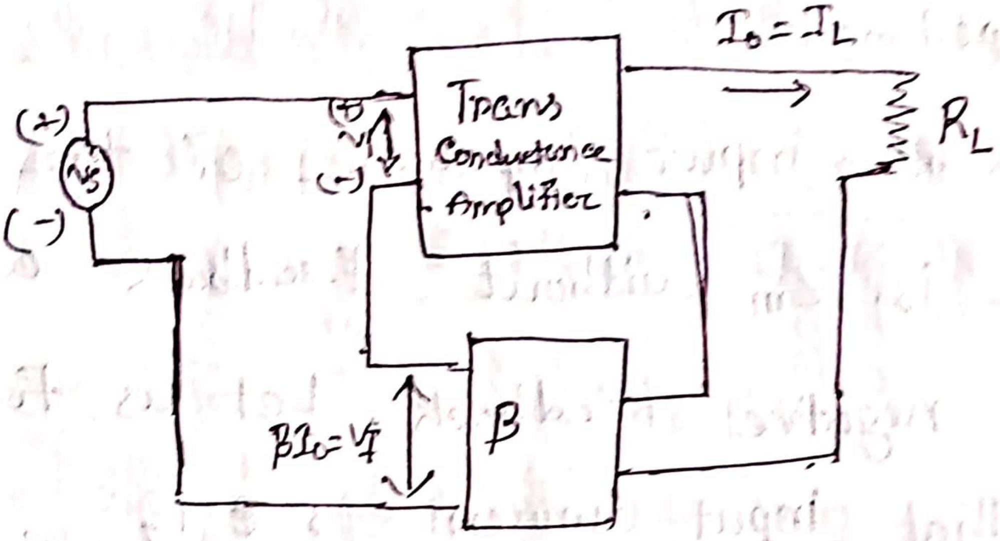


Fig:- Transconductance Amplifier with Current Series Feedback

(c)

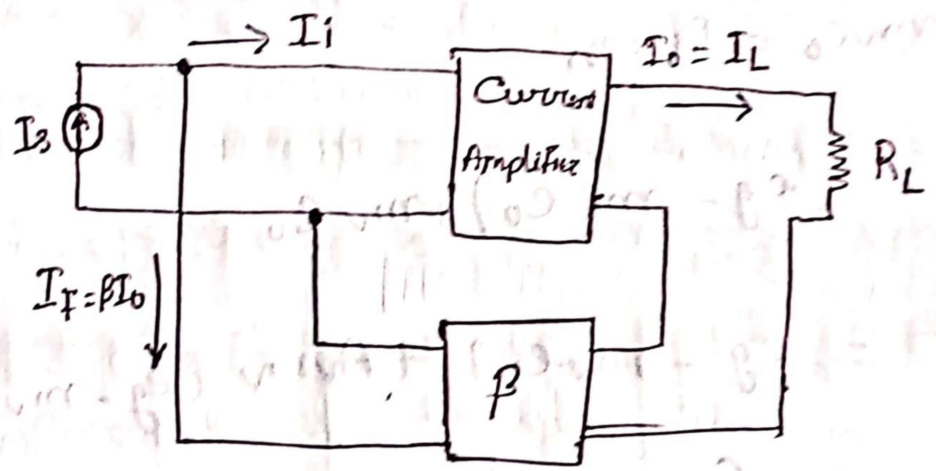


Fig:- Current amplifier with current shunt Feedback.

(d)

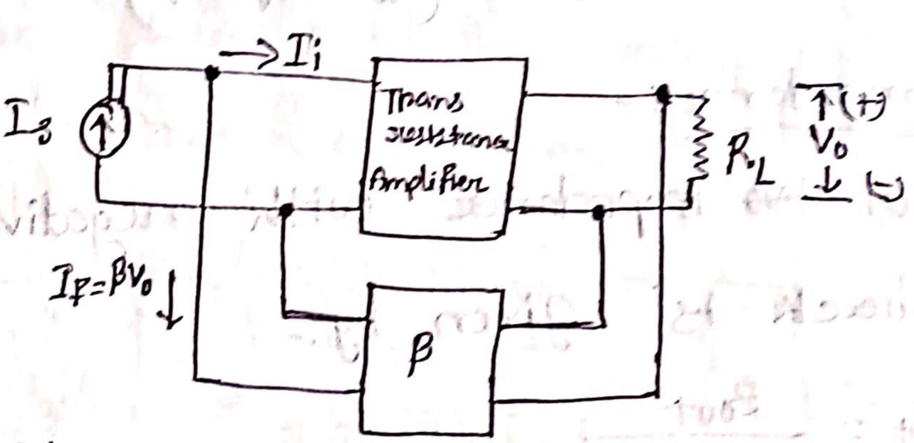


Fig:- Transresistance amplifier with voltage shunt Feedback

Input Impedance :-

IF the input impedance of the amplifier is Zin without feedback an Z'in with negative feedback. Let us further assume that input current is i_1.

we have,

$$e_g - m_v e_o = i_1 Z_{in}$$

$$e_g = (e_g - m_v e_o) + m_v e_o$$

$$= (e_g - m_v e_o) + A_v m_v (e_g - m_v e_o)$$

$$= (e_g - m_v e_o)(1 + A_v m_v)$$

$$= i_1 Z_{in}(1 + A_v m_v)$$

Output Impedance :-

Output impedance with negative voltage feedback is given by :-

$$Z'_{out} = \frac{Z_{out}}{1 + A_v m_v}$$

Z'_{out} = of output impedance with negative voltage feedback

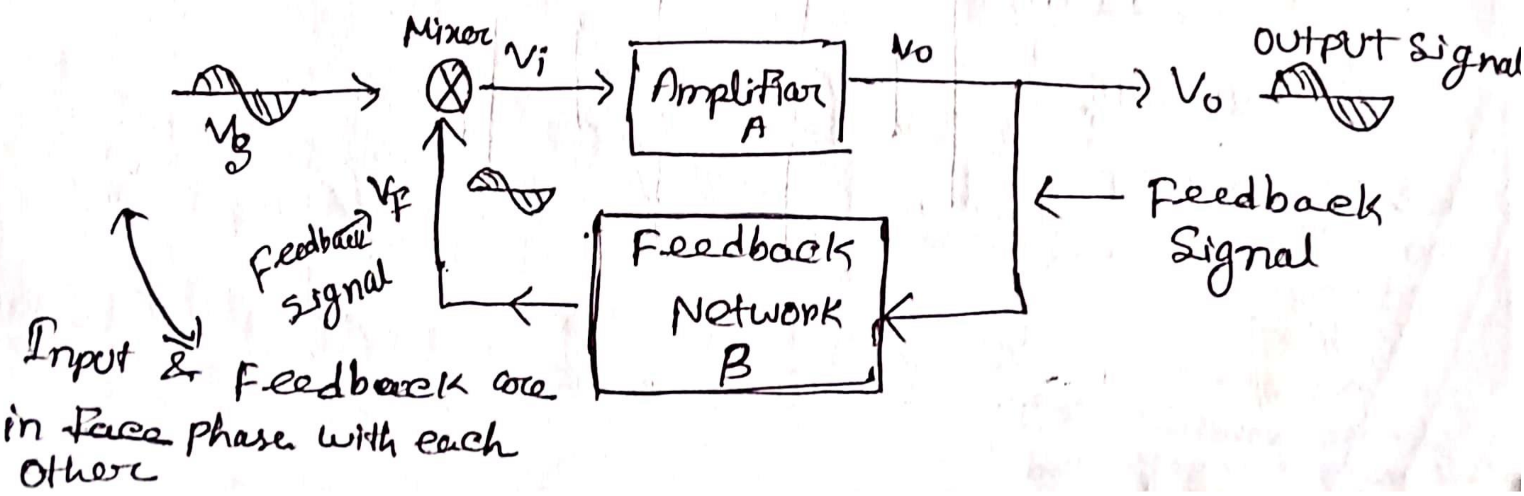
Z_{out} = Output impedance without Feedback

Oscillators (दोलक) (Chapter-4 180 page)

=) The positive feedback results into oscillations and hence used in electronic circuit to generate the oscillations of desired frequency. Such circuits are called oscillators.

Concept of positive feedback:-

The feedback is a property which allows to feedback the part of the output to the same circuit as its input. This is said to be as positive whenever the part of the output that is fed back to the amplifier as its input, is in phase with the original input signal applied to the amplifier.



Assume that a sinusoidal input signal (voltage) V_s is applied to the circuit. As amplifier is non-inverting, the output voltage V_o is in phase with the input signal V_s.

The part of the output is fed back to the input with the help of a feedback network. How much part of the output is to be fed back gets decided by the feedback network gain β. No phase change is introduced by the feedback network. Hence the feedback voltage V_F is in phase with the input signal V_s.

Barkhausen Criterion:-

$$A_{VF} = \frac{A_V}{1-\beta \cdot A_V}$$

A_{VF} = Voltage gain with ~~by~~ applying the Feedback Signal (F/b)

A_V = Voltage gain without Feedback F/b or, open loop gain

Here,

$\beta \cdot A_V = 0$

Then whole value is 0.

$A_{VF} = \frac{A_V}{0}$ [The voltage gain with Feedback $(A_{VF}) = \infty$]

