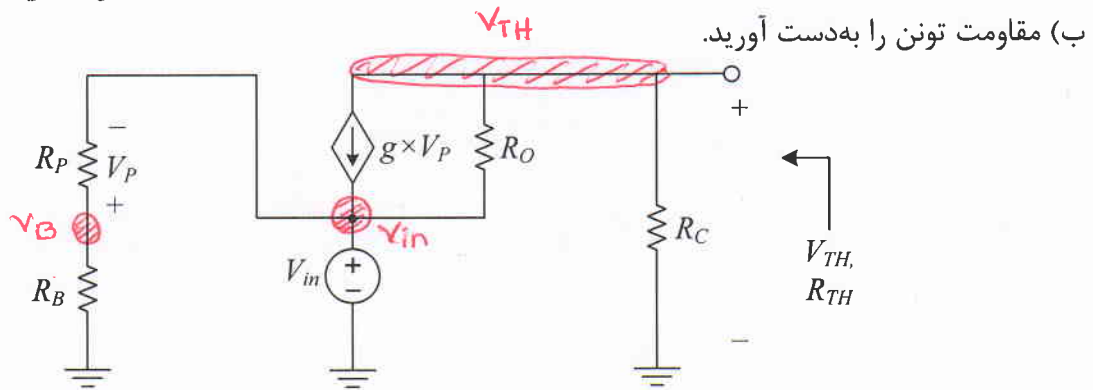




الف) ثابت کنید ولتاژ تونن در مدار شکل زیر، برابر با عبارت روبرو است: $V_{TH} = (g \times \frac{R_p}{R_p + R_B} + \frac{1}{R_O})(R_O \parallel R_C)V_{in}$



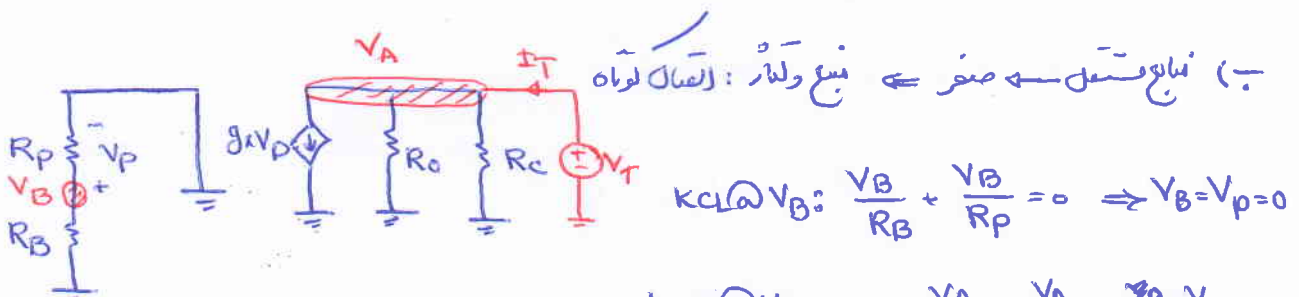
ککل @ V_{TH} : $\frac{V_{TH}}{R_C} + \frac{V_{TH} - V_{in}}{R_O} + g \times V_p = 0$ (۱)

ککل @ V_B : $\frac{V_B - V_{in}}{R_p} - \frac{V_B}{R_B} = 0 \Rightarrow V_B = \frac{R_B}{R_B + R_p} V_{in}$ (۲)

(۱) $\Rightarrow V_p = V_B - V_{in} = -\frac{R_p}{R_B + R_p} V_{in} \Rightarrow V_{TH} (\frac{1}{R_C} + \frac{1}{R_O}) = V_{in} (\frac{1}{R_O} + g \times \frac{R_p}{R_B + R_p})$

$\Rightarrow V_{TH} = (\frac{1}{\frac{1}{R_C} + \frac{1}{R_O}}) \times (\frac{1}{R_O} + g \times \frac{R_p}{R_B + R_p}) \times V_{in}$

$\Rightarrow V_{TH} = (R_C \parallel R_O) (\frac{1}{R_O} + g \times \frac{R_p}{R_B + R_p}) V_{in}$



ککل @ V_B : $\frac{V_B}{R_B} + \frac{V_B}{R_p} = 0 \Rightarrow V_B = V_p = 0$

ککل @ V_A : $-I_T + \frac{V_A}{R_C} + \frac{V_A}{R_O} + g \times V_p = 0$

$V_p = 0$
 $V_A = V_T \Rightarrow V_T (\frac{1}{R_C} + \frac{1}{R_O}) = I_T \Rightarrow R_{TH} = \frac{V_T}{I_T} = R_C \parallel R_O$