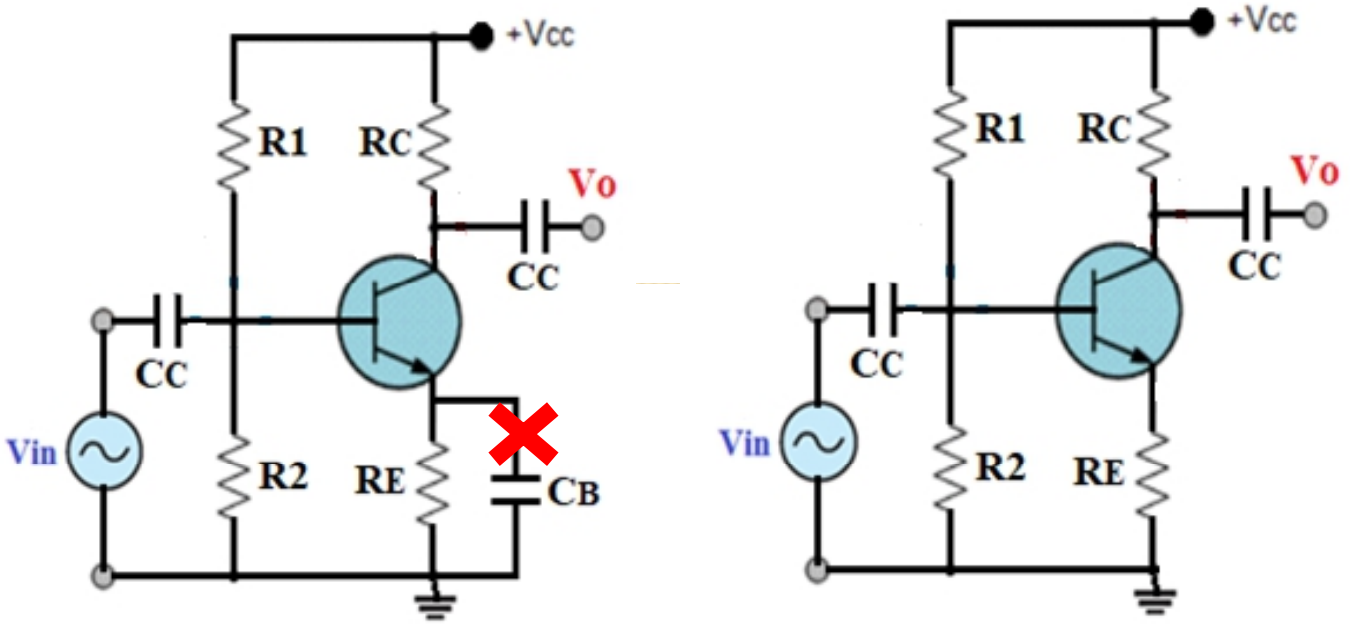
App 2: Common Emitter Voltage divider bias amplifier (unbypassed R_E)



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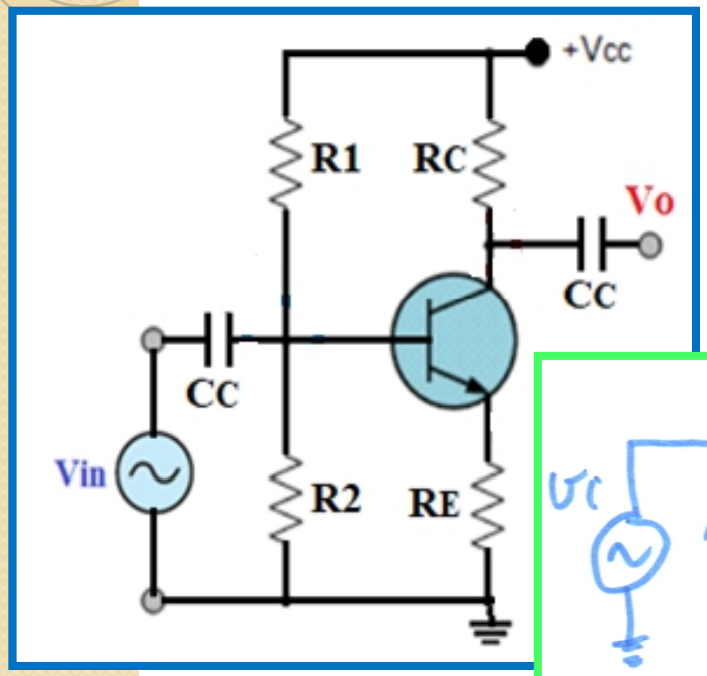

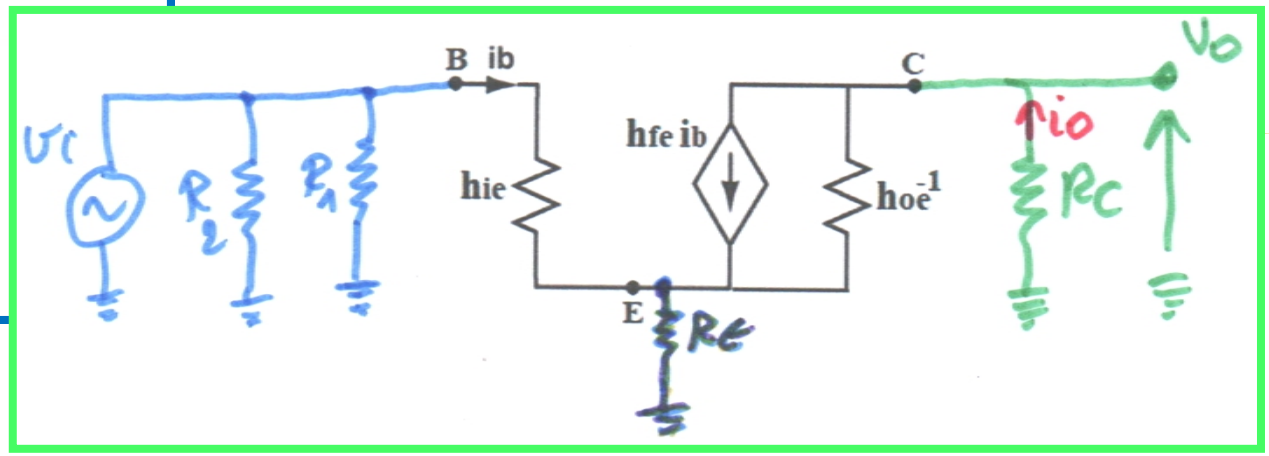

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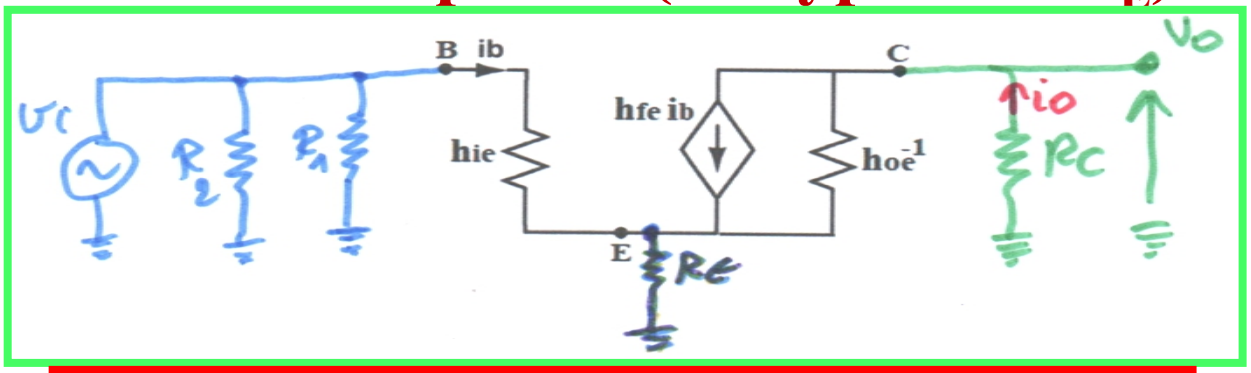