SO, practically not possible

$A_{VF} = \frac{V_o}{V_{in}}$

if,

$A_{VF} = \infty$ $\boxed{V_{in} = 0}$

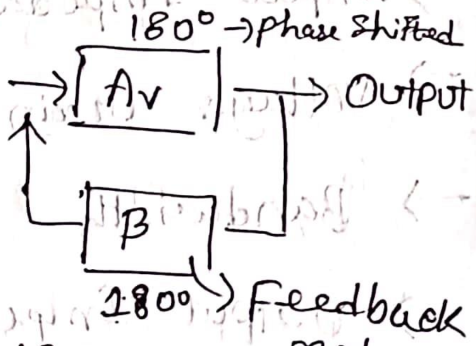
Barkhausen criteria

1st condition OF BC:-

① $\beta \cdot A_V = 1$

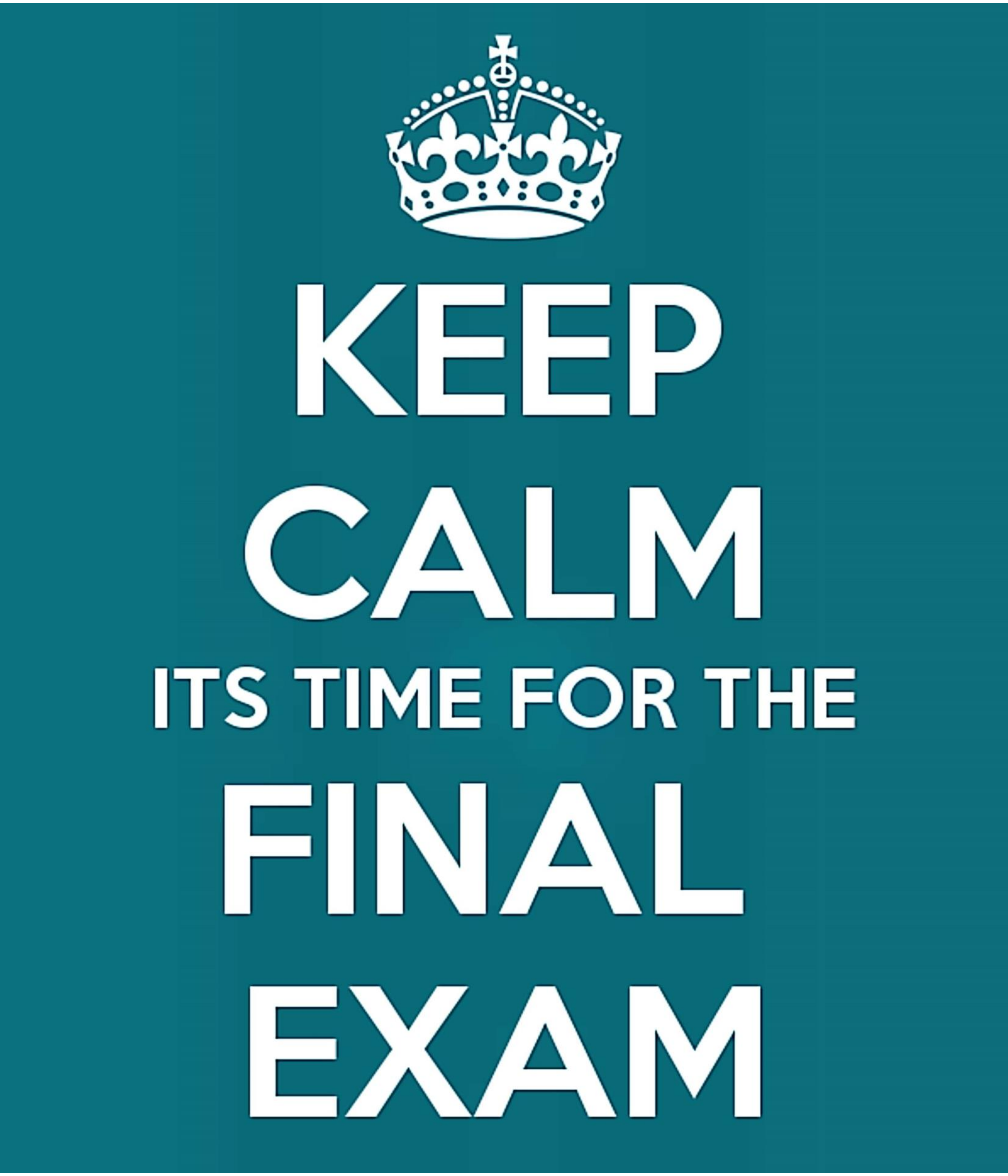
[To produce the sustain Oscillation or to produce un oscillations $\beta \cdot A_V = 1$]

② Input → A_V → Output



+. Phases = 180° + 180° = 360° = 0°

$\angle \beta \cdot A_V = 0°$ or 360° → The input or Feedback signal both 0° or 360° Phase shifted


KEEP
CALM
ITS TIME FOR THE
FINAL
EXAM

Phase Shift Oscillator

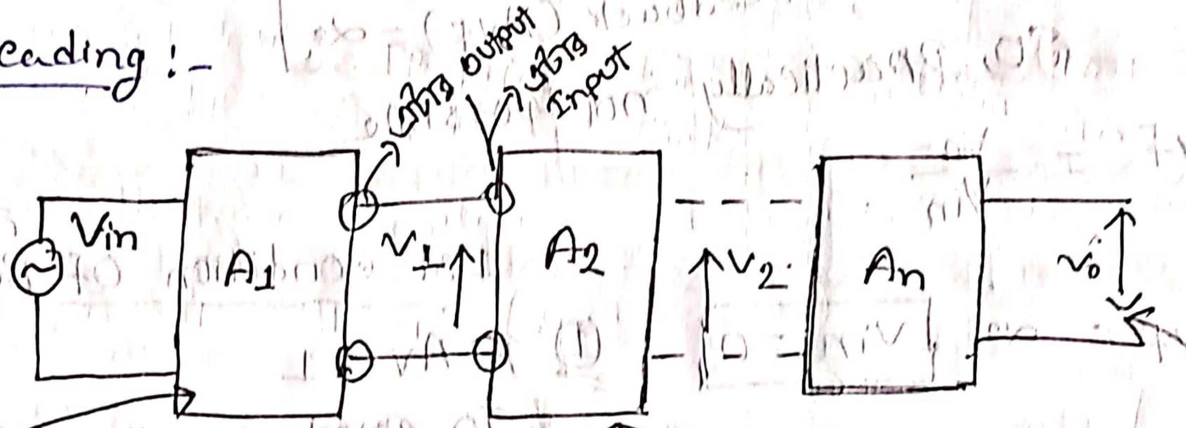
RC oscillator → Kind of

{Final Exam}

Multistage Transistor Amplifiers

[PdF: VKMehta (P-280)]

Cascading :-



[parameters] →

→ Input Impedance

→ Voltage Gain

→ Bandwidth

→ Output Impedance

Input → [1st Stage] → [Coupling] → [Second Stage] → [Coupling] → [3rd Stage] → Output

Overall Voltage Gain:- (Cascading Configuration)

$$A_V = \frac{V_o}{V_i}$$ → voltage output / → Voltage input

$A_V = \frac{V_o}{V_{o2}}$ → last Amplifier এর output

$$\Rightarrow A_V = \frac{V_o}{V_{o2}} \times \frac{V_{o2}}{V_{o1}} \times \frac{V_{o1}}{V_i}$$

↓ A_{V3} ↓ A_{V2} ↓ A_{V1}

→ 3 Amplifier থাকলে, → Amplifier2 → Amp1

Amp 3 → voltage gain

$\Rightarrow A_V = A_{V1} \times A_{V2} \times A_{V3}$ [যতগুলো Amplifier Connect তাদের সবগুলোর voltage gain এর product]

Overall current Gain:-

$A_I = A_{I1} \times A_{I2} \times A_{I3}$ [যতগুলো Amplifier Connect তাদের সবগুলোর Current gain এর product]

↓ current gain → = =

→ Amp1 → Amp2 → Amp3

⇒ R_i → Overall Input Resistance

⇒ R_o → Overall output Resistance

Gain in Decibles

① Power Gain, $dB = 10 \log_{10} [P_o / P_i]$ db

P_o → Output power
P_i → Input power

② Overall voltage gain,

$$dB = 20 \log_{10} [V_o / V_i]$$

V_o → Output voltage of Amplifier
V_i → Input voltage of Amplifier

The common logarithm (log to the base 10) of power gain is known as bel power gain

③ Current gain, $= 10 \log_{10} \frac{I_{out}^2 R}{I_{in}^2 R} = 20 \log_{10} \frac{I_{out}}{I_{in}}$

∴ ~~$A_v dB = A_{v1} dB$~~

⊛ Multistage Amplifier হলে এরূপ voltage gain দেওয়া থাকলে:- (Decible এ)

$$A_v dB = A_{v1} dB + A_{v2} dB + \cdots$$

④ Gain can happen with current, voltage, power.

$$* \; G = G_1 \times G_2 \times G_3 \ldots \times G_n$$

The gain of multistage amplifier is equal to the product of gains of individual stages.

Methods OF Coupling Multistage Amplifier :-

- R-C Coupling
- Transformer Coupling
- Direct Coupling

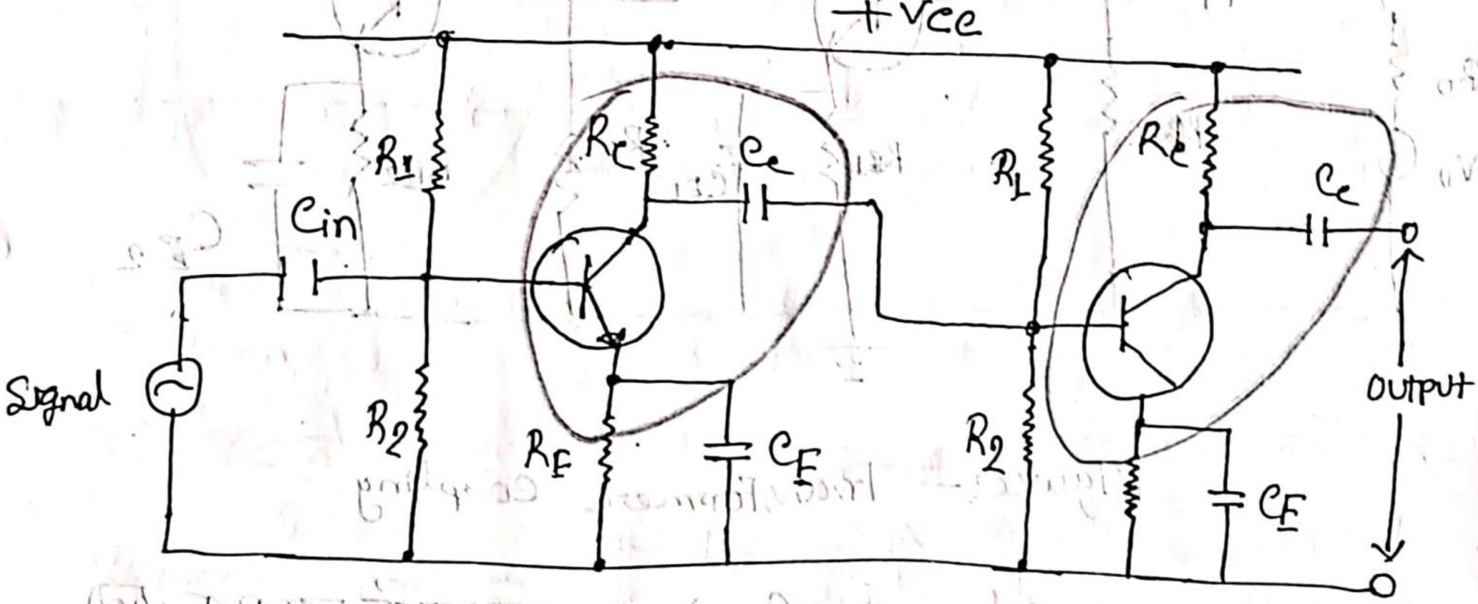


Figure -> R-C Coupling

⇒ উপরোক্ত Amplifier এ Transistor এ Resistor ও Capacitor এ Coupling করা হয়েছে। যা R-C Coupling

