An 8 bit A/D Converter has a reference voltage of $V_{ref} = 10.24$

Find the output word and the corresponding quantization error for $V_{in} = 3.34V$

Answer :

$$3.34 = (2^{-1} b_1 + 2^{-2} b_2 + \cdots + 2^{-8} b_8)\, 10.24$$

$$\frac{3.34}{10.24} = 2^{-1} b_1 + 2^{-2} b_2 + \cdots + 2^{-8} b_8$$

$$\frac{3.34 \times 2^8}{10.24} = b_1 \times 2^7 + 2^6 b_2 + 2^5 b_3 + \cdots + b_8$$

$$83.5 = 128 b_1 + 64 b_2 + 32 b_3 + \cdots + b_8$$

$b_1 = 0$ $b_2 = 1$

$$19.5 = 32 b_3 + 16 b_4 + 8 b_5 + 4 b_6 + 2 b_7 + b_8$$

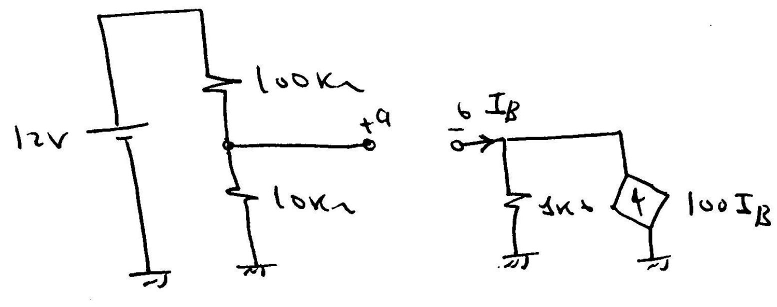
$b_3 = 0$, $b_4 = 1$

$$3.5 = 8 b_5 + 4 b_6 + 2 b_7 + b_8$$

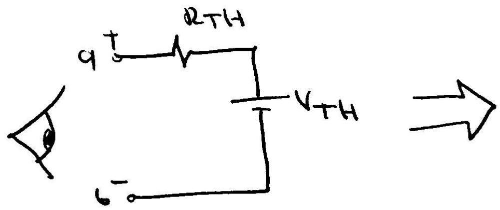
$b_5 = 0$, $b_6 = 1$, $b_7 = 0$ & $b_8 = 0$

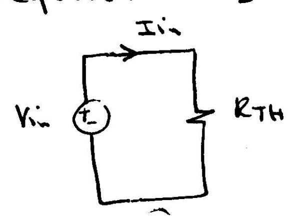
01010100 , -ve

Get the Thevenin equivalent between terminals a & b



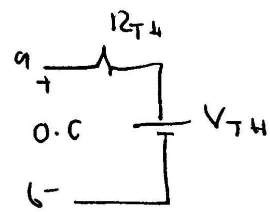
Answer: Two analyses are required to get V_{TH} & R_{TH}





