ECT 202
ANALOG CIRCUITS
ASSIGNMENT

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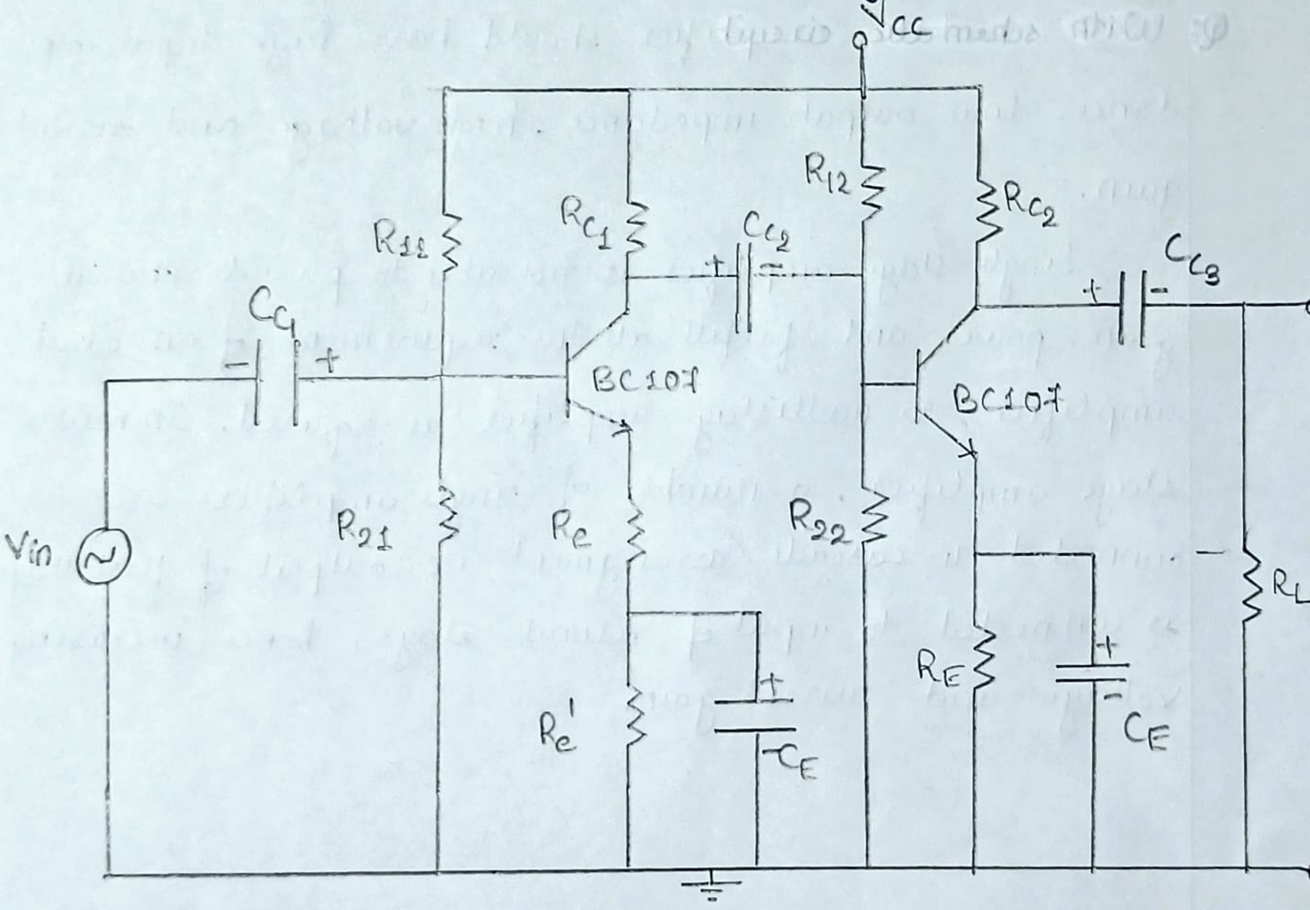
Q: With schematic diagram explain a two stage RC coupled amplifier. What are the effects of cascading in gain and bandwidth of amplifiers.