Transformer Coupling

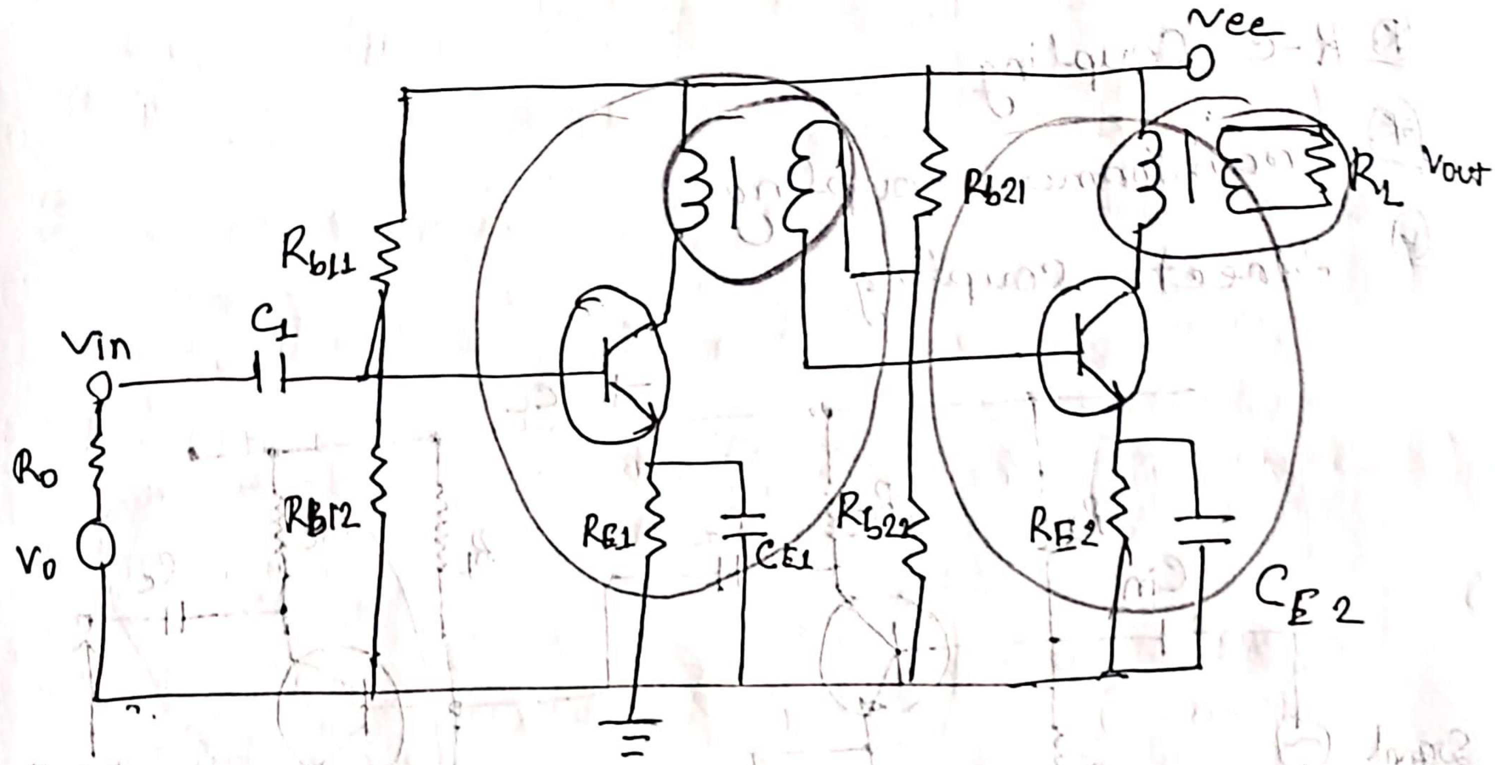


Figure 1- Transformer coupling

=> এখানে, দুইটি স্টেজ (O) কে কানেক্ট করার জন্য Transformer Use করা হয়েছে। তাই একে Transformer Coupling বলা হয়।

Direct coupling :

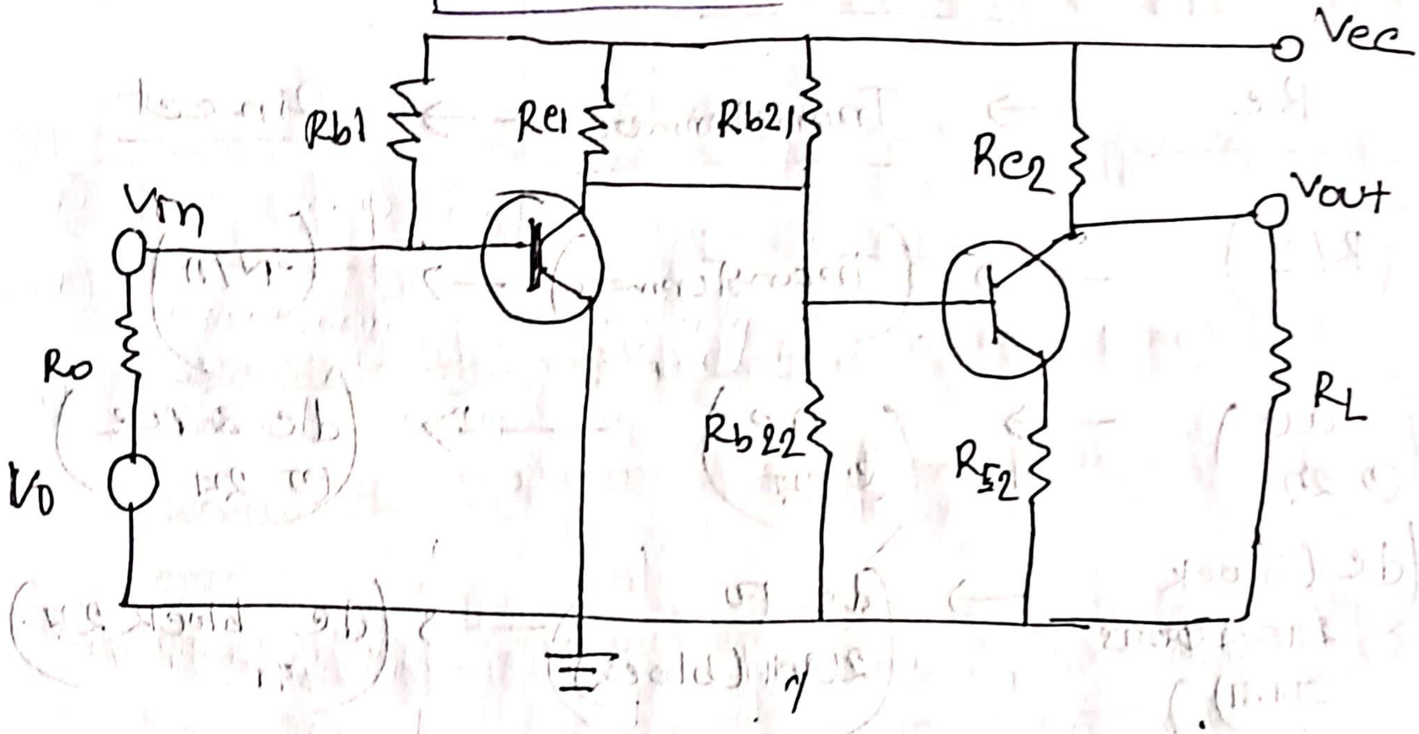


Figure :- Direct coupling

=> এখানে R-C বা Transformer কোনটাই নেই এবং Direct connect করা হয়েছে ; তাই Direct coupling

Difference

	Rc	Transformer	Direct
①	(R/C)	(Transformer)	(N/A)
②	(ac তে হয়)	(ac তে হয়)	(dc & ac তে হয়)
③	(dc (block থাকে অর্থাৎ হবেনা))	(dc তে হবেনা (block))	(dc block হয় না)
④	Dc এর Amplification হয় না	(same)	(same)

Frequency Response & Bandwidth

⊛ Lower 3dB Frequency of a Cascaded multistage Amplifier:-

=> Cascade করলে বা Cascaded করলে multistage bandwidth হবে তা less than হবে। তাহলে,

→ Multistage Amplifier এর Bandwidth, Singlestage Amplifier হতে কম হবে।

=> Single Stage > Multistage

$$\therefore \boxed{\text{Bandwidth} = F_H(L) - F_L(n)} \longrightarrow (1)$$

Here,

$F_L(n)$ → Lower 3dB Frequency

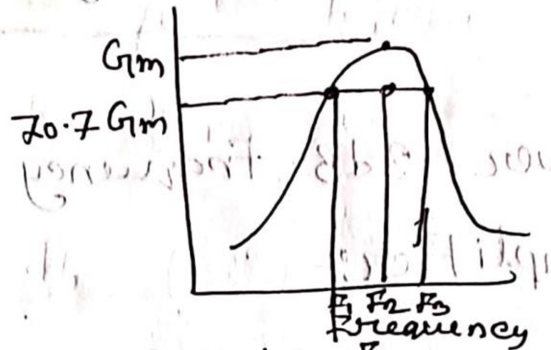
$$\Rightarrow \boxed{F_L(n) = \frac{F_L}{\sqrt{2^{1/n} - 1}}}$$

F_L → lower single stage amplifier এর lower 3dB frequency

n = number of stages connected

⊛ The voltage gain of an amplifier varies with single frequency. Because the reactance of the capacitors in the circuit changes with signal frequency. The curve between voltage gain & signal frequency of an amplifier is known as frequency response.

Upper 3dB Frequency :-

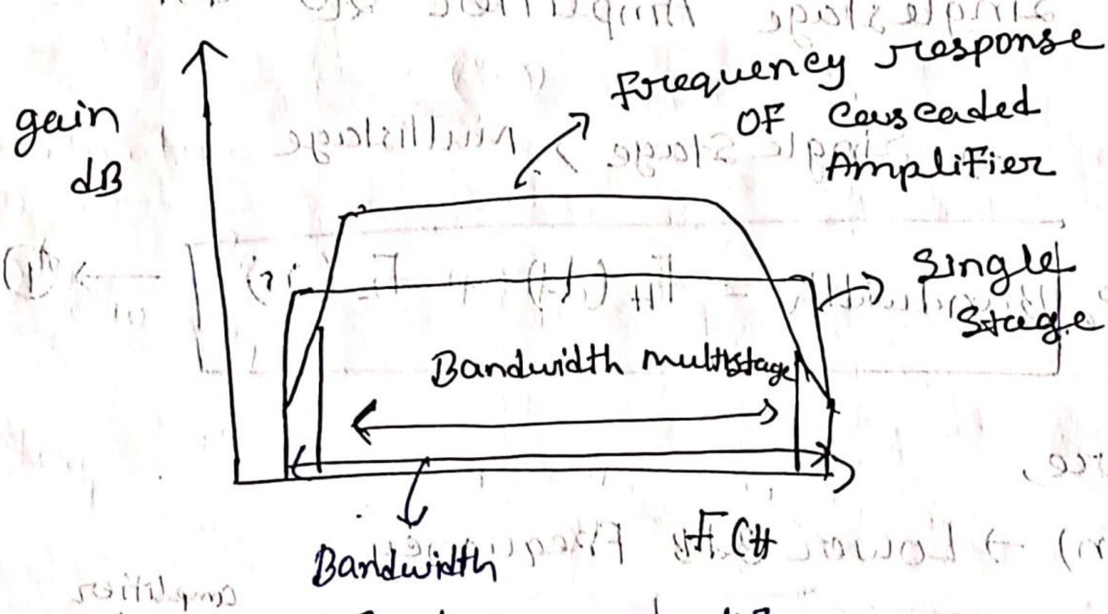


$$F_H(n) = F_H\sqrt{2^{1/n} - 1}$$

F_H = Single stage of upper 3 dB Frequency

n = no. of stage

Bandwidth OF Cascaded multistage Amplifier:-



So, $$\text{Bandwidth} = F_H(n) - F_L(n)$$

Bandwidth:- ~~That~~ The range of Frequency over which the voltage gain is equal to or greater than 70.7% of the maximum gain is know as Bandwidth.

Bypass Capacitors

A bypass capacitor is connected in parallel with a circuit to bypass the a.c signal and hence the name.