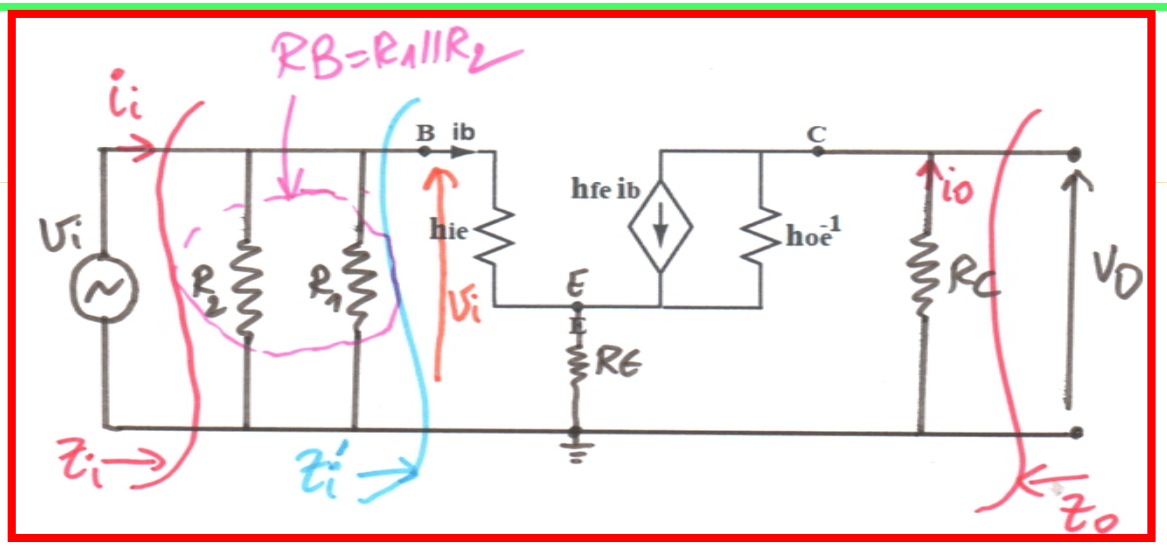

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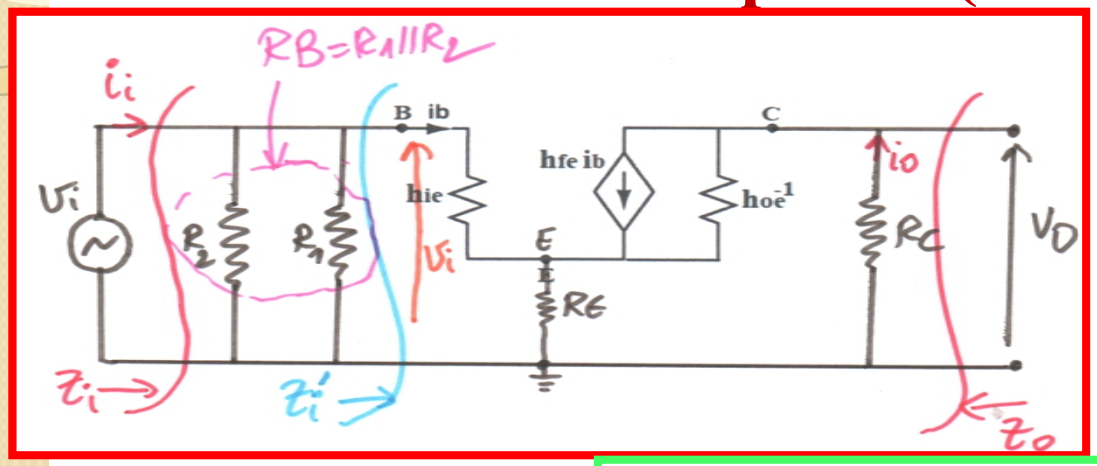
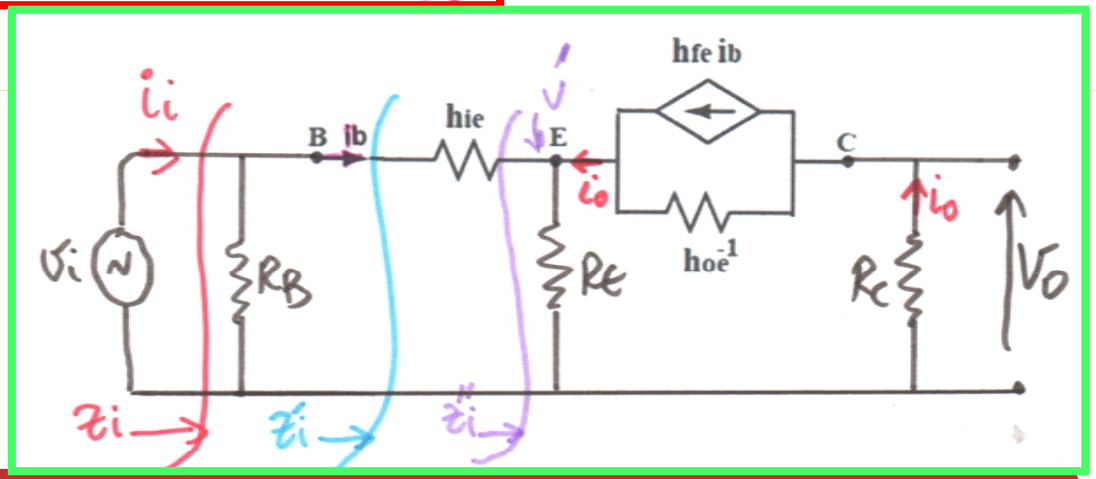
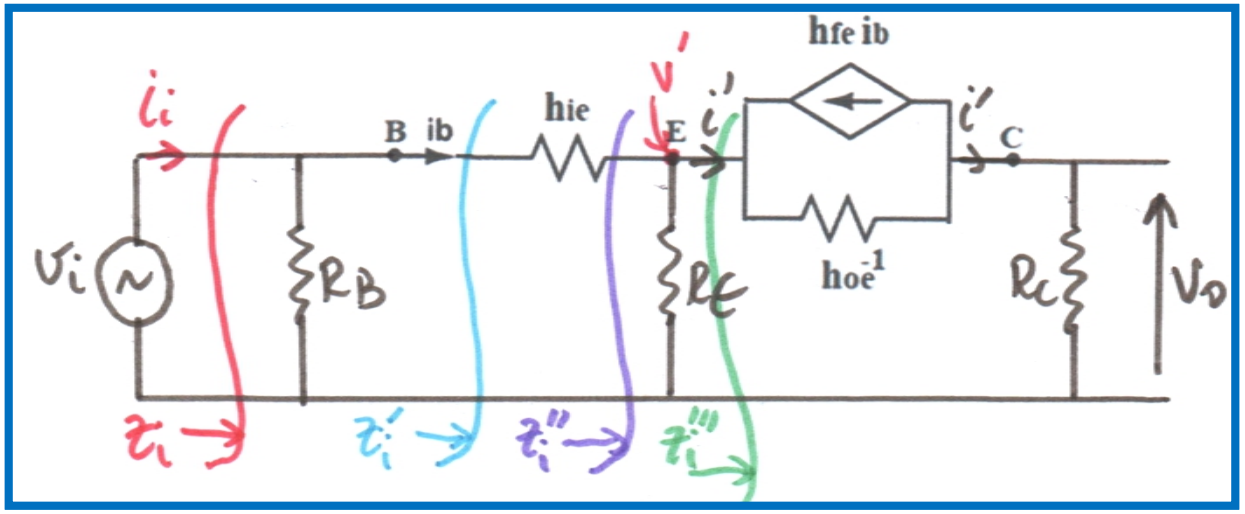
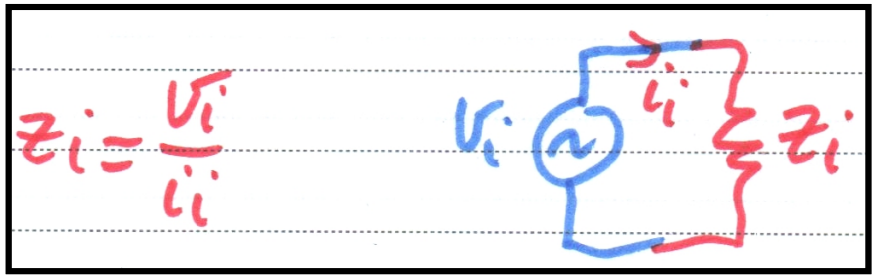


