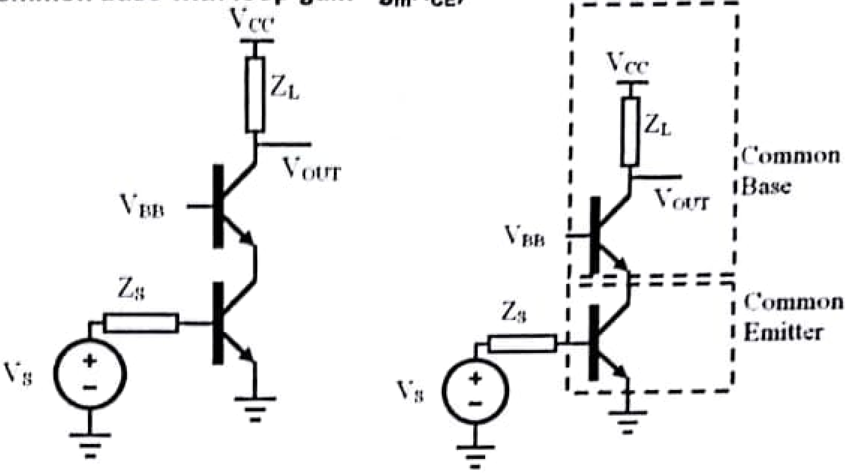
Cascode amplifier

- Wideband voltage amplifier
- CE stage operates at gain=-1, minimising miller loading of input.
- CB gives all the voltage gain, acting as transimpedance of value Z_L
- The cascode has a much higher output impedance (other than Z_L) than the CE amplifier (the common emitter Early resistance acts as series-series feedback to the common base with loop gain $=g_m R_{CE}$)



Points to be Noted:

① The Cascode is a two stage amp. Composed of Transconductance (CE) amp. followed by a Current buffer (CB)

② Characteristics of Cascode amp: (Advantages)

ⓐ Higher i/p - o/p isolation
ⓑ ~~Higher~~ Moderate i/p impedance
ⓒ Higher o/p impedance
ⓓ Higher gain
ⓔ Higher Band width
ⓕ Reduced Miller's capacitive effect
ⓖ Cascode Configuration is very stable (i.e. no self oscillations occur)
ⓗ High slew Rate

③ Disadvantages: Needs 2 transistors and require high supply voltages.

④ Application area: ① Very useful in multiplying Mixer circuit in Super heterodyne receivers. [RF is given base of CE and Local oscillator signal is given at base of CB stages.]
② As a Current Mirror ckt.

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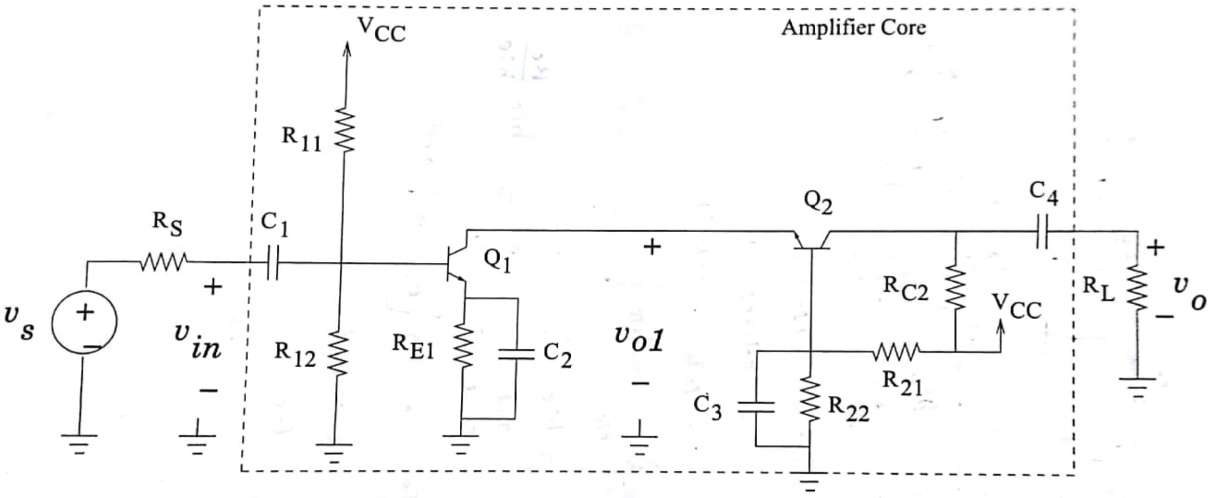

Figure 1. Simple BJT cascode amplifier core.