Math on (PdF: VK-Mehta page: 285)

* Find the gain in dB

① voltage gain 30

$= 20 \log_{10} 30$ db

$= 29.54$ db

② power gain 100

$= 10 \log_{10} 100$

$= 20$ db

* Express the gain in number:-

① power gain of 40db

= power gain = 40 db = 4 bel

[IF we want to find the gain as a number, we should work from logarithm back to the original number.]

∴ Gain = Antilog 4 $= 10^4 = 10,000$

(Ans)

(ii) power gain of 43 db

= Power gain = 4.3 bel

$\Rightarrow$ Antilog 4.3

$= 2 \times 10^4$

$= 20,000$

(Ans)

Alternatively:-

$$10 \log_{10} \frac{P_2}{P_1} = 43 \text{ db}$$

$$\Rightarrow \log_{10} \frac{P_2}{P_1} = \frac{43}{10} = 4.3$$

$$\Rightarrow \frac{P_2}{P_1} = (10)^{4.3} = 20,000$$

Format:- $\frac{V_2}{V_1} = (10)^{\text{gain in db}/20}$

$$\frac{P_2}{P_1} = (10)^{\text{gain in db}/10}$$

❀ An amplifier has an open-circuit voltage gain of 70db & an output resistance of 1.5 kΩ. Determine the minimum value of load resistance so that voltage gain is not more than 67 db.

A_o 70 db → [67 db] A_V

⇒ Open circuit Voltage gain, $A_o = 70\,db$

Output Resistance, $R_o = 1.5\,k\Omega$

voltage gain, $A_V = 67\,db$

So,

$$20\log_{10} A_o - 20\log_{10} A_V = 70 - 67$$

Or, $$20\log_{10}\frac{A_o}{A_V} = 3$$

Or, $$\log_{10}\frac{A_o}{A_V} = \frac{3}{20}$$

Or, $$\frac{A_o}{A_V} = (10)^{(3/20)}$$

Or, $$\frac{A_o}{A_V} = 1.413$$

But, $$\frac{A_V}{A_o} = \frac{R_L}{R_{out} + R_L}$$

Or, $\frac{1}{1.41} = \frac{R_L}{1.5 + R_L}$

$\therefore R_L = 3.65\,\Omega$

(Ans)

[] power properties of db gain:-

(i) Each time the ordinary power gain increases/decreases by a factor of 10, the db power gain increases/decreases by 10 db.

$\therefore$ Increase in db power gain $= 10\log_{10}1000 - 10\log_{10}100$

$= 30 - 20 = 10\text{ db}$

(ii) Each time the ordinary power gain increases/decreases by a factor of 2, the db power gain increases/decreases by 3db.

For example, suppose the power gain increases from 100 to 200

$\therefore$ Increase in db power gain $= 10\log_{10}200 - 10\log_{10}100$

$= 23 - 20$

$= 3\text{db}$

→ when there is an even number of cascaded stages (2, 4, 6 ...) the output signal is not inverted from the input.

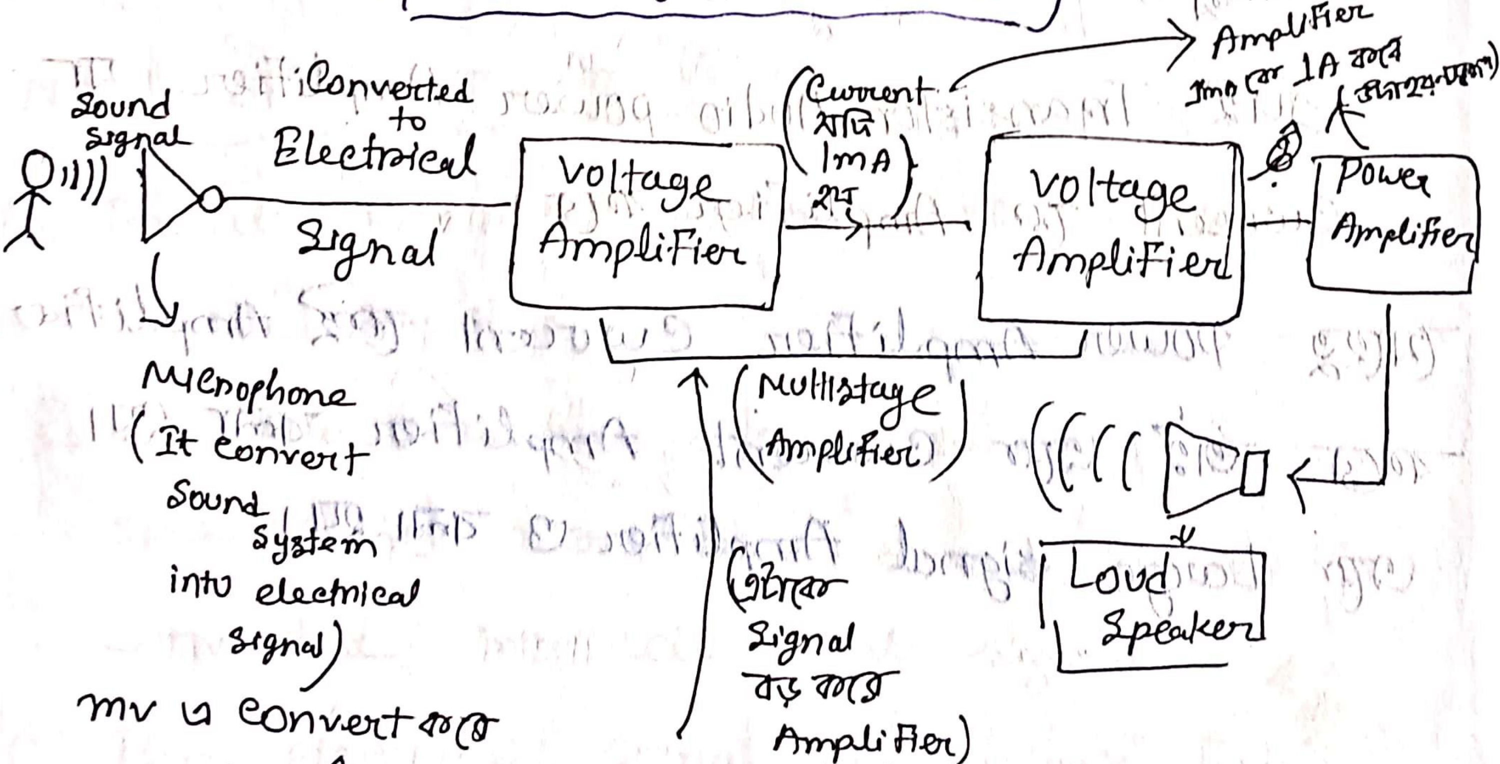
→ when ~~there~~ odd number (1, 3, 5, ...) the output signal is inverted from the input.

[আরও Math পড়ো]

Transistor AUDIO Amplifier | PdF: VK-mehta page → 306

or

Large Signal Amplifier



mv কে convert করে

$mv = 10^{-3} = \frac{1}{10^3} = \frac{1}{1000} V$ (খুব ছোট signal)

10V বাড়ে (অ্যামপ্লিফাই)

so, $P = VI$

$\Rightarrow$ 10 w (watt) = 10V × 1 A

= 10 VA

= 10 W (watt)

অতঃপর এই 10W (watt) এর signal Loud speaker এ যাবে এবং এ পরিমান sound বের হবে।

যদি, power Amplifier লাগানো না হতো যত volt এর signal - ই দেওয়া হোক না কেনো কাঙ্ক্ষিত sound signal পাওয়া যেতো না।

এটাই Transistor Audio power Amplifier যা current কে Amplifier করে।

যেহেতু power Amplifier current কেই Amplifier করে, তাই একে current Amplifier বলা হয়। একে Large signal Amplifier ও বলা হয়।

Audio → 20 Hz to – 20 KHz or 20,000 Hz

এই Range এর ভিতর আমরা শুনতে পারি। আর এত ক্ষুদ্র signal কেই Amplify করে আর একেই বলা হয় power Amplifier।

Transistor Audio power Amplifier:-

Is a special Amplifier is a device or amplifier which amplify (raise) power level of the signal with audio Range we call is TAPA (Transistor Audio--).

Need of power Amplifier:-

① In all Electrical system, last stage is power Amplifier.

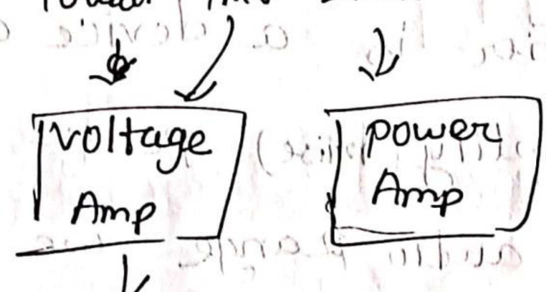
② In public address system, when a person speaks into microphone, sound signal is converted into electrical signal.

③ This electrical signal is few mV. This signal fed to voltage Amplifier (Multistage Amplifier) which amplifies weak signal and amplify in mV to volt (signal)

(4) But loudspeaker requires sufficient power level, so we use power amplifier which amplify power level (Amplify current)

$P = V I$

Before:- 10 volt, 1mv, 1MA



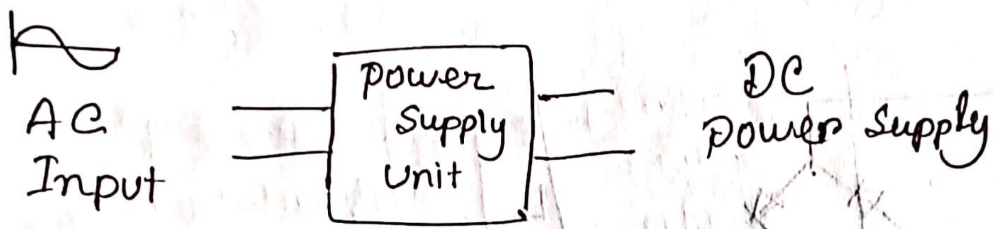
After:- 10 V × 1 A

= 10 VA

∴ P = 10 watt

Regulated DC power Supply

DC power supply হলো AC হতে DC - তে নেওয়া



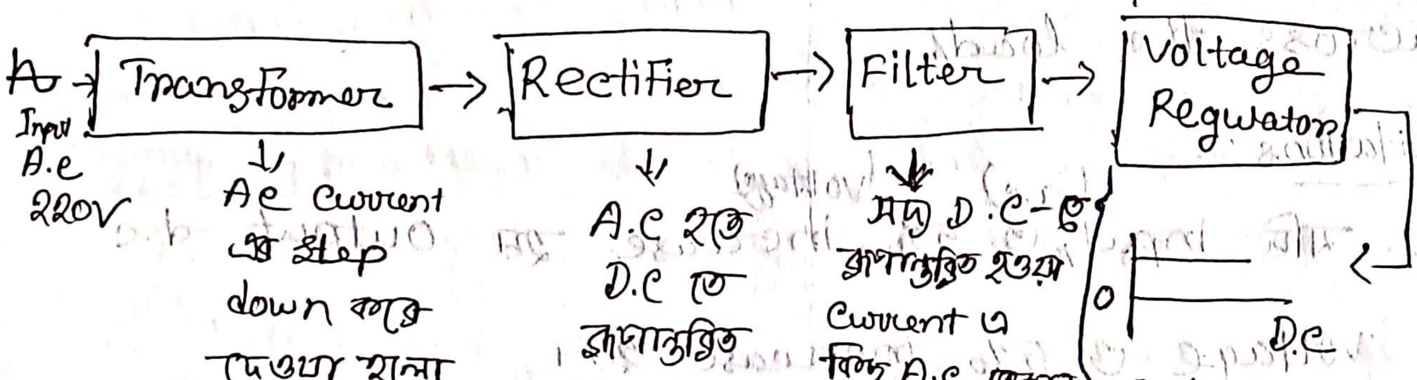
এখানে দুই ধরনের DC power Supply পাওয়া যায়

(i) Regulated P.S (Filtering করা থাকে)

(ii) Unregulated P.S (" " নয় ")

Transformer - এ Current উঠা-নামা করলে Output এর DC তেও অসামঞ্জস্যতা থাকবে যা Circuit এর জন্য ক্ষতি। তাই Voltage Regulated circuit ব্যবহার করা হয়েছে।

Block Diagram



- Transformer ↓ AC current এর step down করে দেওয়া হলো
- Rectifier ↓ A.C হতে D.C তে রূপান্তরিত করা হবে
- Filter ↓ সদ্য D.C - তে রূপান্তরিত হওয়া Current এ কিছু A.C ভেজাল হিসেবে থাকে যাকে Filtred করতে হয়।
- Output (Output গুলো pure DC হয়)

Use:- Television, Computer

Ordinary DC Power Supply

(সাধারণ DC power Supply)

An ordinary, Unregulated DC power supply contains a rectifier, Filter circuit.

