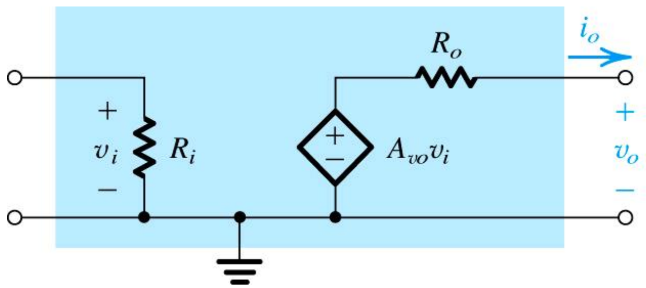
Last Lecture → Chapter 1.5

Concepts learned…

- voltage amplifier circuit model
  - ✓ ideal
  - ✓ non-ideal
- circuit analysis
- other types of amplifiers models
  - ✓ current amp.
  - ✓ trans-conductance amp.
  - ✓ trans-resistance amp.

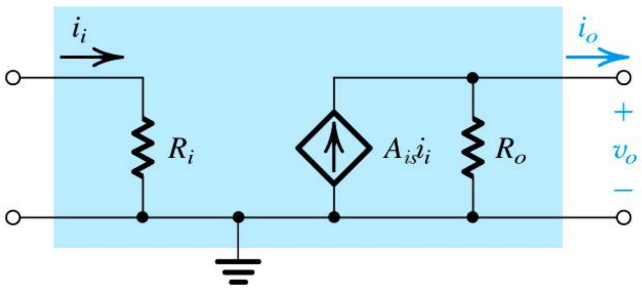
Gain → A_v [V/V] $R_i = \infty$ $R_0 = 0$

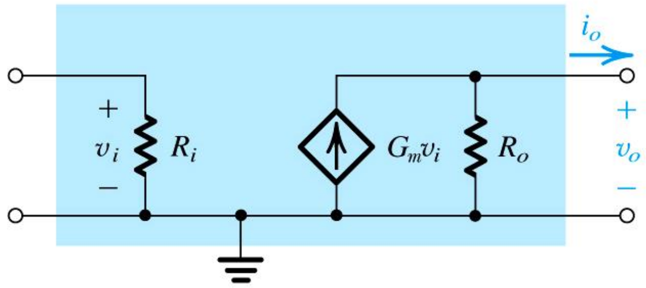
Voltage Amplifier



Gain → A_i [A/A] $R_i = 0$ $R_0 = \infty$

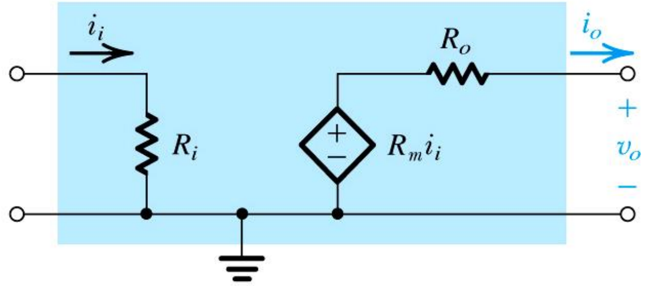
Current Amplifier





Trans-conductance Amplifier

Gain → G_m [A/V] $R_i = \infty$ $R_0 = \infty$



Trans-resistance Amplifier

Gain → R_m [V/A] $R_i = 0$ $R_0 = 0$

Last Lecture → Problem D1.49

A designer has available voltage amplifiers with an input resistance of 10kΩ, an output resistance of 2kΩ, and an open-circuit voltage gain of 10V/V. The signal source has a 10kΩ resistance and provides a 10-mV_{rms} signal, and it is required to provide a signal of at least 2V_{rms} to a 2kΩ load. How many amplifier stages are required? What is the output voltage actually obtained?