Ans: Multistage amplifiers are used in cascade to improve parameters such as voltage gain, current gain, input resistance and output resistance. For example, common emitter stages can be cascaded to increase the voltage gain. A two stage amplifier provides an overall voltage gain of $A_1 \cdot A_2$, where A_1 and A_2 are the gains of first and second stages respectively.

Since each stage provides a phase inversion, the final output signal is in phase with input signal.



The input of the second stage is in parallel with R_{C1} of the first stage. The voltage gain of first stage is

$$A_1 = \frac{R_{C1} \parallel R_{12}}{r_e + R_e}$$

where R_{12} is the input resistance of the second stage.

$$R_{12} = R_{12} \parallel R_{22} \parallel (1+h_{fe}) r_e$$

$h_{fe} = 100$

The AC voltage gain of second stage is

$$A_2 = \frac{R_{C_2} \parallel R_L}{r_e}.$$

Care must be taken while selecting A_1 & A_2, If A_1 is large, the input to second stage will become too high. The gain of first stage can be controlled by a negative feedback in series with the emitter. This is achieved by unbypassed resistor R_e.

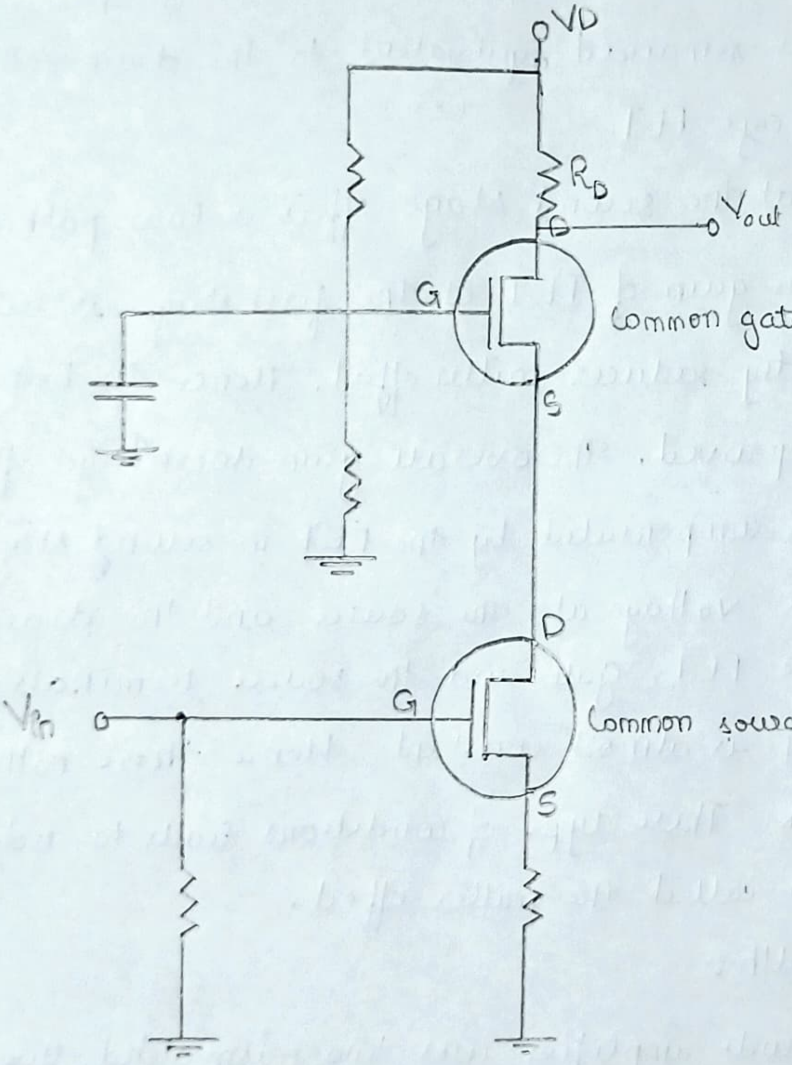
Effects of cascading on gain and bandwidth:-

Ideal amplifier should have high input impedance, low output impedance, high voltage and current gain.