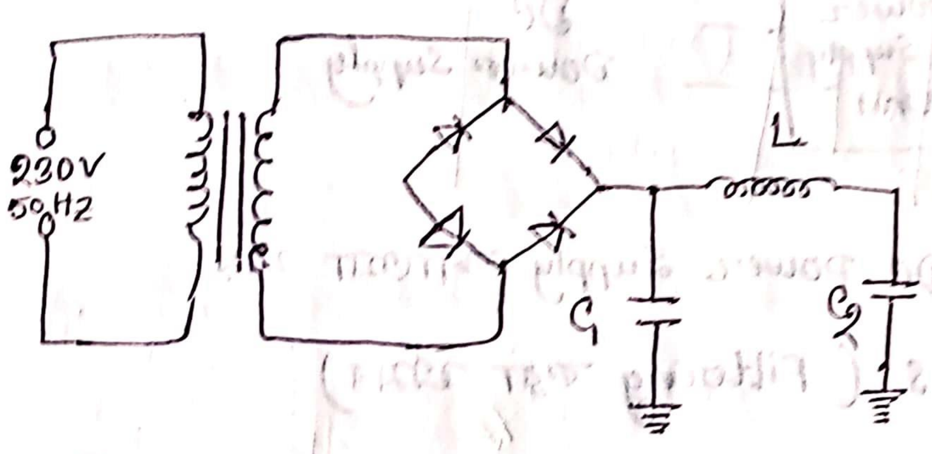


Fig:- ⑥ Ordinary unregulated DC power sup circuit

⇒ The Filter circuit removes the a.c component so that steady D.C voltage is obtained across the load.

Limitations :-

① যদি input(a.c) এ 5% increase হয় output d.c voltage এ 5% increase হয়।

② load current বাড়লে d.c output voltage কমে

(i) transformer windings (ii) rectifier (iii) Filter circuit এগুলোতে voltage drop হয়

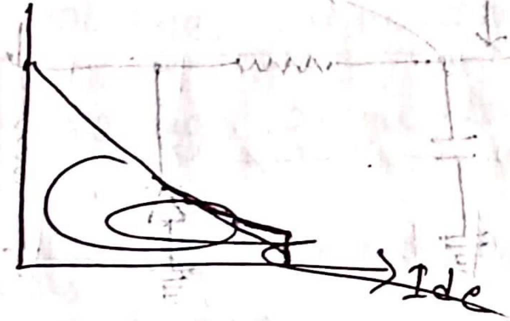
Voltage Regulation

The variation of output voltage the amount of load current drawn from the power supply is known as voltage Regulation.

$$\% \text{voltage Regulation} = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$$

V_{NL} = d.c output voltage at no-load

V_{FL} = d.c output voltage at Full load



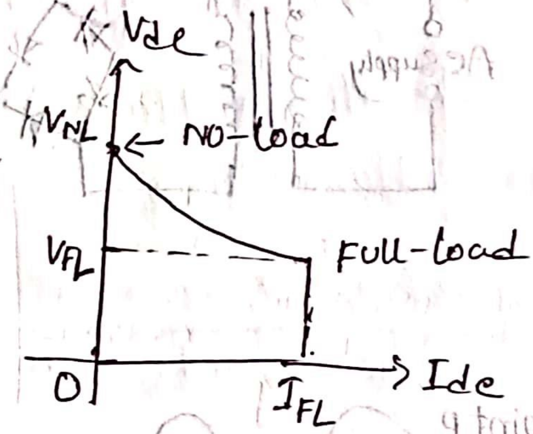


Figure:- Voltage regulation curve

Minimum load Resistance:-

IF a power-supply is required to deliver a full-load current I_{FL} at Full-load voltage V_{FL}, then

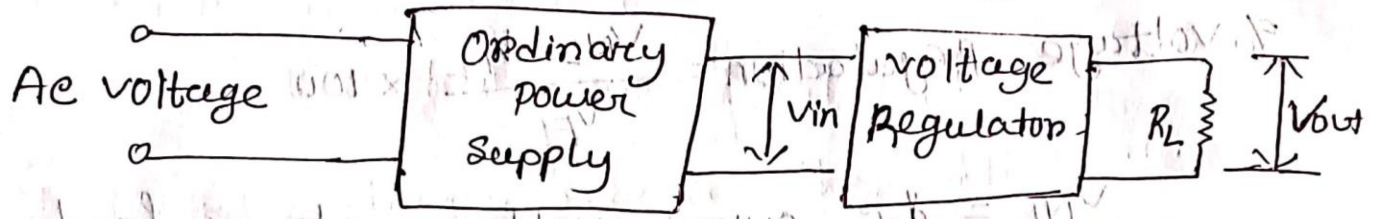
$$\text{Minimum load Resistance, } R_{L(min)} = \frac{V_{FL}}{I_{FL}}$$

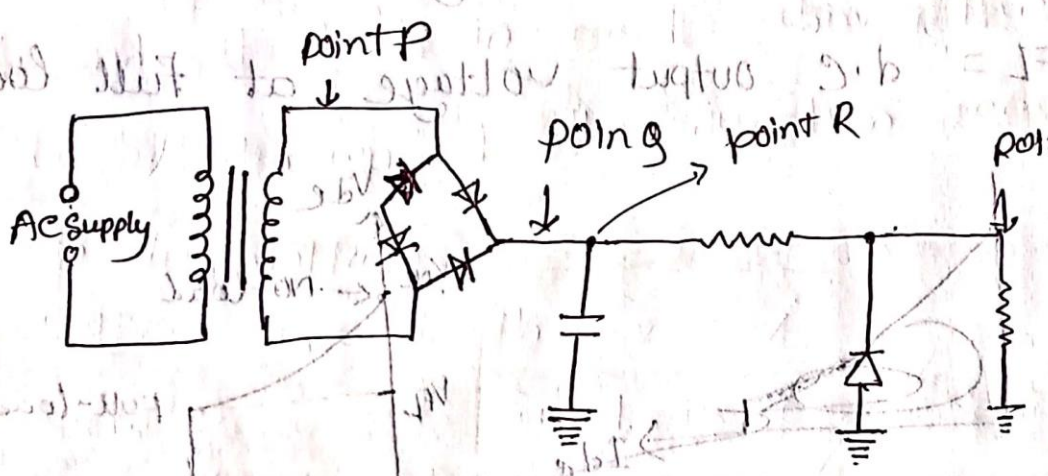
* IF any attempt is made to decrease the value OF R_L below this value, the rated d.c. output voltage

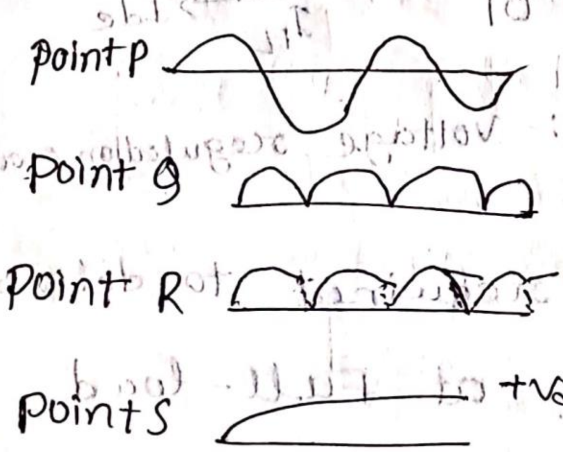
will not be available.

(math on this topic in -444 page) -446

Regulated power supply







Bridge rectifier converts transformer secondary a.c voltage (point P) into pulsating voltage (point Q).

Pulsating dc voltage is applied to the capacitor filter. which reduces the pulsations in the rectifier d.c output voltage (point R).

Then a Zener voltage regulator performs :-

(i) reduces the variations in the filtered output voltage.

(ii) Keeps output voltage (Vout) nearly constant whether the load current changes or there is change in input ~~d.c~~ a.c voltage.

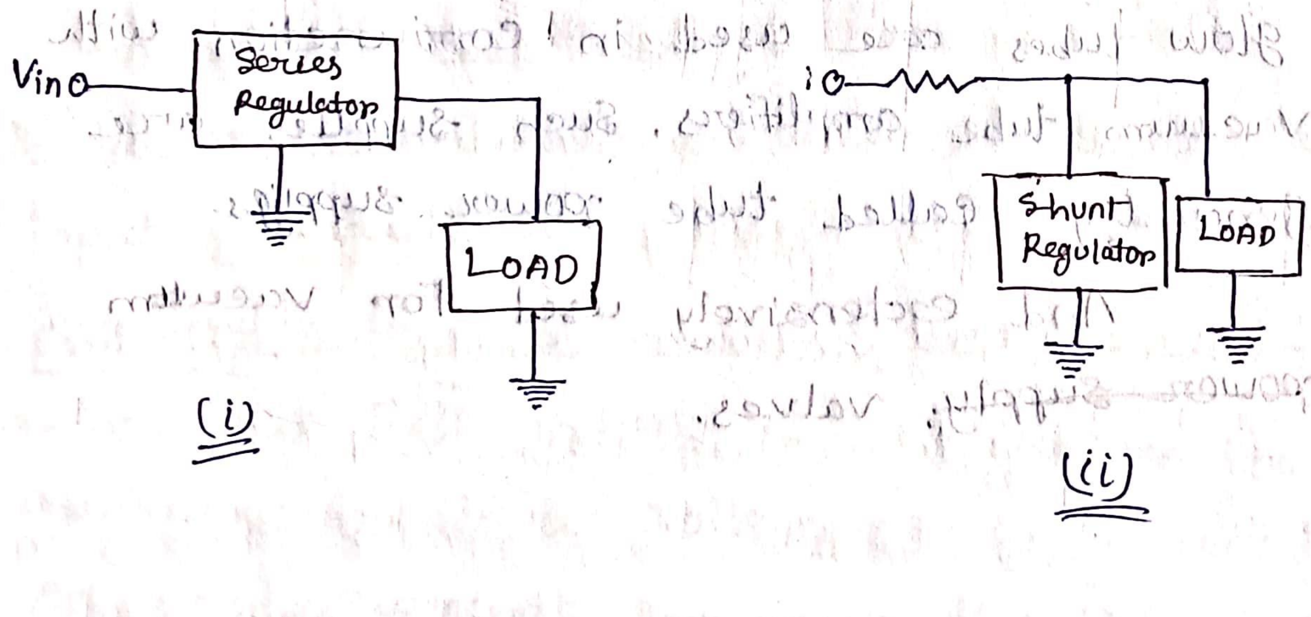
Types OF Voltage Regulators

A device which maintains the output voltage OF an ordinary power supply constant irrespective of load variations, or changes in input a.c voltage is known as voltage regulator.