first analysis

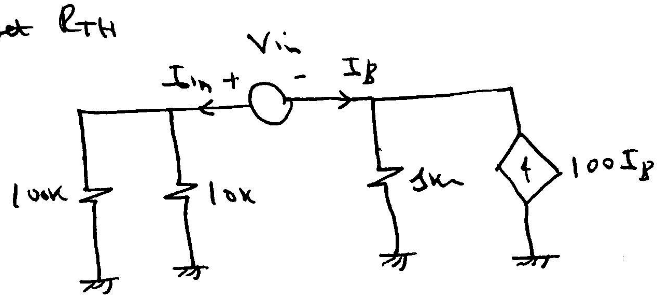
second analysis



* first we get V_{TH}. As $I_B = 0 \Rightarrow 100 I_B = 0$

$$V_{ab} = V_{TH} = V_a - V_b = 12 * \frac{10}{110} - 0 = 1.09\,V$$

* second we get R_{TH}



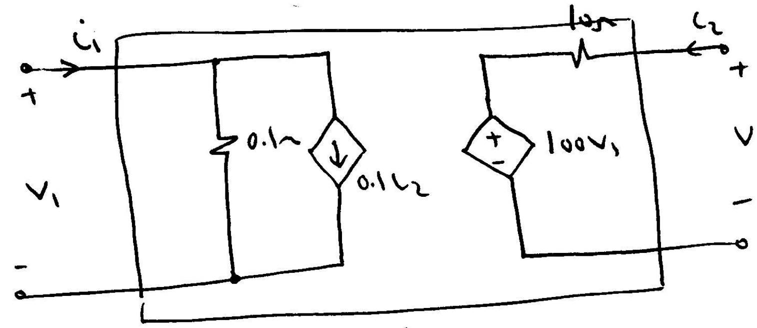
$V_{in} = I_{in} * (100K // 10K) - 101\, I_B * 1K\Omega$

$= I_{in} * (100K // 10K) + 101\, I_{in} * 1K$

$V_{in} = 9.09K * I_{in} + 101K * I_{in} = 110K * I_{in}$

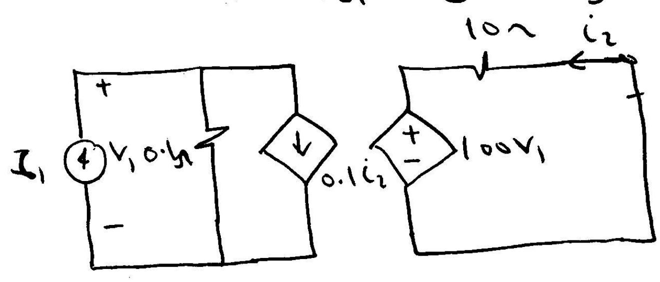
$\therefore R_{TH} = \frac{V_{in}}{I_{in}} = 110K$

Find the h parameters for the shown circuit



$$\begin{bmatrix} V_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} i_1 \\ V_2 \end{bmatrix}$$

* we first obtain h_{11} & h_{21} by setting $V_2 = 0$



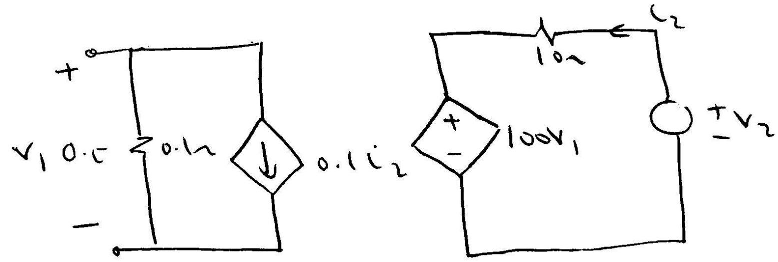
$i_2 = -10 V_1$

$V_1 = (I_1 - 0.1 i_2)\, 0.1 = (i_1 + V_1) * 0.1$

$0.9 V_1 = 0.1\, i_1 \Rightarrow \frac{V_1}{i_1} = h_{11} = \frac{1}{9} = 0.111\,\Omega$

$h_{21} = \frac{i_2}{i_1} = \frac{i_2}{V_1} * \frac{V_1}{i_1} = -10 * \frac{1}{9} = -1.111$

To get h_{12} & h_{22} we set $i_1 = 0$ (o.c. at input)



$$i_2 = \frac{v_2 - 100 v_1}{10} \quad \text{but} \quad v_1 = -0.01\, i_2$$

$$\therefore \quad i_2 = \frac{v_2 + i_2}{10} \Rightarrow 0.9\, i_2 = 0.1\, v_2$$

$$\boxed{h_{22} = \frac{i_2}{v_2} = \frac{1}{9} = 0.111}$$

$$h_{12} = \frac{v_1}{v_2} = \frac{v_1}{i_2} * \frac{i_2}{v_2} = -0.01 * \frac{1}{9} = -\frac{1}{900} = -1.111e^{-3}$$