Single stage amplifier is not able to provide enough gain, power and fulfill all the requirement of an ideal amplifier, so multistage amplifier is required. In multi-stage amplifier, a number of single amplifiers are connected in cascade arrangment i,e output of first stage is connected to input of second stage, hence incrasing voltage and current gain.

Q. With circuit schematic explain the working of Cascode amplifier. How wide bandwidth is obtained in cascode amplifiers?

Ans A cascode amplifier is a double staged circuit having a buffer amplifier that follows a transconductance amplifier. When compared with single-stage amplifier, double stage has more benefits in aspects of gain, Impedance, output isolation.



If an amplifier comprises of BJTs then the input stage is C-E configuration that feeds to the common base at which output is collected. This type of amplifier is known as cascode amplifier.

Working :-

The input signal is applied to the terminal gate at initial stage. The second stage that is o/p stage which driven from the output of initial stage is configuration common drain. The final output is collected from the drain terminal at which the resistor R_D is connected.

The gate of the FET at the second stage is grounded. So, the value of the source voltage of the 2nd stage FET has remained equivalent to the drain voltage of the first stage FET.

FET at the second stage offers a low path of resistance. The gain of FET at the first stage is reduced which indirectly reduces miller effect. Hence the band-width is improved. The overall gain doesn't get affected because it is compensated by the FET in second stage

As the voltage at the source and the drain of the first stage FET, gate and the source terminals of 2nd stage FET is almost constant. Hence there nothing to be feedback. These type of conditions leads to isolating the situation called the miller effect.

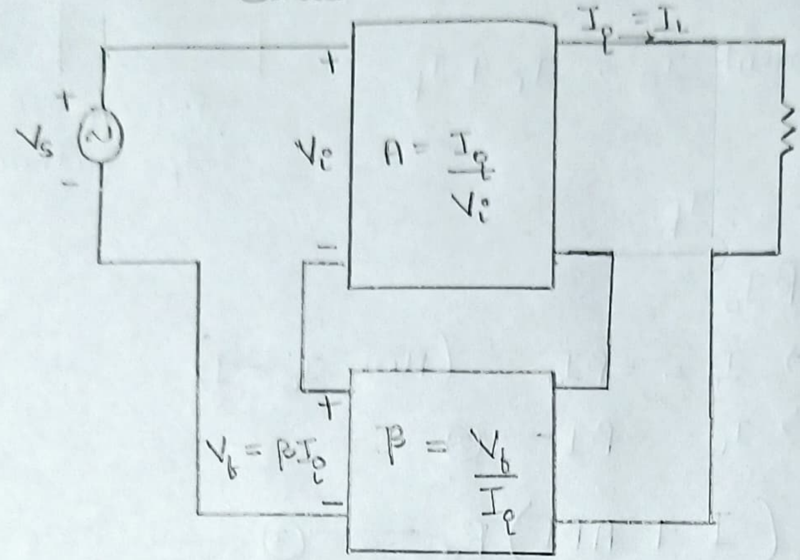
High bandwidth :-

A cascode amplifier uses two mismatched stages in order to minimise the reverse voltag feed. No negative feedback technique is useful at high frequencies. Next, because of CB stage, the Miller capacitance of transistor is minimized by limiting voltage gain of amplifier to 1. Avoiding the miller capacitance boosting is biggest ad-vantage.

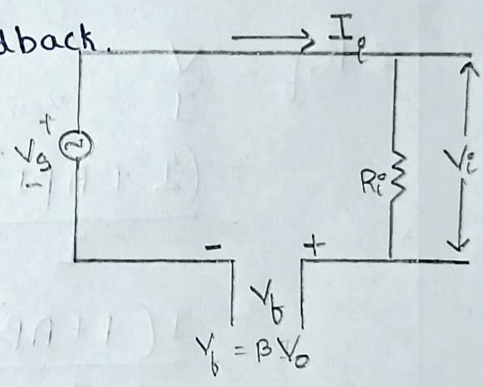
Q8 Derive expression for Voltage gain, input impedance and output impedance of current series and current shunt amplifiers with feedback. (Discrete circuits using BJT).