There are two types OF voltage regulators:-

(i) Series voltage regulator

(ii) Shunt voltage regulator



[1] For low voltages:-

D.C output voltages (upto 50V), either Zener diode alone or Zener in conjunction with transistor is used. Such supplies are called transistorised power supplies.

This can ~~aly~~ only give low stabilised voltages because the safe value 50 V. And if it is increased above this value the breakdown of the junction may occur.

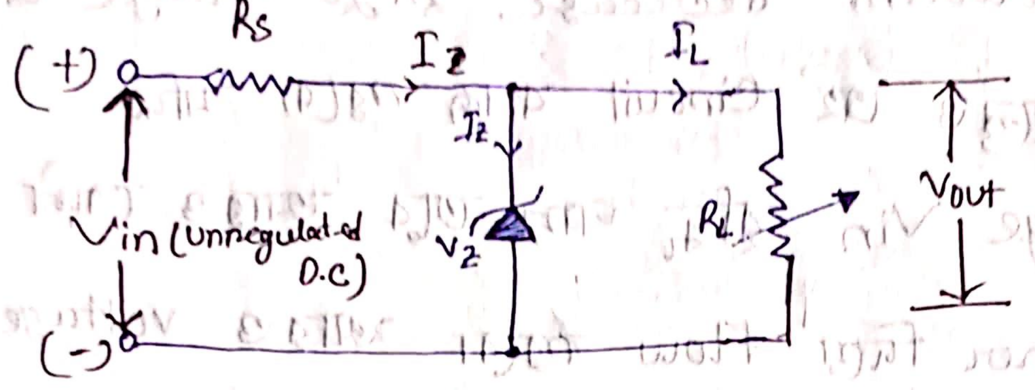
[2] For High voltages:-

voltage greater than 50V

glow tubes are used in conjunction with vacuum tube amplifiers. Such supplies are generally called tube power supplies.

And extensively used for vacuum ~~power supply~~. valves.

17.5] Zener Diode voltage Regulator



=> Breakdown অথবা Zener Region -এ Zener Diode operate করা হলে, the voltage across it is substantially constant for a large change of current through it. আর এই characteristic -টাই voltage Regulator এর।

Vin is greater than V_Z here. R_S with which is the series limiting resistance limits the input current.

Operations:- Zener maintains ~~con~~ Constant voltage across the field Inspite of changes in Load current or input voltage.

As load current increases, the Zener current decreases. So that, current through resistance R_S is constant.

As output voltage = $V_{in} - IR_S$, and I is Constant.

Therefore, output voltage remains unchanged.

In reverse it would be true should the load current decrease. ইনপুট voltage এর পরিবর্তন হলেও এই circuit কাজ করবে। যদি input voltage Vin বৃদ্ধি পায় তবে আরও বেশি current zener দিয়ে flow করবে। আরও voltage drop হবে R_s -এ, কিন্তু load voltage constant থাকবে। The reverse would be true should the input voltage decrease.

Limitation:-

(i) It has low efficiency for heavy load currents. It is because if the load current is large, there will be considerable power loss in the series limiting resistance.

(ii) The output voltage slightly changes due to zener impedance as, $V_{out} = V_Z + I_Z Z_Z$, changes in load current produce changes in zener current. Consequently, the output voltage also changes. Therefore, the use of this circuit is limited to only such applications where variations in load current & input voltage are small.

17.6 Conditions for proper operation of Zener Regulator

(i) Zener must operator in the breakdown region:-

between $I_{Z(max)}$ & $I_{Z(min)} = 10mA$.

(ii) Zener এর maximum dissipation break করা উচিত হবে না। না হলে এটা destroy হয়ে যাবে।

$$P_{Z(max)} = V_Z I_{Z(max)}$$

$$I_{Z(max)} = \frac{P_{Z(max)}}{V_Z}$$

Math Solve in (449) ---.

Transistor Series Voltage Regulator

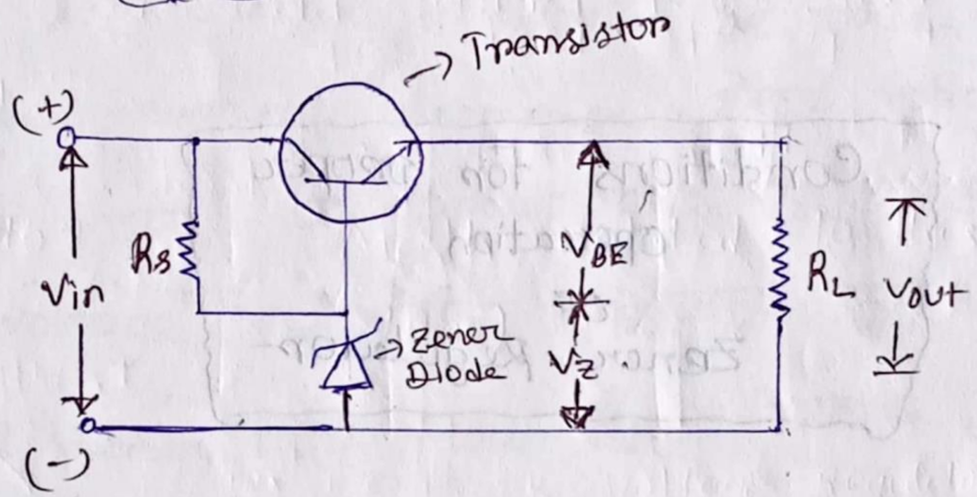


Figure:- Transistor series Voltage Regulator.

⇒ This circuit is called as series voltage regulator because the load current passes through the series transistor Q_1.

Here, Unregulated D.C power supply is fed to the input terminals & the regulated output is obtained across the load. The Zener diode ~~re~~ provides the reference voltage.

Operation:-

The base voltage of transistor Q_1 is held to a relatively constant voltage across the Zener diode.

$$V_{out} = V_Z - V_{BE}$$

① যদি output voltage কমে, ~~কারণ~~ the increased base-emitter voltage causes transistor Q_1 to conduct more, thereby raising the output voltage.

As a result, the output voltage is maintained at a constant level.

② যদি output voltage বাড়েঃ-

base-emitter এর ~~vo~~ কমে থাকা voltage, transistor Q_1 এর উৎপাদন কমায়, যা output voltage কে কমিয়ে ফেলে।

Consequently, output voltage is maintained at a constant level.

③ The Advantage:-

~~This circuit~~ The changes in zener current are reduced by a factor β. Therefore, the effect of zener impedance is greatly reduced & much more stabilised output is obtained.

Limitation:

① Zener current এর পরিবর্তন কমলেও, output পুরোপুরি constant হয় না। কারণ, V_{BE} এবং V_Z ক্রমে তাপমাত্রা বাড়ার সাথে সাথে কমে যায়।

② Output voltage কে এত সহজে পরিবর্তন করা সহজ নয় কারণ যেরকম কিছু প্রদান করা হয় না।

(452 ..... Math related to this topic)

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Series Feedback Voltage Regulator (Page 454)

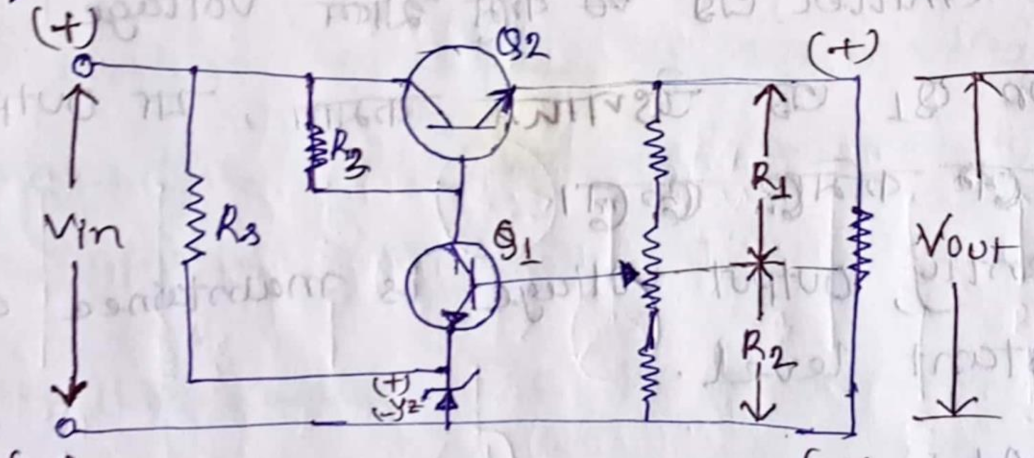


Figure:- Series Feedback Voltage Regulator.

⇒ It employs principles of negative feedback to hold the output voltage almost constant despite changes in line voltage & load current.

Q_2 is called pass transistor cause all load current passes through it.

There are the voltage dividers that consists of R_1 & R_2. The voltage divider samples the output voltage & delivers a negative feedback voltage to the base of Q_1. The feedback voltage V_F controls the collector current of Q_1.

<u>Operations:-</u>

The unregulated D.C supply is fed to the voltage regulator. The circuit maintains constant output voltage irrespective of the variations in load or input voltage.

