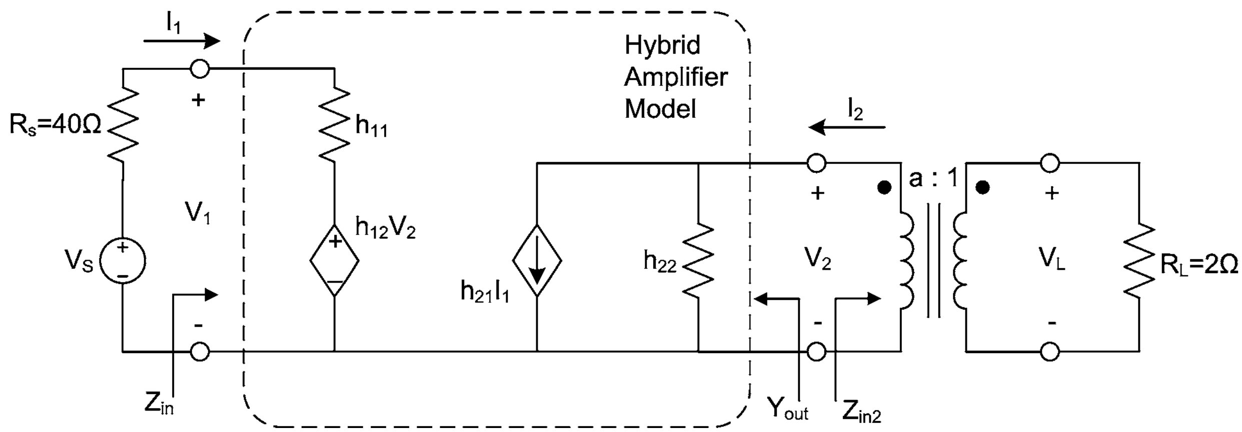
ECE 202 Linear Circuit Analysis II (Sp'09)

Homework #20 Solution (77–78)

Problem 77–78



Amplifier Specifications:

1. When I_1 is zero, the ratio $\frac{V_1}{V_2} = 0$, when a source is applied to port 2.
2. There must be maximum power transfer from the amplifier output to the load under the condition that $Z_{out}(s) = 800\Omega$.
3. $\frac{V_1}{V_s} = \frac{25}{26}$
4. The voltage gain $\frac{V_2}{V_1} = -100$

The two port Hybrid parameters are:

$$V_1 = h_{11}I_1 + h_{12}V_2 \tag{77.1}$$
$$I_2 = h_{21}I_1 + h_{22}V_2 \tag{77.2}$$

$$h_{11} = \left.\frac{V_1}{I_1}\right|_{V_2=0} [\Omega] \qquad h_{12} = \left.\frac{V_1}{V_2}\right|_{I_1=0}$$
$$h_{21} = \left.\frac{I_2}{I_1}\right|_{V_2=0} \qquad h_{22} = \left.\frac{I_2}{V_2}\right|_{I_1=0} [\mathrm{S}]$$

(a) h_{12}

$$h_{12} = \left.\frac{V_1}{V_2}\right|_{I_1=0} = \boxed{0} \qquad \text{From condition 1.}$$

(b) Y_{out}, h_{22}, and turn ratio a

Given the condition that the value of $Z_{out} = 800\Omega$,

$$Y_{out} = \frac{1}{Z_{out}} = \boxed{\frac{1}{800} = [\text{S}]}$$

h_{22} is defined as $\left.\frac{I_2}{V_2}\right|_{I_1=0}$. When I_1 is zero, the value of the dependent current source $h_{21}I_1$ is zero and it becomes an open circuit. As a result,

$$h_{22} = Y_{out} = \boxed{\frac{1}{800} = [\text{S}]}$$

From the condition 2, we want the impedances Z_{out} and Z_{in2} to match.

$$\begin{aligned} Z_{out} &= Z_{in2} \\ &= a^2 R_L \\ \Rightarrow a &= \sqrt{\frac{Z_{out}}{R_L}} = \sqrt{\frac{800}{2}} = \boxed{20} \end{aligned}$$

(c) h_{11}

Because $h_{12} = 0$, the dependent voltage source becomes a short circuit and $Z_{in} = h_{11}$. Given $\frac{V_1}{V_s} = \frac{25}{26}$,

$$\begin{aligned} \frac{V_1}{V_s} = \frac{Z_{in}}{Z_{in} + R_s} = \frac{25}{26} &= \frac{h_{11}}{h_{11} + R_s} \\ \Rightarrow h_{11} &= \boxed{1\text{k}\Omega} \end{aligned}$$

(d) Z_{in}

From part c) we found that $Z_{in} = h_{11} = \boxed{1\text{k}\Omega}$.

(e) h_{21}

When port 2 is connected to the load Z_{in2}, then the I_2 in (eq.77.2) becomes $-V_2Y_{in2}$. Then it simplifies to:

$$\begin{aligned}
I_2 =& h_{21}I_1 + h_{22}V_2 \\
-V_2Y_{in2} =& h_{21}I_1 + h_{22}V_2 \\
\Rightarrow h_{21} =& -\frac{V_2(h_{22} + Y_{in2})}{I_1} \\
=& -\left(\frac{V_1}{I_1}\right)\left(\frac{V_2}{V_1}\right)(h_{22} + Y_{in2}) \\
=& -(Z_{in})(-100)\left(\frac{1}{800} + \frac{1}{800}\right) \\
=& \boxed{250}
\end{aligned}$$

(f) Ratio of Power delivered to the load to the power delivered to R_L

$$\begin{aligned}
P_{load} =& \frac{(V_2)^2}{Z_{in2}} \\
P_{R_L} =& \frac{(V_L)^2}{R_L} = \frac{(V_2/a)^2}{R_L} \\
\therefore \frac{P_{load}}{P_{R_L}} =& \frac{(V_2)^2}{Z_{in2}}\frac{a^2R_L}{(V_2)^2} = \frac{(400)(2)}{800} = \boxed{1}
\end{aligned}$$