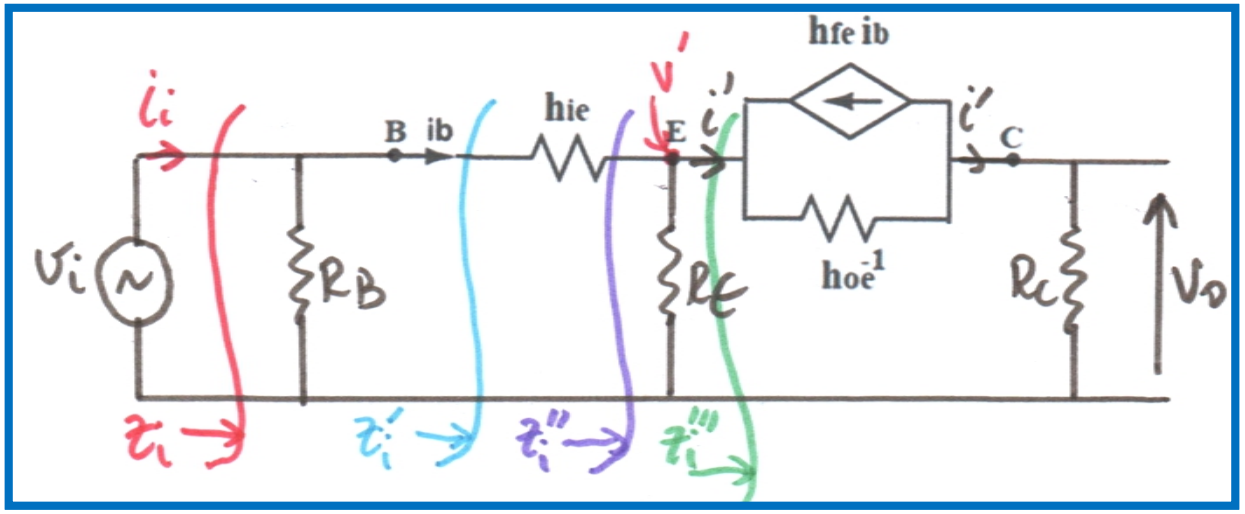


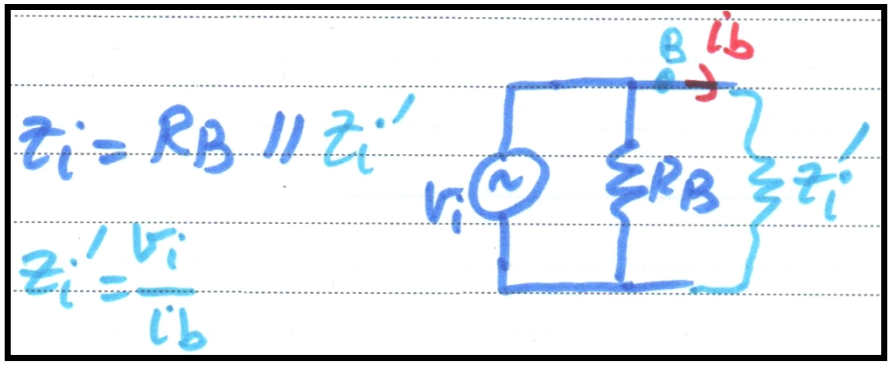
App 2: Common Emitter Voltage divider bias amplifier (unbypassed R_E)



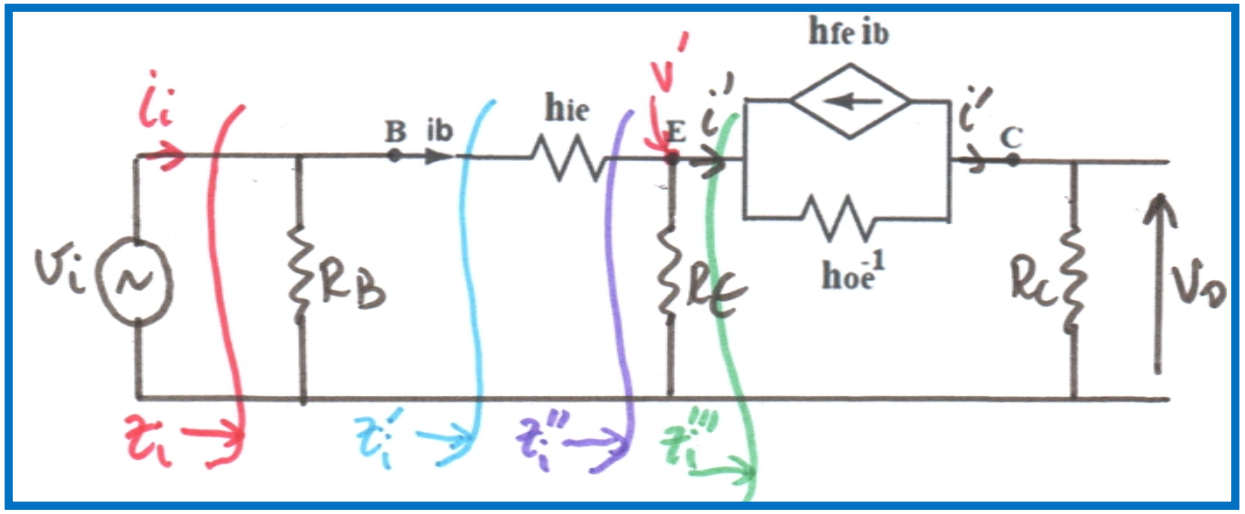


App 2: Common Emitter Voltage divider bias amplifier (unbypassed R_E)



