SOME USEFUL NETWORK THEOREMS

Thevenin’s Theorem
NORTON THEOREM

\[ a \]

\[ a' \]

\[ Z_i \]

\[ I_n \]

\[ Z_n \]

\[ B \]

\[ A \]

\[ a \]

\[ a' \]

\[ I_n \]

\[ A \]

\[ a \]

\[ a' \]
Note that $I_n = \frac{V_i}{Z_i}$, $Z_n = Z_i$.

Note:

In either Thevenin’s or Norton’s theorem, network A should be connected to network B through only two wires.

Example:
\[ V_{oc} = V_t = V^+ \times \frac{R_2}{R_1 + R_2} \]

\[ Z_t = \frac{R_1 R_2}{R_1 + R_2} \]
∴

\[ V^+ \frac{R_2}{R_1 + R_2} \]

\[ v_{t} \]

\[ R_3 \]

\[ R_4 \]

\[ V_i = V^+ \frac{R_4}{R_3 + R_4} \]

\[ R_i = \frac{R_3 R_4}{R_3 + R_4} \]
Source-Absorption theorem:

Example:
From the circuit, $v_{\pi} = -v_t$

$R_{in} = \frac{v_t}{i_t}$

From the circuit, $v_{\pi} = -v_t$

$\therefore$ Voltage across dependent current source $(g_mv_{\pi}) = v_{\pi}$

$\therefore$ Dependent current source can be replaced by a resistance.

$$= \frac{v_{\pi}}{g_mv_{\pi}} = \frac{1}{g_m}$$
$R_{in} = r_\pi \parallel \left( \frac{1}{g_m} \right)$

**MILLER’S THEOREM**
The Miller equivalent circuit is valid as long as the conditions that existed in the network when \( K \) was determined are not changed. It shows that the Miller equivalent circuit cannot be used directly to determine the output resistance of amplifiers.

**Example:**
At node A, apply KCL:

\[
\frac{V_i - V_o}{R_f} = \frac{V_o}{R_o} + G_m V_i
\]

\[
\therefore V_i \left( \frac{1}{R_f} - G_m \right) = V_o \left( \frac{1}{R_f} + \frac{1}{R_o} \right)
\]

\[
\therefore K \equiv \frac{V_o}{V_i} = \frac{-G_m + 1/R_f}{1/R_o + 1/R_f} = -0.1 + 10^{-6}
\]

\[
\approx -1000
\]

\[
\frac{1}{R_1} = y_1 = y(1 - K) = \frac{1}{R_f}(1 - K)
\]

\[
\therefore \frac{1}{R_1} = 10^{-6}(1 + 10^3) = 10^{-3}(1/\Omega)
\]

\[
\therefore R_1 = 10^3 \Omega = 1k\Omega
\]

\[
\frac{1}{R_2} = y_2 = y(1 - \frac{1}{K}) = \frac{1}{R_f}(1 - \frac{1}{K}) = \frac{1}{R_f}(1 - \frac{1}{K}) = 10^{-6}(1 - 10^{-3}) \approx 10^{-6}(1/\Omega)
\]

\[
\therefore R_2 = 10^6 \Omega = 1M\Omega
\]