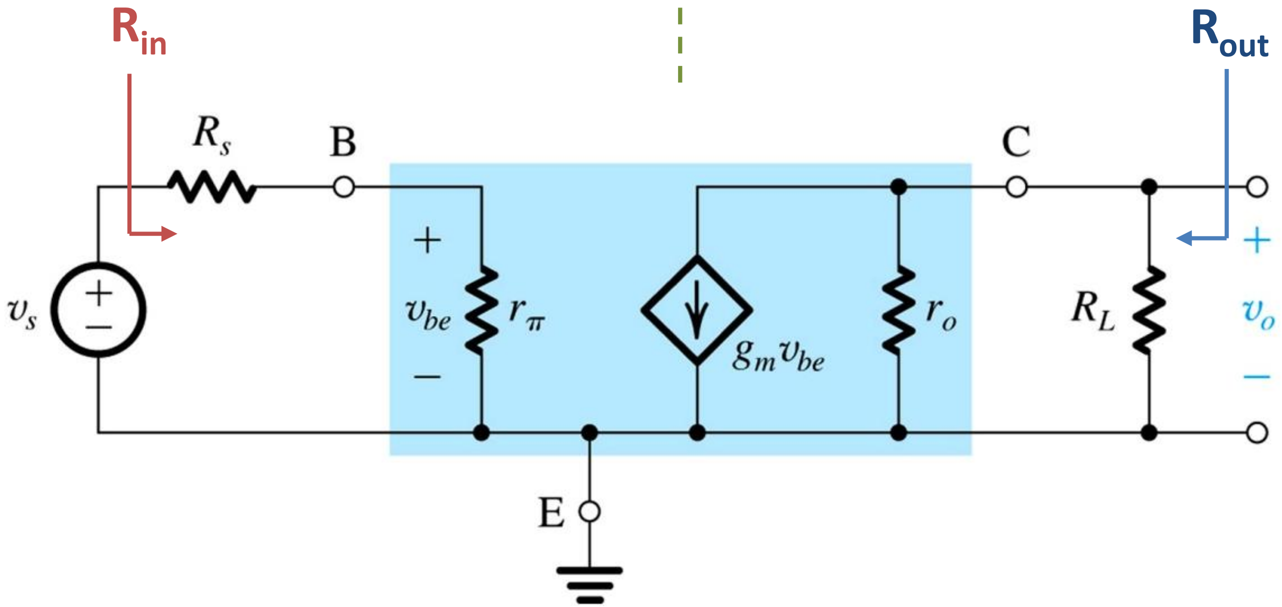
Input / Output Impedance of a Circuit

- **How can one calculate input resistance from terminal behavior?**

  1. place a test source V_x at the input terminals
  2. observe v_x and i_x
  3. calculate via $R_{in} = v_x / i_x$

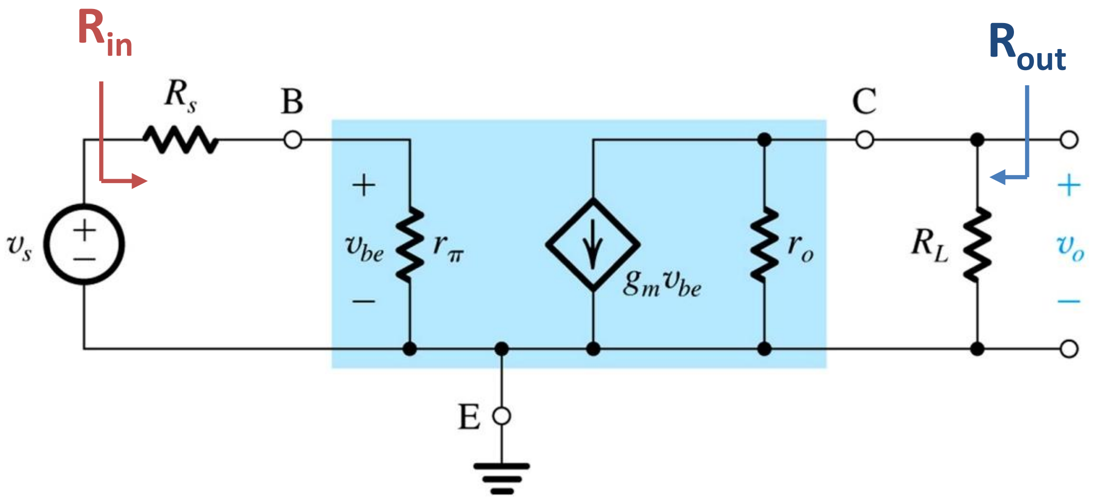
- **How can one calculate output resistance from terminal behavior?**

  1. place a test source V_y at the output terminals
  2. *turn of the input source (V_s=short!, I_s=open!)*
  3. observe v_y and i_y
  4. calculate via $R_{out} = v_y / i_y$



Example 1.4

For the following circuit derive an expression for the voltage gain v_o/v_s, and evaluate its magnitude for the case R_s=5kΩ, r_π=2.5kΩ, g_m=40mA/V, r_o=100kΩ, and R_L=5kΩ. What would be the gain value if the effect of r_o were neglected? Calculate the value for the impedance seen by the source and at the output terminals.



$$A_v = \frac{v_0}{v_s} = \left[\frac{v_0}{v_{be}}\right]\left[\frac{v_{be}}{v_s}\right] = \left[\frac{r_\pi}{r_\pi + R_s}\right][g_m r_0 \| R_L] = [0.33][190] = 63\text{ V/V}$$

$$\text{for } r_0 = 0 \quad \rightarrow A_v = [0.33][200] = 66\text{ V/V}$$

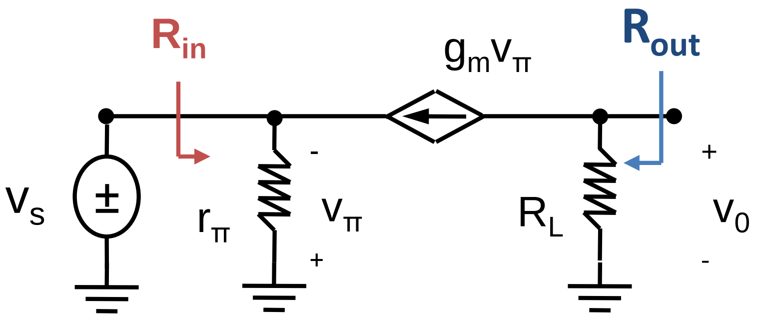
$$R_{in} = \frac{V_X}{I_x} = R_s + r_\pi = 7.5\text{ k}\Omega$$

$$R_{out} = \frac{V_y}{I_y} = r_0 \| R_L = 4.76\text{ k}\Omega$$

Problem

For the circuit provided below find the expression for the

a) Voltage gain V_0/V_s
b) Output resistance R_{out} (assume the source exhibits a series resistance R_s not shown)
c) Input resistance R_{in}



$$R_{out} = \frac{V_y}{I_y} = R_L$$

$$R_{in} = \frac{V_X}{I_x} = \frac{1}{g_m}\left[\frac{1}{1 + \frac{1}{g_m r_\pi}}\right]$$

$$A_v = \frac{V_0}{V_s} = g_m R_L$$

for $g_m r_\pi \gg 1 \rightarrow R_{in} = \frac{V_X}{I_x} = \frac{1}{g_m}$