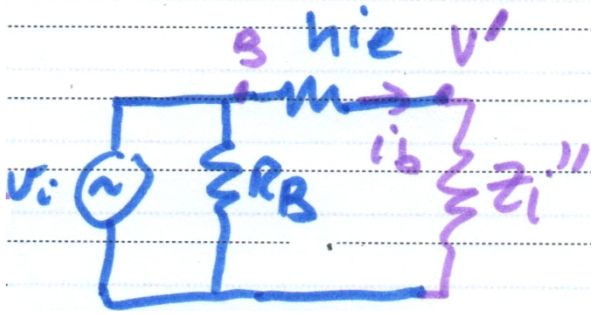


App 2: Common Emitter Voltage divider bias amplifier (unbypassed R_E)

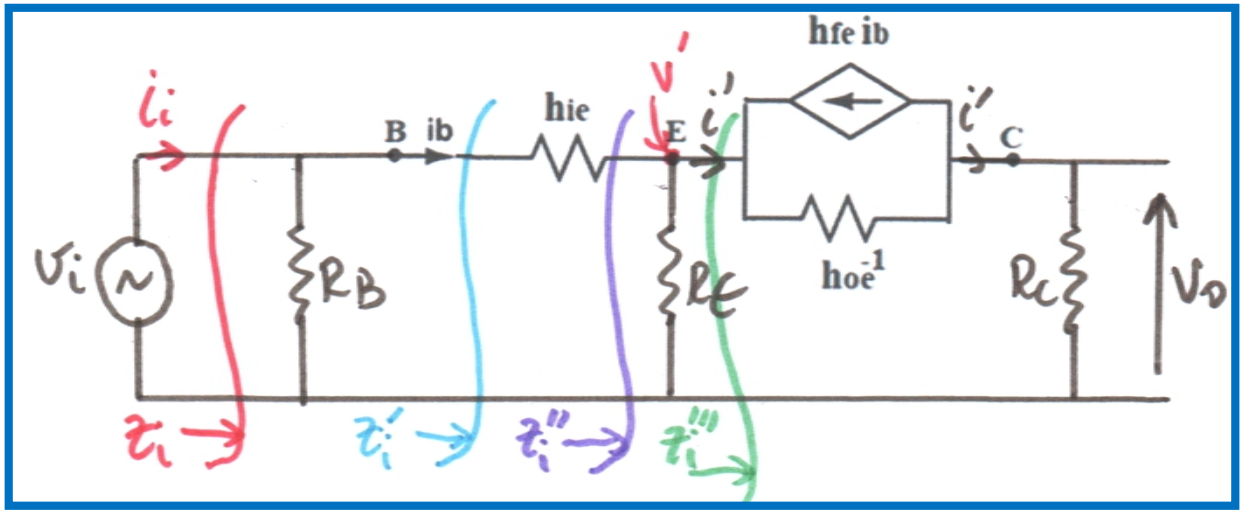


$$Z_i = R_B // [h_{ie} + Z_i'']$$

$$Z_i'' = \frac{V'}{i_b}$$

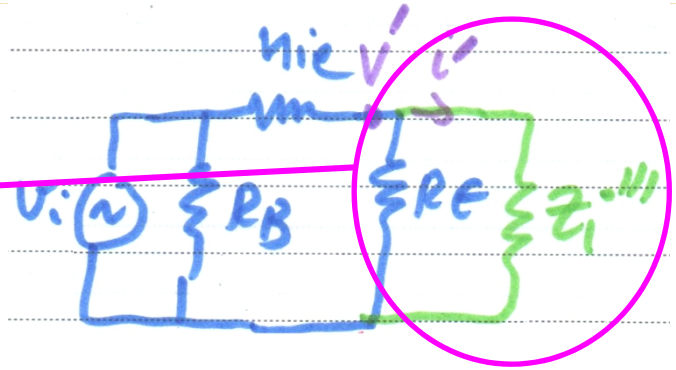


App 2: Common Emitter Voltage divider bias amplifier (unbypassed R_E)