Ans 1) Current series feedback :-

Circuit



(i) Input impedance of current series feedback.



$$R_{if} = \frac{V_s}{I_i}$$

We know that $V_s = V_i + V_f$

$$\Rightarrow R_{if} = \frac{V_i + V_f}{I_i}$$

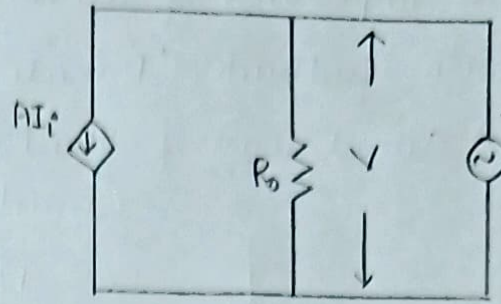
$\because V_f = \beta V_o \quad \rightarrow \quad R_{if} = \frac{V_i + \beta V_o}{I_i}$

$$R_{if} = \frac{V_i}{I_i}\left(1 + \frac{\beta V_o}{V_i}\right)$$

$\because \frac{V_o}{V_i} = A \quad \Rightarrow \quad R_{if} = \frac{V_i}{I_i}(1 + \beta A)$

$\because \frac{V_i}{I_i} = R_i \quad \rightarrow \quad R_{if} = R_i \underline{(1 + A\beta)}$

(ii) output impedance of current series amplifier and output impedance of current shunt amplifier with feedback :-



Total current, $I = \frac{V}{R_o} + AI_i$

$\Rightarrow V = (I - AI_i)R_o$ —— ①

R_o :- o/p resistance

I_f :- feedback current

Source current $I_s = I_i + I_f$

$I_s = 0$.

$\Rightarrow I_i = -I_f$.

$\because I_f = \beta I_o$

$\Rightarrow I_i = -\beta I_o$ (Here $I_o = I$)

$\Rightarrow I_i = -\beta I$ —— ②.

$\Rightarrow V = (I + A\beta I)R_o$ —— ③.

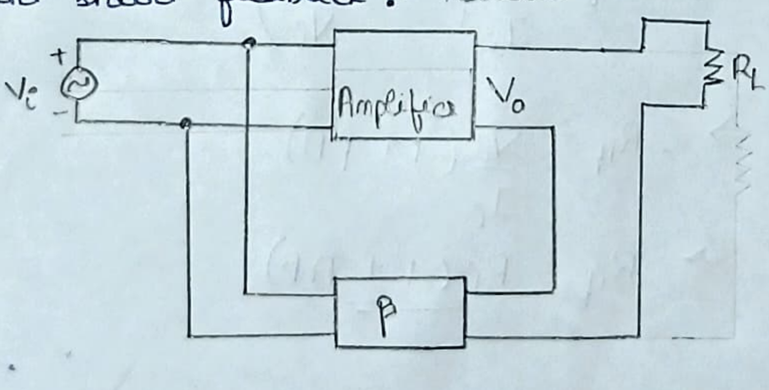
$\therefore R_{of} = \frac{V}{I}$

$= \frac{(I + A\beta I)R_o}{I}$

$= \frac{I(1 + A\beta)R_o}{I}$

$R_{of} = (1 + A\beta)R_o$

2) Current shunt feedback :- Circuit



(iii) Current shunt feedback :-

Input impedance :-

We know that :

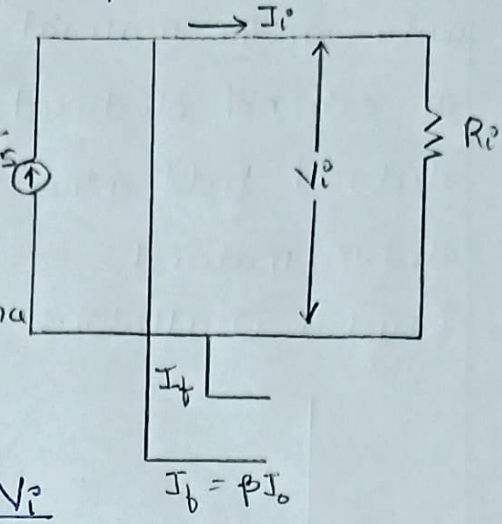
$$R_{if} = \frac{V_i}{I_s}$$

I_s : Source current

I_i : i/p current

R_i : i/p resistance

equivalent circuit :-



$\because I_s = I_i + I_f$

$\because I_f = \beta I_o$.