(PTO)

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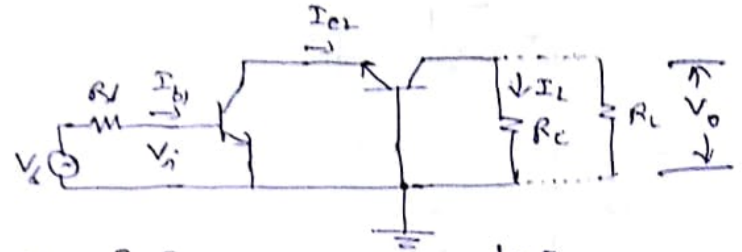
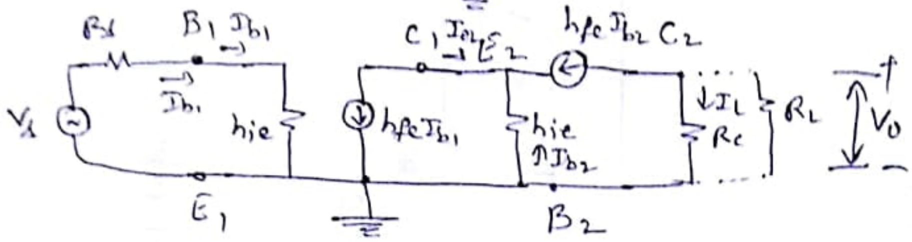
Analysis:

Ac equivalent ckt can be obtained as below





① $A_I = \frac{I_L}{I_{b1}}$; $I_L = -h_{fe} I_{b2}$

$I_{e2} = -(1+h_{fe}) I_{b2}$

$\therefore -h_{fe} I_{b1} = -(1+h_{fe}) I_{b2}$

$$\boxed{\therefore A_I = -\frac{h_{fe}^2}{1+h_{fe}} \simeq -h_{fe}}$$

② $R_i = \frac{V_i}{I_{b1}} \simeq h_{ie}$

③ $A_V = \frac{V_o}{V_i} = \frac{I_L R_c}{I_{b1} R_i} = A_I \frac{R_c}{R_i} = -h_{fe} \frac{R_c}{h_{ie}}$

④ $Y_o = \frac{I_o}{V_o} = 0 \Rightarrow \boxed{R_o = \infty}$ and

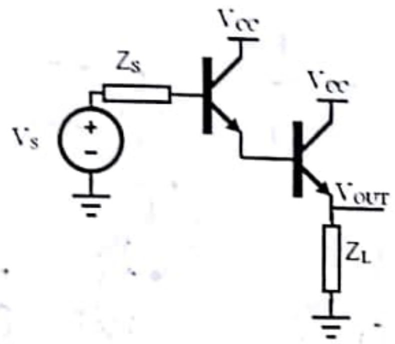
$R_o' = R_o \| R_c$

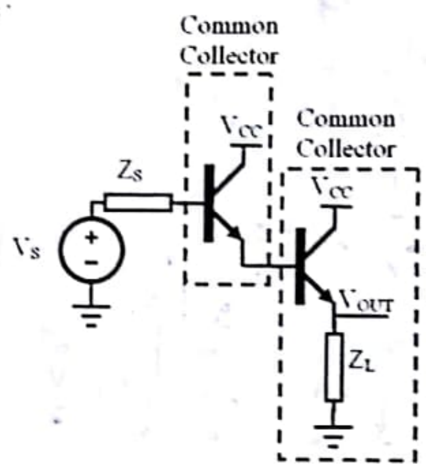
$R_o' \simeq R_c$

-END-

Darlington pair (SUPER-ALFA PAIR)

- The darlington pair is a high gain power amplifier it has:
  - *Unity voltage gain*
  - *High current gain equal to the product of the two transistor current gains*
- Often used as a single transistor for higher beta. But :
- has high input DC voltage drop
- Good frequency response due to the absence of shunt Miller feedback.
- However, series Miller feedback introduces driving capacitive loads.





Points to be noted:

① It consists of 2 CC stages cascaded.

② characteristics: (Adv.)
- ⓐ V. High current gain
- ⓑ V. High input impedance
- ⓒ Easy to ~~obtain~~ made from 2 transistors.
- ⓓ Available as a single module with 3 terminals
- ⓔ unity voltage gain
- ⓕ Good frequency response
- ⓖ Less affect of Miller's feedback capacitance.
- ⓗ V. High power gain.

③ Disadvantages:
- ⓐ slow switching speeds
- ⓑ Limited Bandwidth (Compare to cascode)
- ⓒ introduces phase shift. may lead to instability
- ⓓ High DC drop i.e. higher overall V_{BE} ($= V_{BE1} + V_{BE2}$)
- ⓔ Higher saturation voltage (0.7V) which leads to higher power dissipation.