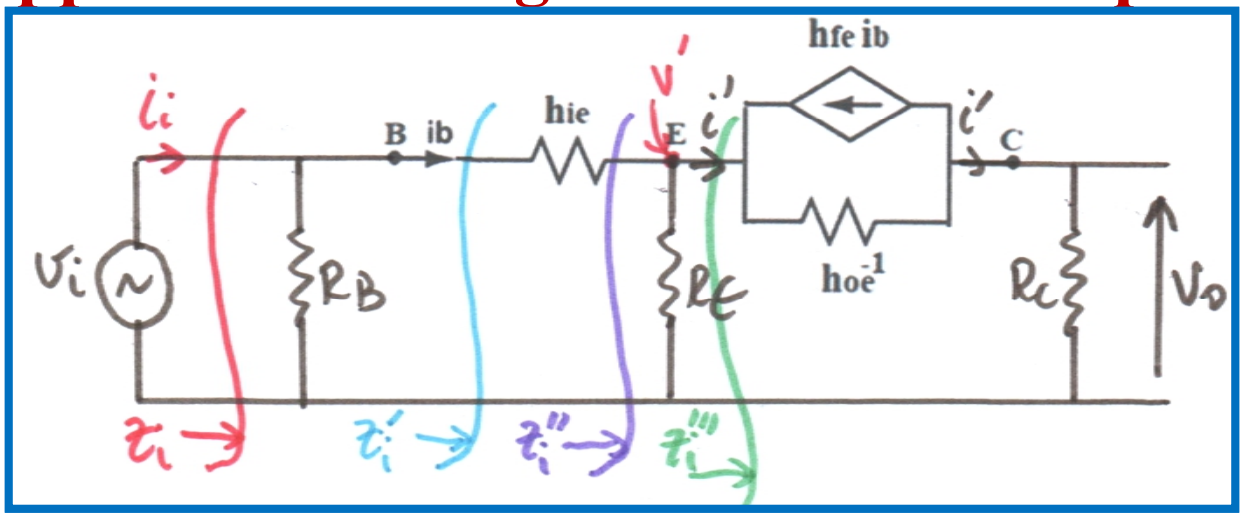


$$Z_i = R_B \,//\, [h_{ie} + (R_E \,//\, Z_i''')]$$

$$Z_i''' = \frac{V'}{i'}$$



App 2: C-E Voltage divider bias amplifier



$$z_i = R_B \parallel z_i'$$

$$z_i' = \frac{v_i}{i_b}$$

$$v_i = h_{ie} i_b + h_{oe}^{-1}(i' + h_{fe} i_b) + R_C i' \quad \ldots (1)$$

$$v_i = h_{ie} i_b + R_E (i_b - i') \quad \ldots (2)$$

$$(2) \Rightarrow i' = \frac{(h_{ie} + R_E) i_b - v_i}{R_E} \quad \ldots (3)$$

App 2: C-E Voltage divider bias amplifier

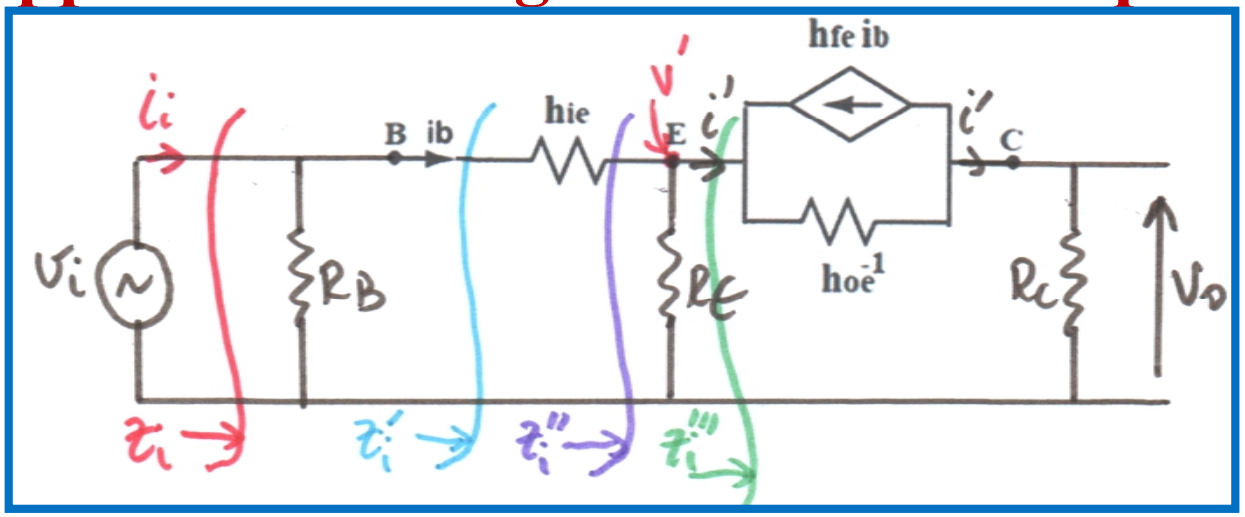
(3) in (1)

$$V_i\left[1+\frac{h_{oe}^{-1}+R_C}{R_E}\right]=i_b\left[h_{ie}+h_{oe}^{-1}h_{fe}+(h_{oe}^{-1}+R_C)\left(\frac{h_{ie}+R_E}{R_E}\right)\right]$$

$$Z_i'=\frac{V_i}{i_b}=\frac{h_{ie}+h_{oe}^{-1}h_{fe}+\left[(h_{oe}^{-1}+R_C)(h_{ie}+R_E)/R_E\right]}{1+\left[(h_{oe}^{-1}+R_C)/R_E\right]}$$

$$Z_i=R_B/\!/Z_i'$$

App 2: C-E Voltage divider bias amplifier

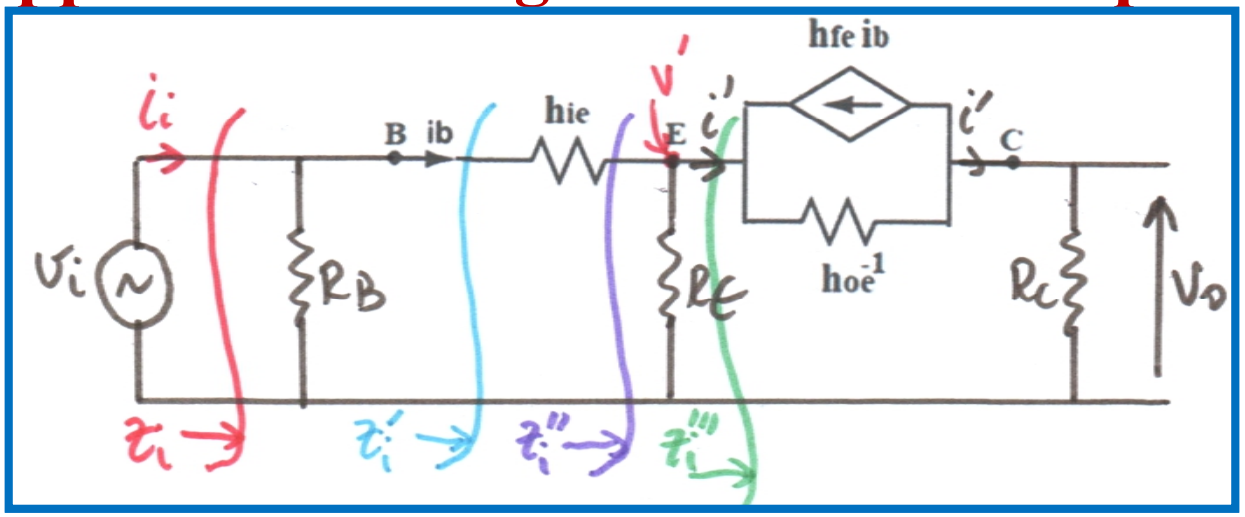


$$A_V = \frac{V_o}{V_i}$$

$$V_i = h_{ie} i_b + h_{oe}^{-1}(i' + h_{fe} i_b) + V_o \quad \ldots (1)$$

$$V_i = (h_{ie} + h_{oe}^{-1} h_{fe}) i_b + h_{oe}^{-1} i' + V_o \quad \ldots (1)'$$

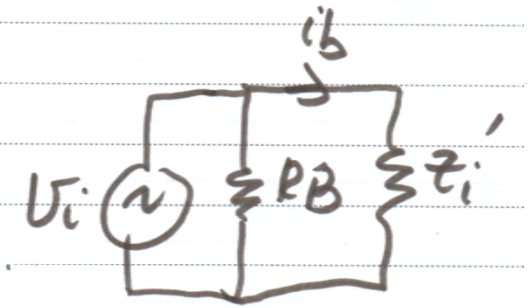
App 2: C-E Voltage divider bias amplifier



$$i' = \frac{V_o}{R_C} \quad \ldots\ldots (2)$$

$$i_b = \frac{V_i}{z_i'} \quad \ldots (3)$$

(2) and (3) in (1)'



App 2: C-E Voltage divider bias amplifier

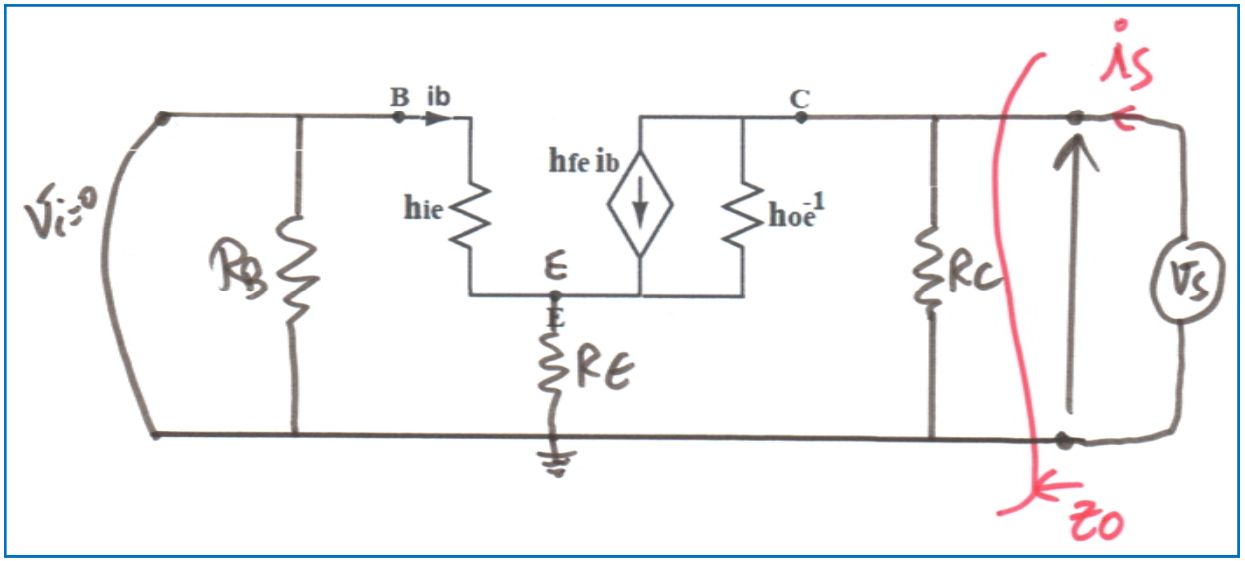
② and ③ in ①'

$$V_i = \left(h_{ie} + h_{oe}^{-1} h_{fe}\right)\frac{V_i}{Z_i'} + h_{oe}^{-1}\frac{V_o}{R_C} + V_o$$