(i) Output voltage বেড়ে গেলে K_L region (R_2) তে ও voltage বেড়ে যায়। এর ফলে V_F Transistor (Q_1) এ fed-back হয়। এবং সেখানে Q1 এর collector current উৎপন্ন হয়। বেশির ভাগ collector current R_3 এর মধ্য দিয়ে যাওয়ায়, Q_2 এর base voltage কমে যায়। এর ফলে output voltage এর পরিমান কমে এবং অভ্যন্তরীন voltage বাড়ে। এভাবে output voltage constant থাকে।

(ii) output voltage যদি কমে যায়, feedback voltage V_F কমে যায়। এটি Q_1 এবং R_3 এর current ও কমিয়ে ফেলে। এর ফলে Q_2 এর Base voltage এবং output voltage ও বাড়ে।

এভাবেই output voltage original level এ থাকে

17.9 Short-Circuit Protection:-

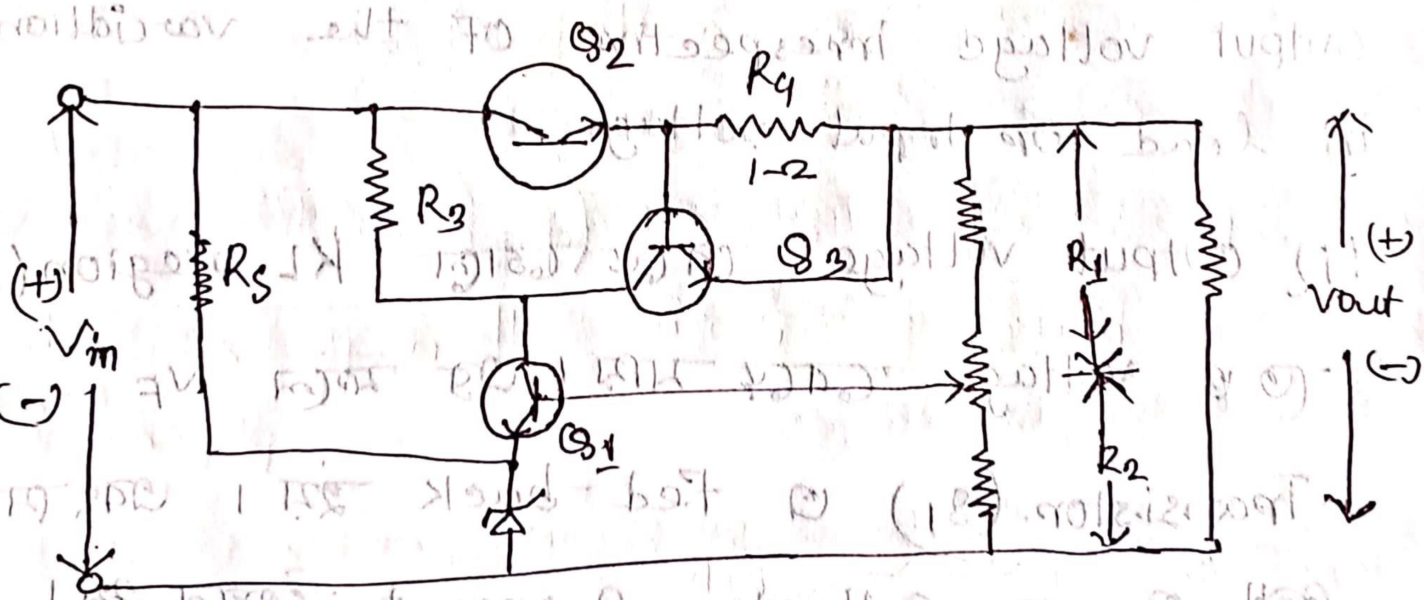


Fig: Short circuit protection

⇒ The pass transistor can be destroyed by excessive load current if the load is accidently shorten, in any series circuit.

So, a current limiting circuit is added to a series regulator.

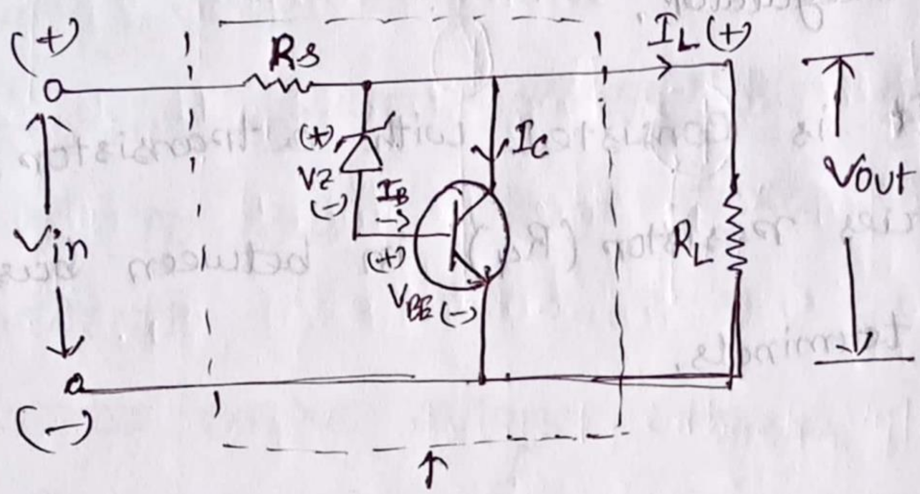
~~Autre~~ It is consisted with a transistor (Q_3) & a series resistor (R_4) in between base & emitter terminals.

Operation:-

(i) Load current কম থাকলে, voltage R_4 ছোট হবে এবং Q_3 বন্ধ থাকবে।
এই Condition এ circuit সাধারনভাবে কাজ করবে।

(ii) যদি load current অত্যধিক বেড়ে যায়, R_4 এর voltage বেড়ে যায় যা Q_3 কে চালু করে ফেলে। Q_3 এর collector current R_3 এর দিকে যেতে থাকে। যা Q_2 এর base voltage কমিয়ে ফেলে। Base voltage এর কমে যাওয়া pass transistor এর উৎপাদন কমিয়ে ফেলে, load current এর বৃদ্ধি না ঘটিয়ে। যাতে load current সার্কিটে 700 mA এর মতো হয়।

17.10 Transistor Shunt Voltage Regulator:-



Shunt Regulator

Output voltage, $V_{out} = V_Z + V_{BE}$

V_Z → Zener voltage

V_{BE} → Transistor Base-emitter

⇒ The voltage drop across series resistance depends upon the current supplied to the load R_L.

- যদি load Resistance কমে transistor এর base এর current ও কমে যায়। যার ফলে খুব কম পরিমাণ current shunt করা হয়।
- মধ্য আর যখন, Load current বেশি হয়, তখন regulated voltage load এর দিকে maintain করা হয়। বিপরীত হলে load resistance বেড়ে যায়।

(i) ~~ক~~ A large portion of the total current through Rs flows through transistor rather than to the load.

(ii) There is considerable power loss in Rs.

(iii) There are problems of overvoltage protection in this circuit.

এই কারণে, shunt voltage regulator হতে series voltage regulator কে prefer করা হয়।

[17.1] Shunt Feedback Voltage Regulator

[Page:-457]

[P.T.O]

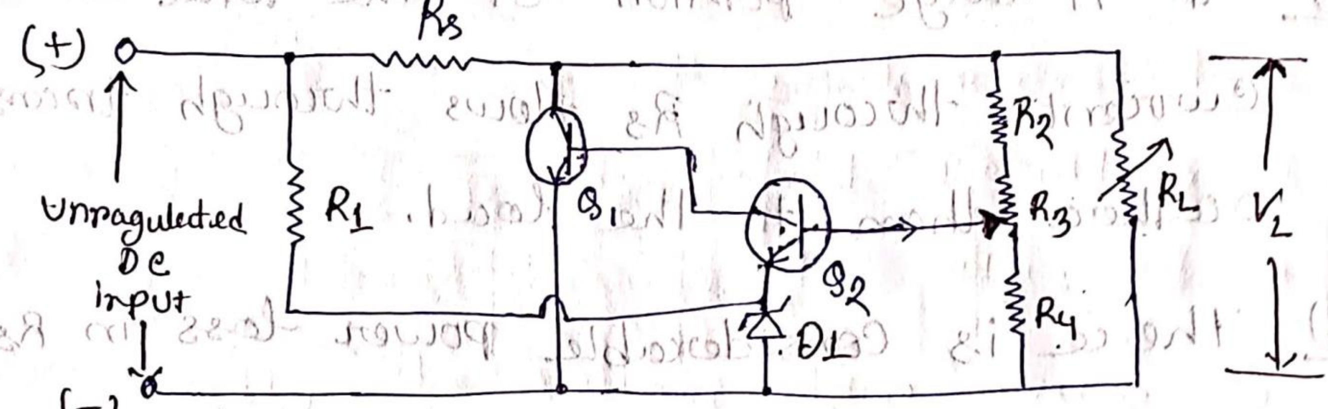


Figure:- Shunt Feedback Voltage Regulator.

=) This circuit is an improved form of the simple series voltage regulator.

(Sample circuit is a simple voltage divider circuit (R_2-R_3-R_4)) In a shunt feedback voltage regulator, the output from the sample & reference circuits ~~are~~ applied (It is made up of Zener D_1 & R_1 & derives the reference voltage from the unregulated D.C input voltage) are applied to the error detector/amplifier Q2. The output from Q_2 controls the conduction current through the shunt transistor Q_1 to maintain the constant load voltage V_L.

[1.12] Glow Tube Voltage Regulator (Zener circuit)

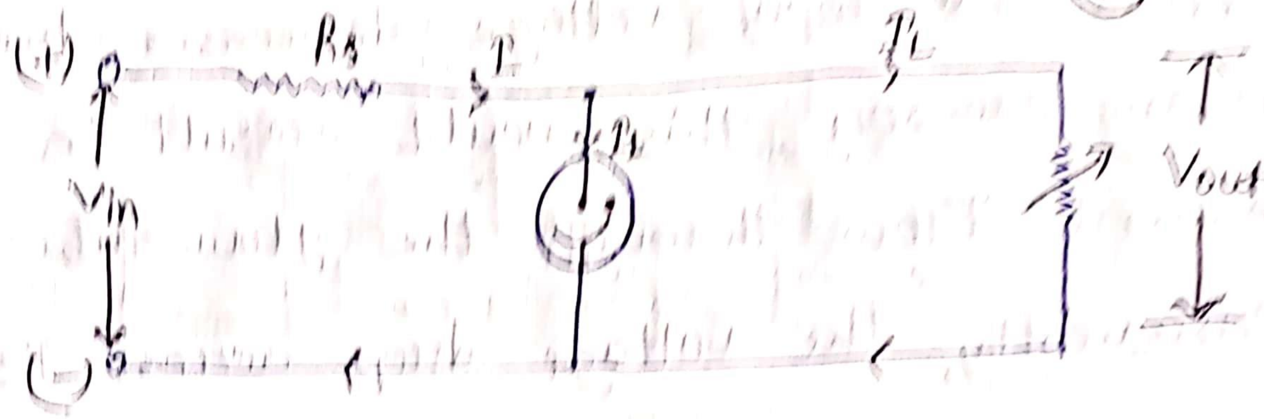


Figure: Glow Tube Voltage Regulator.

⇒ This will maintain constant voltage across the load inspite of changes in load current or input voltage. Now, should the load decrease, the output voltage would tend to increase.

The glow tube will draw more current without any increase in the output voltage. The drop in load current is offset by the increase in tube current and the current through Rs remains constant. As output voltage = Vin − IRs, therefore, output voltage remains unchanged.

Similarly, the circuit will maintain constant output voltage if the input voltage changes. Suppose, the input voltage decreases due to any reason, this would result in less current flow through the glow tube. Consequently, the voltage drop across R_s decreases, resulting in constant voltage across the load.