$$\Rightarrow R_{if} = \frac{V_i}{I_i + \beta I_o} = R_{if} = \frac{V_i}{I_i\left(1 + \frac{\beta I_o}{I_i}\right)}$$

$$Gain = \frac{I_o}{I_i} = A \qquad \Rightarrow R_{if} = \frac{V_i}{I_i\left(1 + \beta A\right)}$$

$$\because \frac{V_i}{I_i} = R_i$$

$$\Rightarrow R_{if} = \frac{R_i}{(1 + A\beta)}$$

Gain with feedback for current series : $A_f = \frac{I_o}{V_s}$

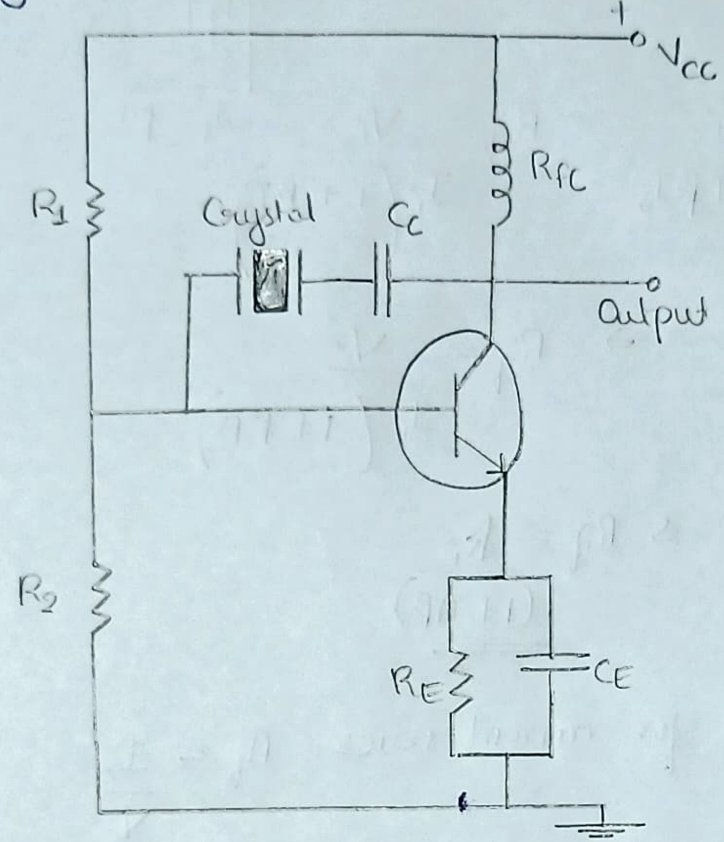
Gain with feedback for current shunt : $A_f = \frac{I_o}{I_s}$

Q: Define piezo electric effect. With circuit schematic explain the working principle of Crystal Oscillator.

Ans Piezoelectric effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress. The unique characteristic of piezo electric effect is that it is reversible.

When piezoelectric material is placed under mechanical stress, a shifting of positive and negative charge centre in the material takes place, which results in an external electrical field. When reversed, an outer electrical field either stretches or compresses the piezo electric material.

Crystal Oscillator :-



- Crystal oscillator is basically a tuned circuit using piezo electric crystal as the resonant tank circuit.
- These oscillators are used wherever higher frequency stability is required such as in communication transmitters and recievers.

• Piezo electric crystal exhibit piezo electric property: the ability to transform mechanical deformation into electrical charge and via versa.

• If a piezo electric material is squeezed it devolops a voltage and if a voltage is applied across it a mechanical dimension occur.

- Crystal oscillators operate on the principle of inverse piezo electric effect, in which alternating voltage is applied causing it to vibrate at its natural frequency.
- It is these vibrations which eventually get converted into oscillations.
- These oscillators are usually made of Quartz crystal.