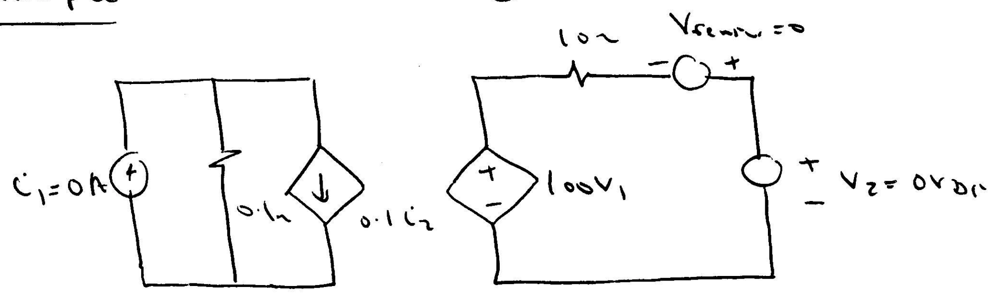
- .TF Directive can be used to get G, h, Y, and Z
- .TF X_{in} X_{out} (X_{in}, X_{out} may be currents or voltages)

output from .TF

$$\frac{\Delta X_{out}}{\Delta X_{in}}, \quad R_{in}(X_{in}), \quad R_{in}(X_{out})$$

* By properly selecting X_{in} & X_{out} we can get all parameters

Example



$$\begin{bmatrix} V_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} i_1 \\ V_2 \end{bmatrix}$$

* if $V_2 = 0$

$$V_1 = h_{11} i_1 \quad \& \quad i_2 = h_{21} i_1$$

$$\therefore \quad h_{11} = \frac{V_1}{i_1} = R_{in}(i_1) \quad \& \quad h_{21} = \frac{\Delta i_2}{\Delta i_1}$$

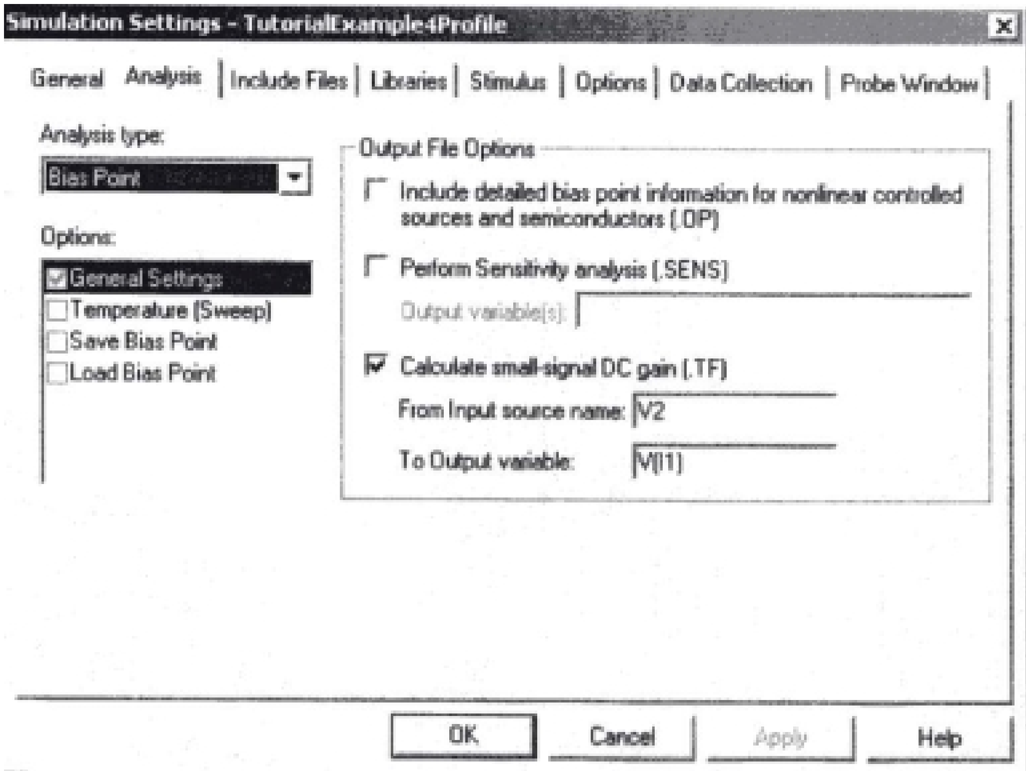
so we select $X_{in} = i_1$ & $X_{out} = i\,(V_{sensor})$

