

ELEN30009 - Electrical Network Analysis and Design

Assignment 4

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Tuesday - 2:15 PM

1. (a) INSERT DIAGRAM HERE

Using KVL in loop 1:

$$\begin{aligned}\Sigma V_{drops} &= 0 \\ \implies V_i + I_i R_i &= 0 \\ \implies V_i &= -I_i R_i\end{aligned}$$

Using KVL in loop 2:

$$\begin{aligned}\Sigma V_{drops} &= 0 \\ \implies -V_o + I_o R_o + A_{voc} V_i &= 0 \\ \implies -V_o + I_o R_o + A_{voc} I_i R_i &= 0 \\ \implies I_i &= \frac{V_o - I_o R_o}{A_{voc} R_i} \\ \implies V_i &= \frac{V_o - I_o R_o}{A_{voc}}\end{aligned}$$

We know that for a two port network, the general matrix equation written in a parameters is:

$$\begin{bmatrix} V_i \\ I_i \end{bmatrix} = \begin{bmatrix} a_{11} & -a_{12} \\ a_{21} & -a_{22} \end{bmatrix} \begin{bmatrix} V_o \\ I_o \end{bmatrix}$$

From the equation obtained before, we can re-write them in matrix form:

$$\begin{bmatrix} V_i \\ I_i \end{bmatrix} = \begin{bmatrix} \frac{1}{A_{voc}} & -\frac{R_o}{A_{voc}} \\ \frac{1}{A_{voc} R_i} & -\frac{R_o}{A_{voc} R_i} \end{bmatrix} \begin{bmatrix} V_o \\ I_o \end{bmatrix}$$

Therefore, the A matrix of this voltage amplifier model is:

$$A = \begin{bmatrix} \frac{1}{A_{voc}} & -\frac{R_o}{A_{voc}} \\ \frac{1}{A_{voc} R_i} & -\frac{R_o}{A_{voc} R_i} \end{bmatrix}$$

- (b) This circuit can be thought of as 3 cascaded two port networks forming a single two port network with a loaded output and a voltage input with source impedance. To find the A parameter matrix of the single two port network, first find the A parameter matrices of each amplifier stage and matrix multiply them together to.

$$\begin{aligned}
A_1 &= \begin{bmatrix} \frac{1}{10} & -\frac{1 \times 10^3}{10} \\ \frac{1}{101 \times 10^6} & -\frac{1 \times 10^3}{101 \times 10^6} \end{bmatrix} \\
A_2 &= \begin{bmatrix} \frac{1}{100} & -\frac{2 \times 10^3}{100} \\ \frac{1}{100200 \times 10^3} & -\frac{2 \times 10^3}{100200 \times 10^3} \end{bmatrix} \\
A_3 &= \begin{bmatrix} \frac{1}{2} & -\frac{50 \times 10^3}{2} \\ \frac{1}{225 \times 10^3} & -\frac{50 \times 10^3}{225 \times 10^3} \end{bmatrix} \\
A &= A_1 A_2 A_3 \\
&= \begin{bmatrix} 457 \times 10^{-6} & 22.885 \, \Omega \\ 457 \times 10^{-12} \, \text{V} & 22.885 \times 10^{-6} \end{bmatrix}
\end{aligned}$$

2. (a) i. We know that in a Thevenin equivalent circuit, maximum power transfer to the load occurs when $Z_L = Z_{Th}^*$, or for entirely resistive circuits, $R_L = R_{Th}$.

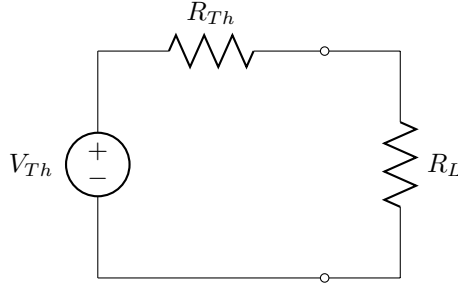


Figure 1: Thevenin equivalent circuit

Now by the formula sheet:

$$\begin{aligned}
R_{Th} &= \frac{a_{12} + a_{22} \cdot R_g}{a_{11} + a_{21} \cdot R_g} \\
&= \frac{10 + 1.5 \cdot 2}{4 + 0.5 \cdot 2} \\
&= 2.6 \, \Omega
\end{aligned}$$

Therefore, when $R_L = 2.6 \, \Omega$, maximum power is transferred to the load resistor.

- ii.
iii.
(b)
3. (a)
(b)
(c)
4. i
ii
iii
5.