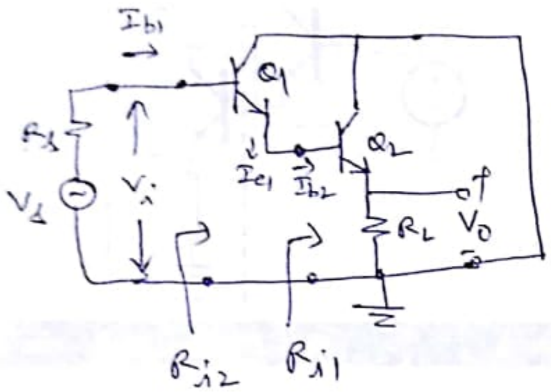
(P.T.O.)

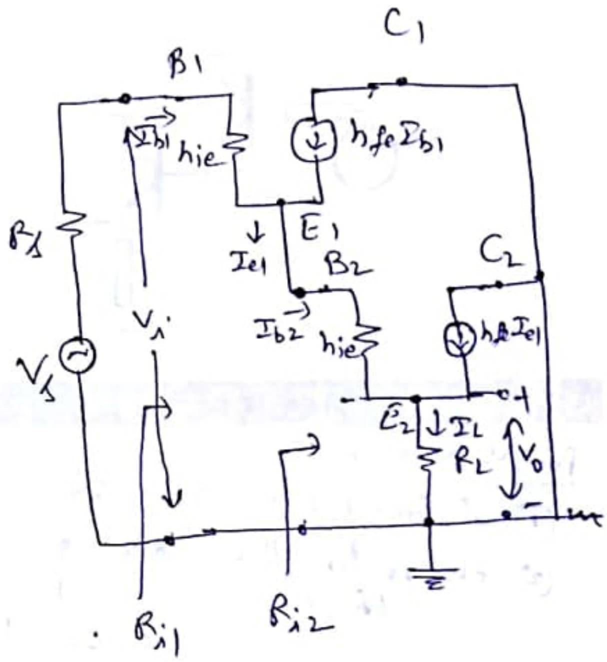
(4) Application Areas:

1. where high current gain is needed at low frequencies
2. Power Regulators
3. Audio amplifier o/p stages
4. Display drivers
5. Motor Controllers
6. Touch and light sensors

Analysis:

AC equivalent





(1) $A_I = \dfrac{I_L}{I_i}$

$$I_L = I_{b2} + h_{fe} I_{b2} = (1+h_{fe}) I_{e1}$$

$$= (1+h_{fe})(1+h_{fe}) I_{b1}$$

$$\boxed{\therefore A_I = (1+h_{fe})^2}$$

(2) $R_{i2} = h_{ie} + (1+h_{fe}) R_L$

& $R_{i1} = \dfrac{V_i}{I_{b1}} = h_{ie} + (1+h_{fe}) R_{i2}$

$$\boxed{R_{i1} = h_{ie} + \cancel{h_{ie}}(1+h_{fe}) + (1+h_{fe})^2 R_L}$$

$$\boxed{R_{i1} \simeq (1+h_{fe})^2 R_L}$$ $(\because h_{ie} << (1+h_{fe}) R_L)$

(P.T.O.)

③ $$A_v = \frac{V_o}{V_i} = \frac{I_L R_L}{I_{i} R_{i}} = A_I \frac{R_L}{R_{i1}}$$

$$\therefore A_v = (1+h_{fe})^2 \times \frac{R_L}{(1+h_{fe})^2 R_L}$$

$$\boxed{A_v \simeq 1}$$

④ $$Y_o = \frac{I_o}{V_o} = \frac{I_L}{V_o} = \frac{I_{e2}}{V_o}$$

$$I_{e2} = (1+h_{fe}) I_{e1}$$

$$I_{e2} = (1+h_{fe})^2 I_{b1}$$

but $V_i = R_{i1} I_{b1}$

$$\therefore I_{b1} = \frac{V_i}{R_{i1}}$$

$$\therefore Y_o = \frac{(1+h_{fe})^2 V_i}{R_{i1} V_o}$$

$$Y_o = \frac{(1+h_{fe})^2}{R_{i1}} \qquad \left[\because \frac{V_o}{V_i} = 1\right]$$

$$\therefore R_o = \frac{R_{i1}}{(1+h_{fe})^2}$$

$$= \frac{h_{ie} + h_{ie}(1+h_{fe}) + (1+h_{fe})^2 R_L}{(1+h_{fe})^2}$$

$$\boxed{R_o = R_L + \frac{h_{ie}}{(1+h_{fe})} + \frac{h_{ie}}{(1+h_{fe})^2}}$$

$$\boxed{R_o \simeq R_L} \qquad \boxed{\because h_{fe} >> 1}$$

If $R_L = \infty$ then

$$R_o = \infty$$

$$\boxed{\therefore R_o = \infty \ \& \ R_o' = R_L}$$

-END.-