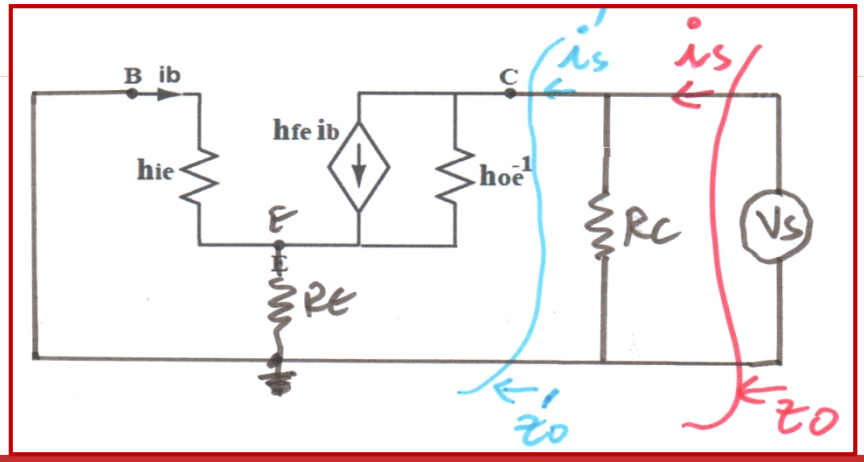
$$V_i\left[1 - \frac{h_{ie} + h_{oe}^{-1} h_{fe}}{Z_i'}\right] = V_o\left[1 + \frac{h_{oe}^{-1}}{R_C}\right]$$

$$A_V = \frac{V_o}{V_i} = \frac{1 - \left(h_{ie} + h_{oe}^{-1} h_{fe}\right)/Z_i'}{1 + \frac{h_{oe}^{-1}}{R_C}}$$

App 2: C-E Voltage divider bias amplifier



$$Z_0 = \frac{V_s}{i_s}\Big|_{V_i=0}$$

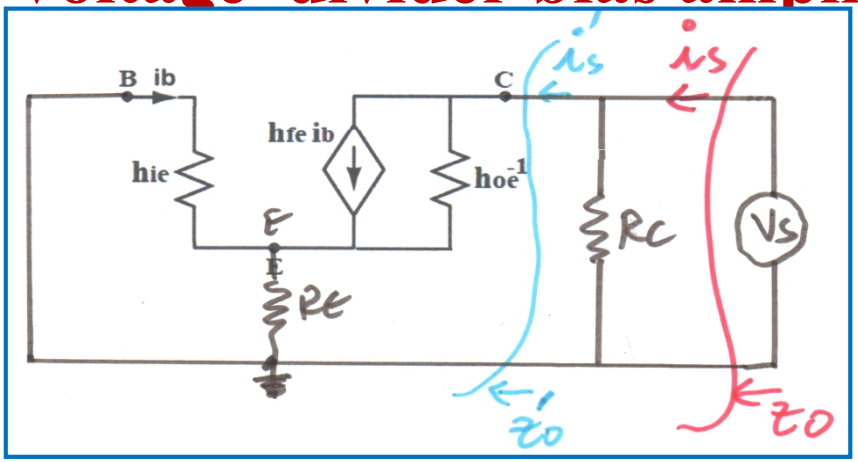


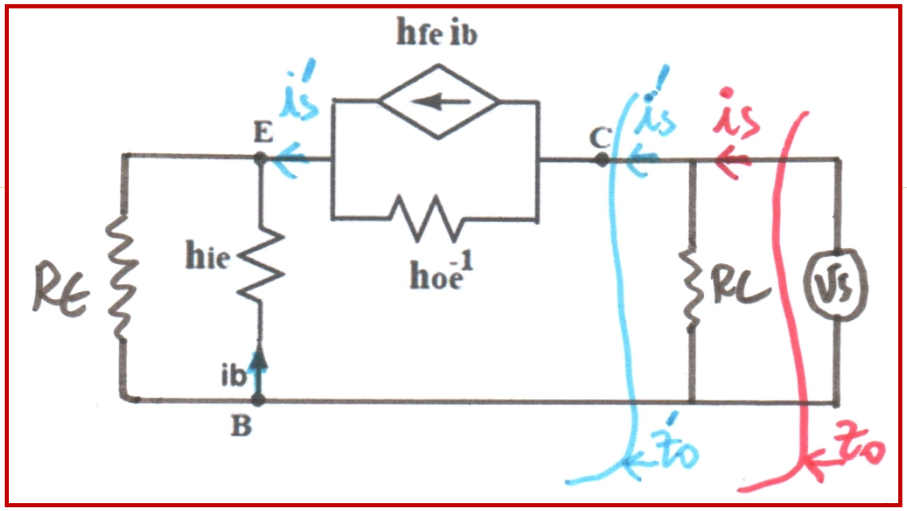
App 2: C-E Voltage divider bias amplifier

$$Z_0 = \frac{V_S}{i_S}\Big|_{V_i=0}$$

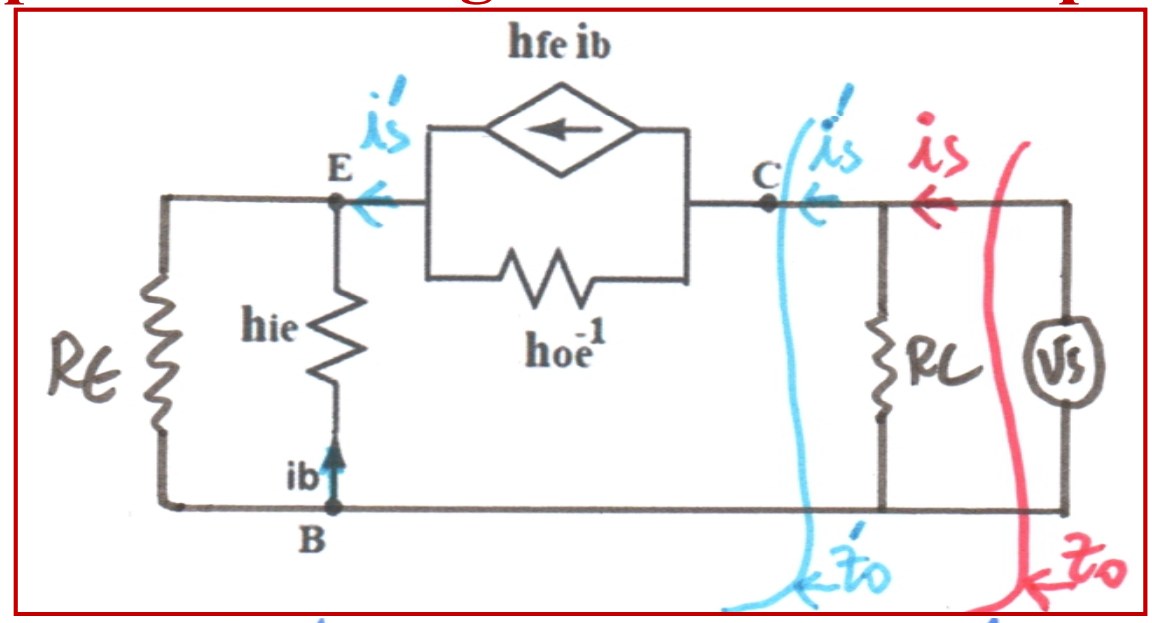
$$Z_0 = R_C \,//\, \frac{V_S}{i_S'} \quad Z_0'$$