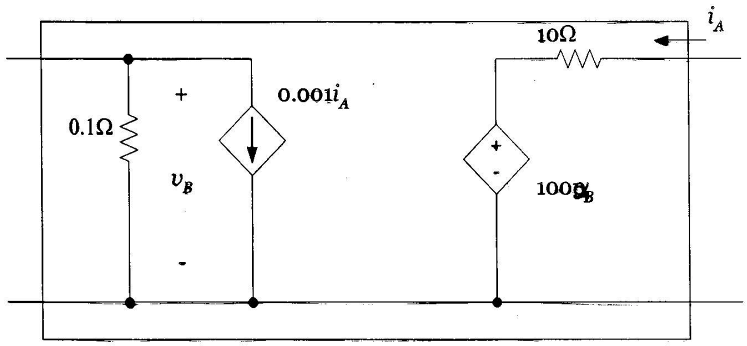
* if $i_1 = 0$

$$V_1 = h_{12} V_2 \quad , \quad i_2 = h_{22} V_2$$

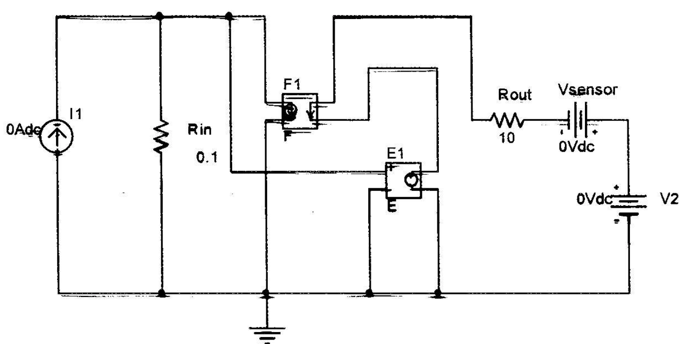
$$h_{22} = \frac{i_2}{V_2} = \frac{1}{R_{in}(i_2)} \quad , \quad h_{12} = \frac{V_1}{V_2} = \frac{\Delta V_1}{\Delta V_2}$$

so we select $X_{in} = V_2$ & $X_{out} = V(i_1)$


Simulation Settings - TutorialExample4Profile
General
Analysis
Include Files
Libraries
Stimulus
Options
Data Collection
Probe Window
Analysis type:
Bias Point
Options:
General Settings
Temperature (Sweep)
Save Bias Point
Load Bias Point
Output File Options
Include detailed bias point information for nonlinear controlled sources and semiconductors (.OP)
Perform Sensitivity analysis (.SENS)
Output variable(s):
Calculate small-signal DC gain (.TF)
From Input source name: V2
To Output variable: V(I1)
OK
Cancel
Apply
Help



calculate the h parameters using the .TF directive in PSpice



The .TF directive is applied twice: first between I1 and I(Vsensor) to get h11 and h21

**** SMALL-SIGNAL CHARACTERISTICS

I(V_Vsensor)/I_I1 = -1.111E+00

INPUT RESISTANCE AT I_I1 = 1.111E-01

OUTPUT RESISTANCE AT I(V_Vsensor) = 9.000E+00

The .TF directive is then applied between V2 and V(I1) (notice reverse polarity)

**** SMALL-SIGNAL CHARACTERISTICS

V(I_I1)/V_V2 = 1.111E-03

INPUT RESISTANCE AT V_V2 = 9.000E+00

OUTPUT RESISTANCE AT V(I_I1) = 1.111E-01