17.13 Series Triode Voltage Regulator

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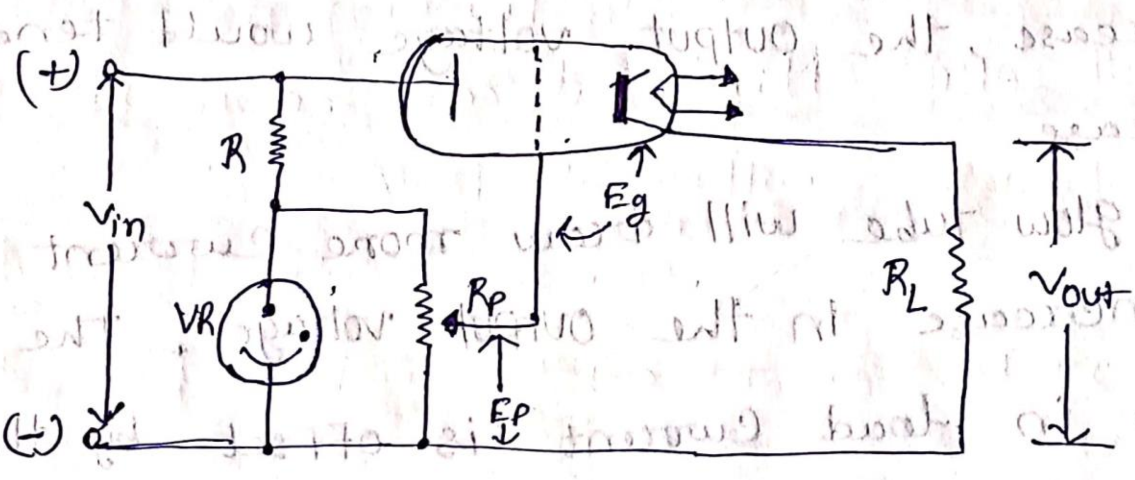
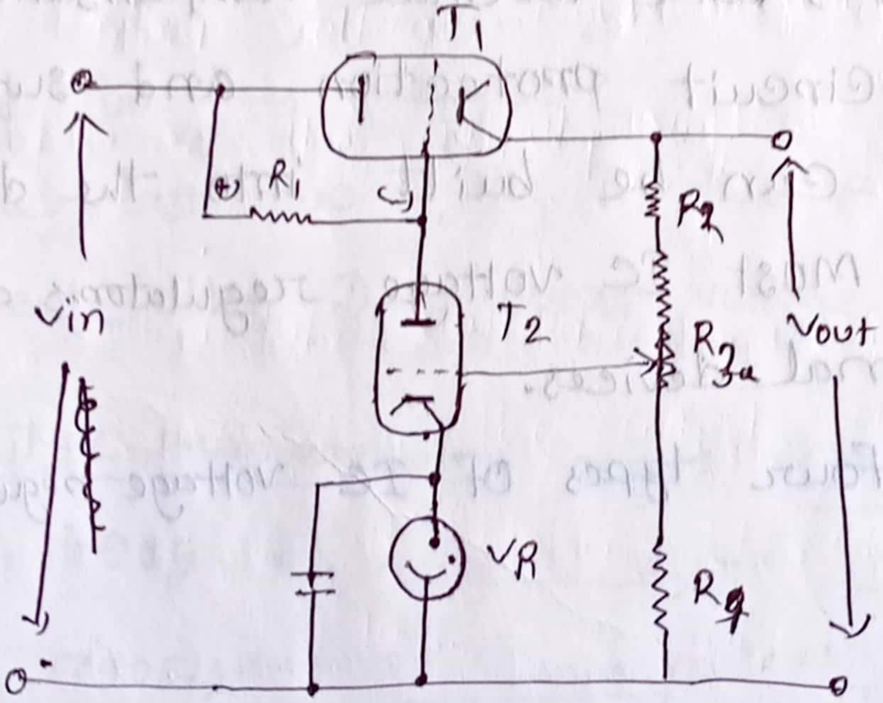


Figure:- Series Triode Voltage Regulator.

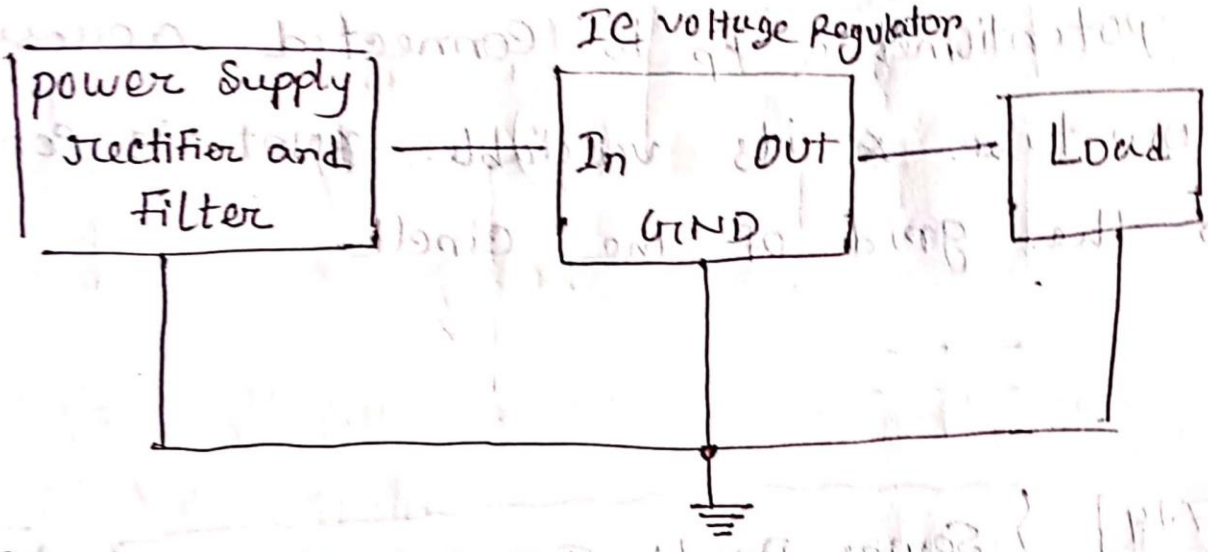
It is similar to series transistor regulator except that here triode & glow tube are used instead of transistor & Zener diode.

The resistance R & glow tube (V.R.) help to maintain constant potential across the load. A potentiometer R_p is connected across the glow tube & its variable point is connected to the grid of the circle.

17.14 **Series Double Triode voltage Regulators** Page 9-459



[17.15] **IC voltage Regulators:**



⇒ One advantage of IC voltage regulators is that properties like thermal compansation, short ~~cct~~ circuit protection and surge protection can be built into the device.

Most IC voltage regulators are three-terminal devices.

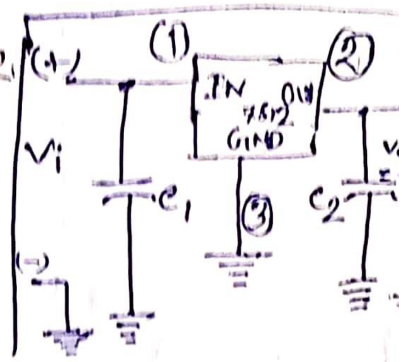
There are four types of IC voltage regulators:

P.T.O

1) Fixed positive voltage Regulators:-

7800 series of IC regulators is the most popular. The last two digits in the part number indicate the D.C output voltage.

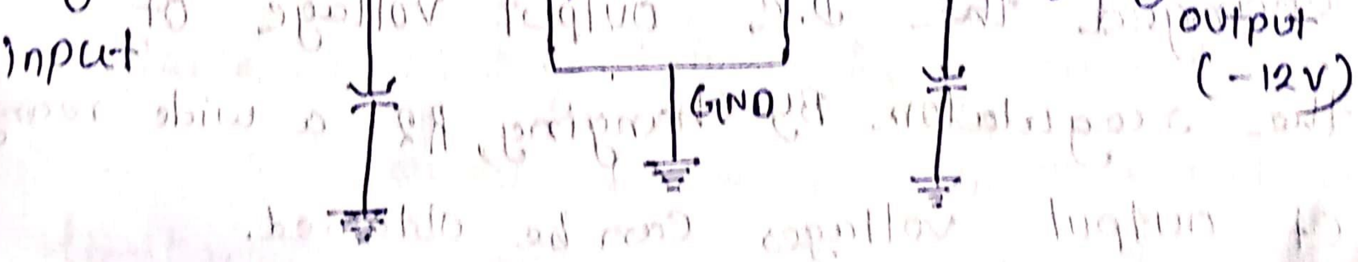
Type number	Output voltage
→ 7812 →	+12.0 V
→ 7824 →	+24.0 V



2) Fixed Negative voltage Regulators:-

The 7900 - series of IC regulators is commonly used for this purpose.
Here last two digits in the part number indicate the D.C output voltage.

Type Number →	Output Voltage
7905 →	− 5.0 V
7905.2 →	− 5.2 V



③ Adjustable voltage Regulator:-

LM317

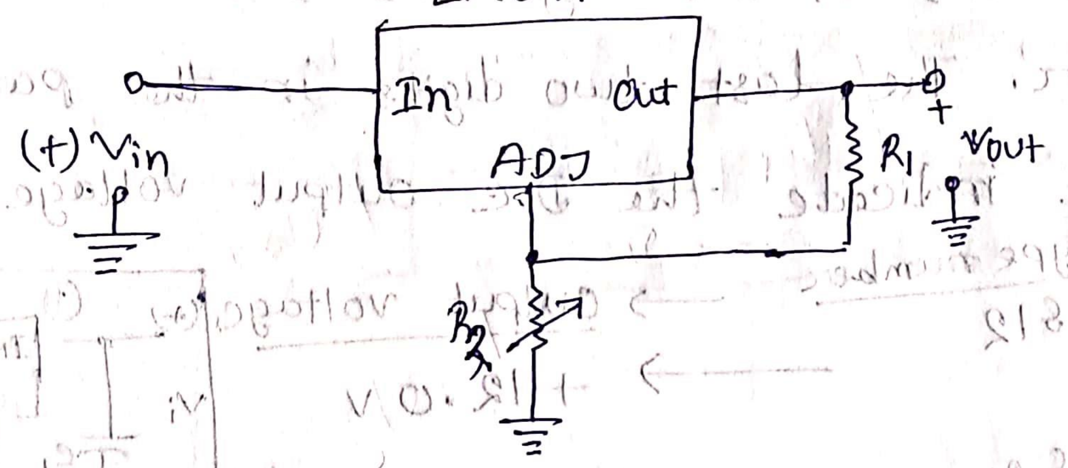


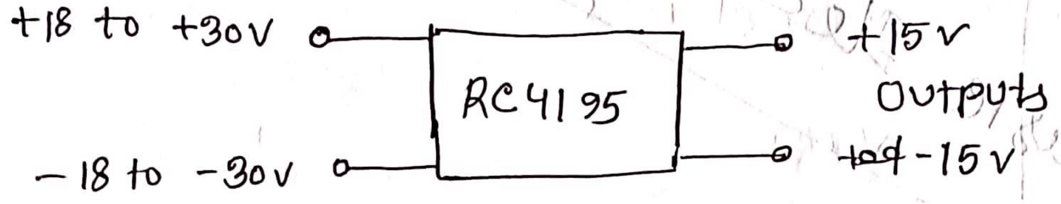
Fig:-

=> The adjustable voltage regulator can be adjusted to provide any D.C output voltage that is within its two specified limits.

The most popular three terminal IC adjustable voltage regulator is the LM317. It has an input terminal, output terminal and an adjustment terminal. An external voltage divider is used to changed the D.C output voltage of the regulator. By changing, R2 a wide range of output voltages can be obtained.

4] Dual-Tracking voltage Regulator:-

This provides equal positive & negative output voltages. This is used when split-supplied voltages are needed.



=> Circuit: RC4195 IC

=> Input:- Pos:- +18 v to +30V

Neg: -18 v to -30V

=> Output:- +15 v or,

-15 V

=> Output Current:- 150 mA for each supply & a load regulation of 3mv.

Adjustable dual tracking regulators are also available. Thes regulators have outputs that can be varied between their two rated limits.