$$Z_0' = \frac{V_S}{i_S'}$$





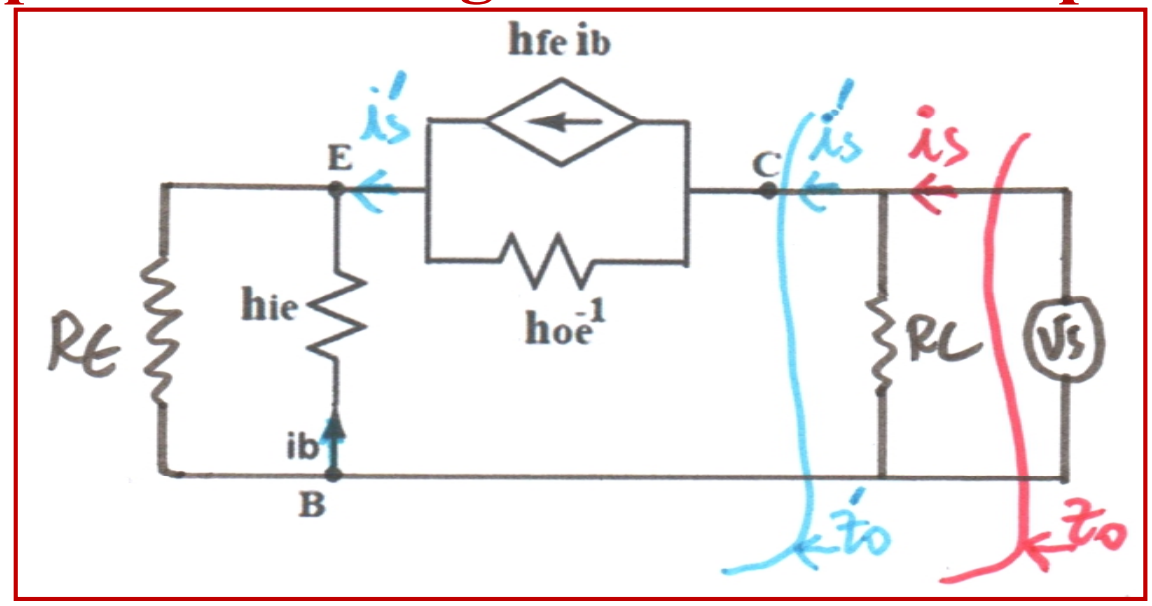
App 2: C-E Voltage divider bias amplifier



$$V_s = h_{oe}^{-1}(i_s' - h_{fe} i_b) + (h_{ie} \parallel R_E) i_s' \quad \ldots (1)$$

$$i_b = -\frac{R_E}{R_E + h_{ie}} i_s' \quad \ldots (2)$$

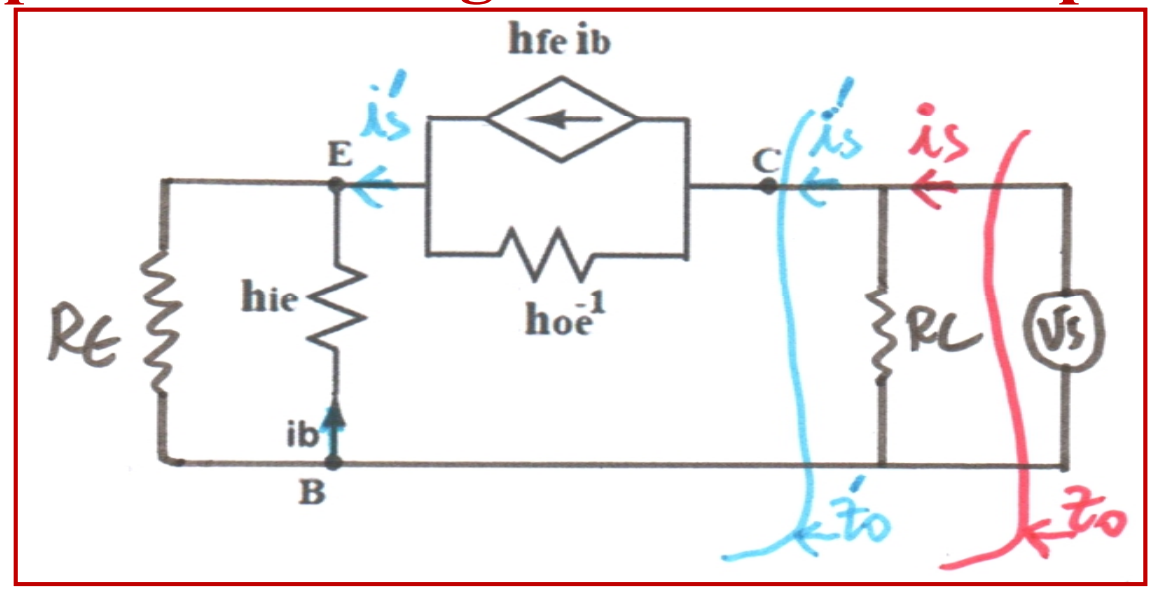
App 2: C-E Voltage divider bias amplifier



$$V_s = h_{oe}^{-1}(i_s' - h_{fe} i_b) + (h_{ie} \parallel R_E) i_s' \quad \ldots (1)$$

