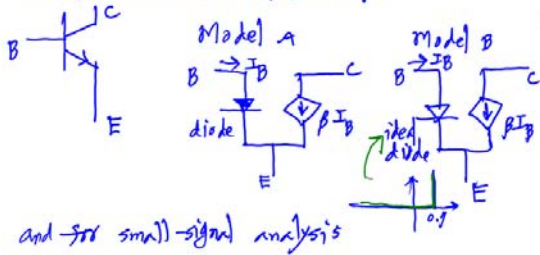


EE101 Lecture 12 Feb 5, 2018  
Operational Amplifiers (OP Amps)

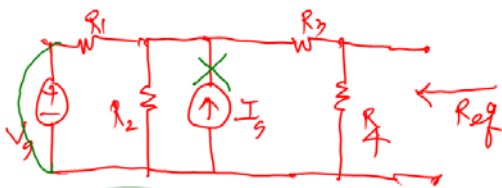
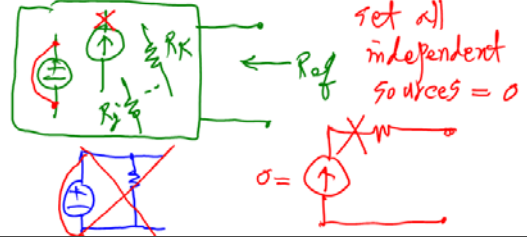
Recall how we handled BJTs



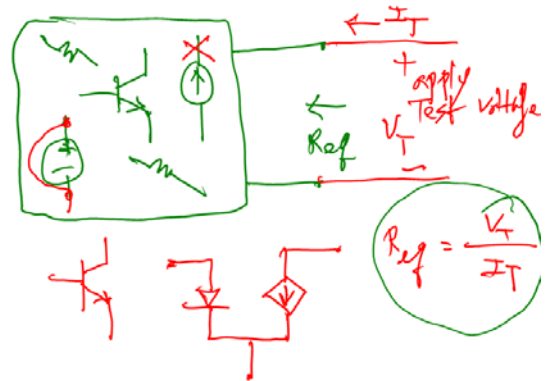
and for small-signal analysis

Q23 Average =  $5 \cdot 58 / 10$   
 $\sigma = 1.62$

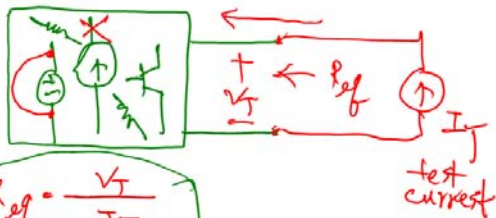
(A) On calculating  $R_{ref}$  when there are no dependent sources



$[(R_1 \parallel R_2) + R_3] \parallel R_4 = R_{ref}$



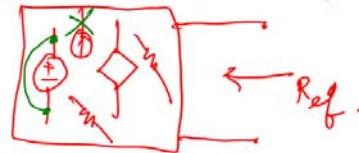
$R_{ref} = \frac{V_T}{I_T}$

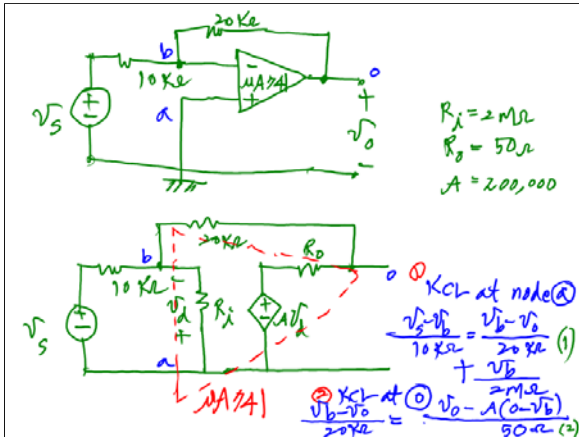
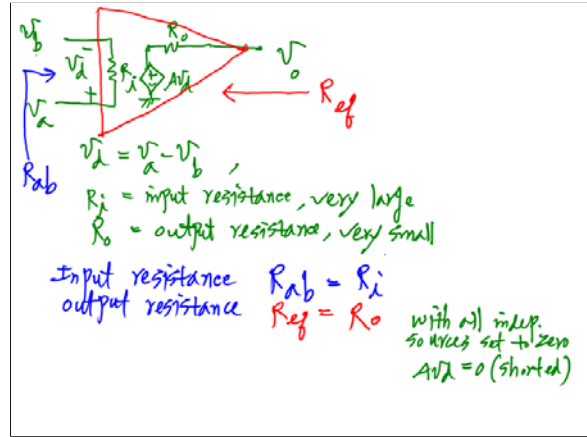
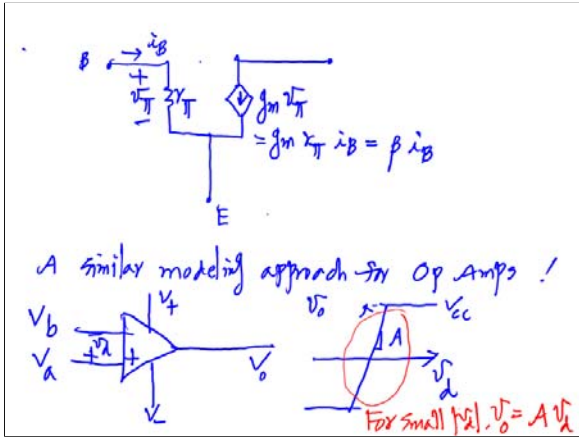


$R_{ref} = \frac{V_T}{I_T}$



(B) When there are dependent sources





(1)  $\times 20k \rightarrow 2(v_s - v_a) = v_a - v_o$  (1)  
 (2)  $\times 20k \rightarrow v_b - v_o = (v_b + A v_a) \cdot 400$  (2)

$\begin{bmatrix} 2 & -1 \\ 400A-1 & 401 \end{bmatrix} = \begin{bmatrix} v_a \\ v_o \end{bmatrix} = \begin{bmatrix} 2v_s \\ 0 \end{bmatrix}$  where  $A = 200,000$

$v_o = \frac{\begin{vmatrix} 2 & 2v_s \\ 400A-1 & -1 \end{vmatrix}}{\begin{vmatrix} 2 & -1 \\ 400A-1 & 401 \end{vmatrix}} = \frac{-2v_s(400A-1)}{2(401) - (-1)(400A-1)}$

divide both sides by  $(400A-1)$ :  $\frac{-2v_s}{1 + \frac{2(401)}{(400A-1)}} \approx \frac{-2v_s}{-1.9999999v_s}$