$$i_b = -\frac{R_E}{R_E + h_{ie}} i_s' \quad \ldots (2)$$

App 2: C-E Voltage divider bias amplifier

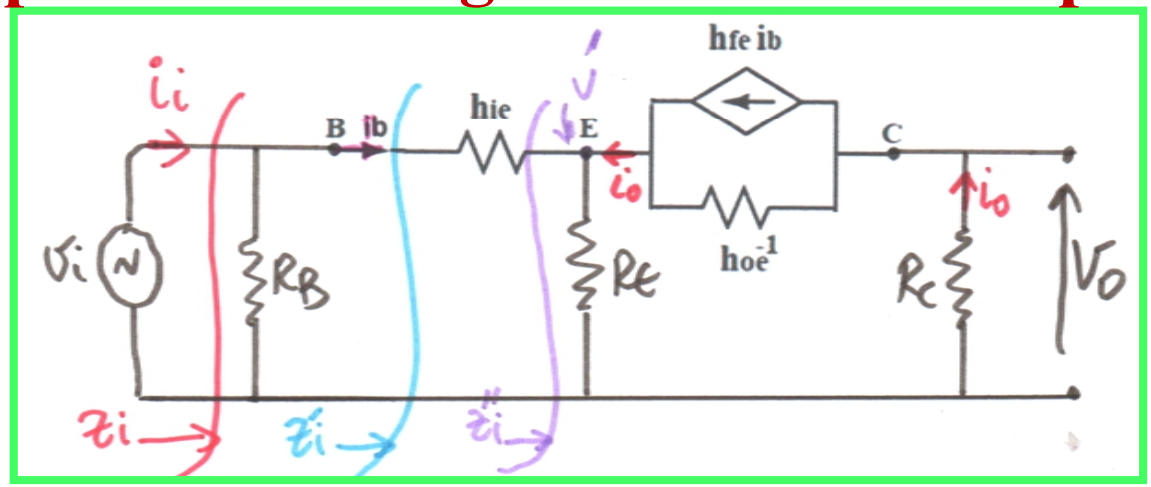


(2) in (1)

$$Z_o' = \frac{V_s}{i_s'} = h_{oe}^{-1} + (h_{ie} \parallel R_E) + \frac{h_{oe}^{-1} h_{fe} R_E}{R_E + h_{ie}}$$

$$Z_o = R_C \parallel Z_o'$$

App 2: C-E Voltage divider bias amplifier



$$A_i = \frac{i_o}{i_i}$$

$$V_i = z_i i_i \quad \cdots (1)$$

$$V_o = -R_C i_o \quad \cdots (2)$$

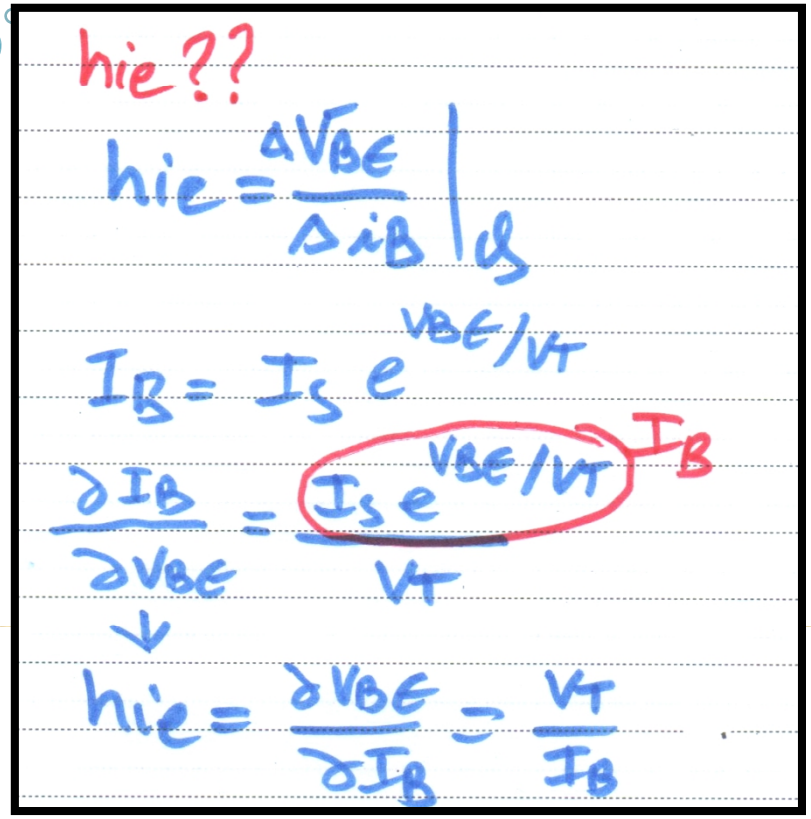
$$\Rightarrow \frac{V_o}{V_i} = -\frac{R_C}{z_i}\frac{i_o}{i_i}$$

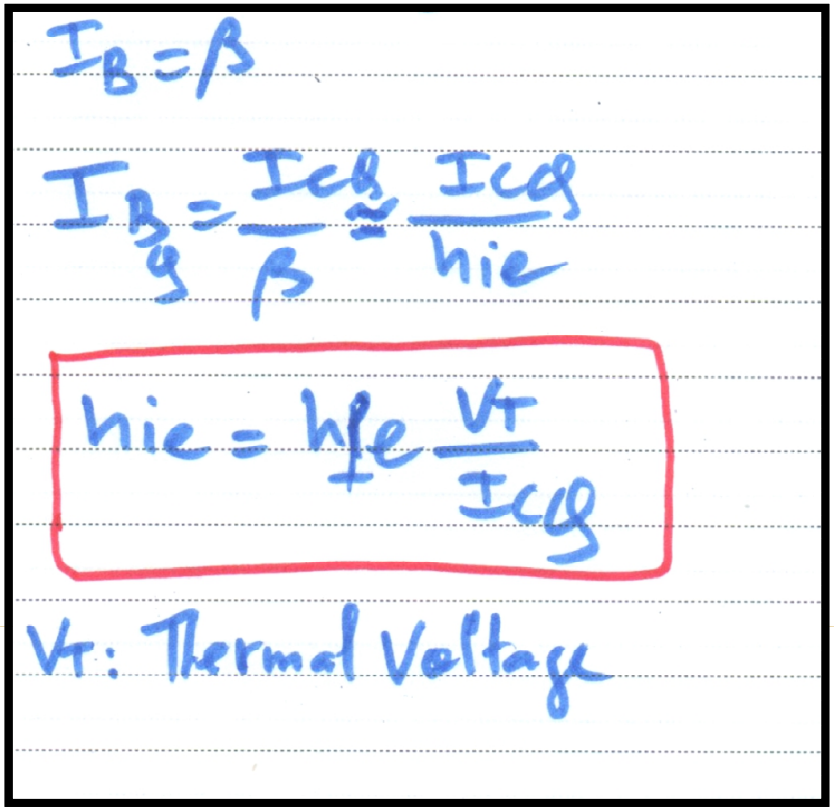
($\frac{V_o}{V_i} = A_V$, $\frac{i_o}{i_i} = A_i$)

$$A_i = -\frac{z_i}{R_C} A_V$$

App 2: C-E Voltage divider bias amplifier

Config.	C-E (bypass.R_E)	C-E (unbypass. R_E)	C-B	C-C
Zi	Medium	High	Low	High
Zo	M	M	M	L
AV_{NL}	H (<0)	M(<0)	H(>0)	L(≈1)
Ai	H (>0)	H(>0)	L(≈-1)	H (<0)


hie??
$h_{ie} = \frac{\Delta V_{BE}}{\Delta i_B}\Big|_Q$
$I_B = I_S e^{V_{BE}/V_T}$
$\frac{\partial I_B}{\partial V_{BE}} = \frac{I_S e^{V_{BE}/V_T}}{V_T}$
I_B
$h_{ie} = \frac{\partial V_{BE}}{\partial I_B} = \frac{V_T}{I_B}$


$I_B = \beta$
$I_{BQ} = \frac{I_{CQ}}{\beta} \cong \frac{I_{CQ}}{h_{ie}}$
$h_{ie} = h_{fe} \frac{V_T}{I_{CQ}}$
V_T: Thermal Voltage

End of presentation