TOOL: Common Source (CS) amplifiers and their AC models are shown here, along with formulas for input resistance, R_{in}, output resistance, R_{out}, and voltage gain, A_v.

Resistive Load

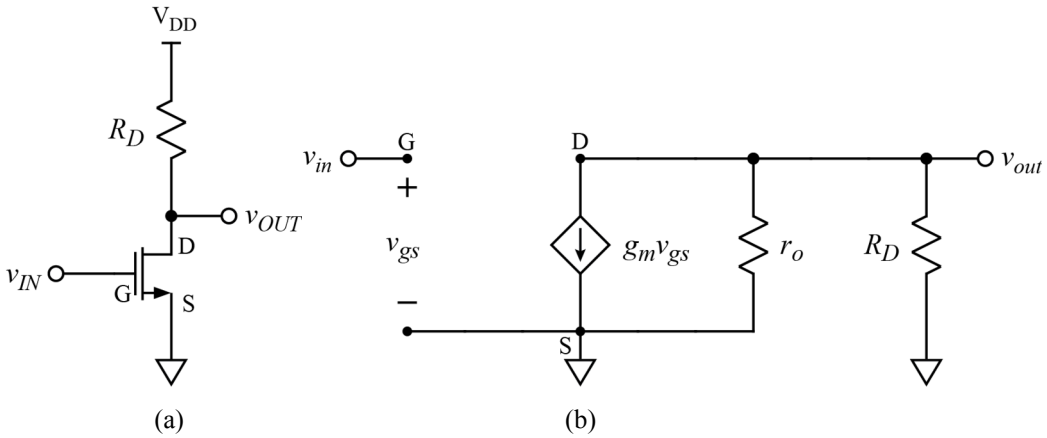

Fig. 1. CS amp with resistive load. (a) circuit, (b) AC model.

$$R_{in} = \infty\ \Omega \qquad R_{out} = R_D||r_o \qquad A_v = -g_m(R_D||r_o)$$

I-source Load

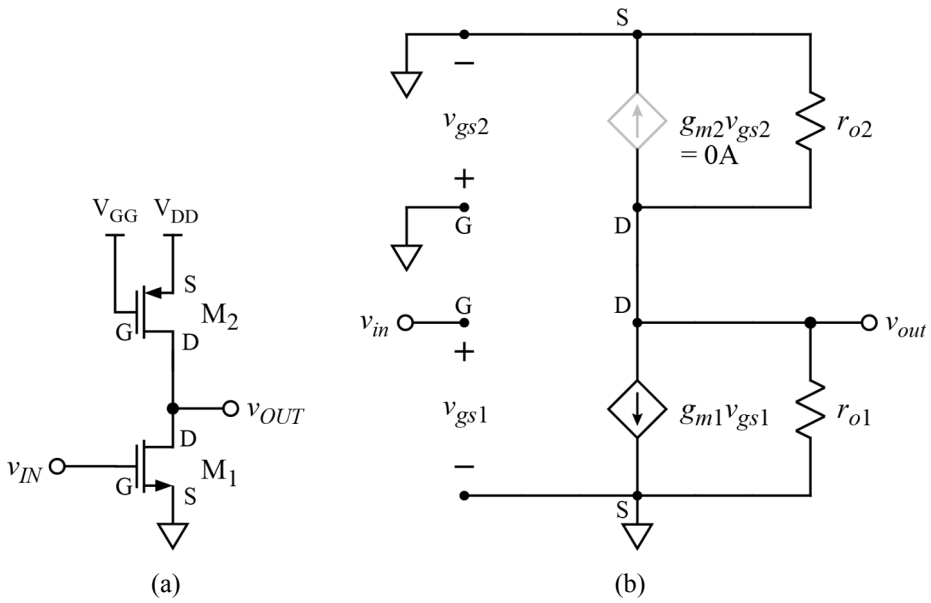

Fig. 2. CS amp with current-source load. (a) circuit, (b) AC model.

$$R_{in} = \infty\ \Omega \qquad R_{out} = r_{o1}||r_{o2} \qquad A_v = -g_{m1}(r_{o1}||r_{o2})$$

Diode Load

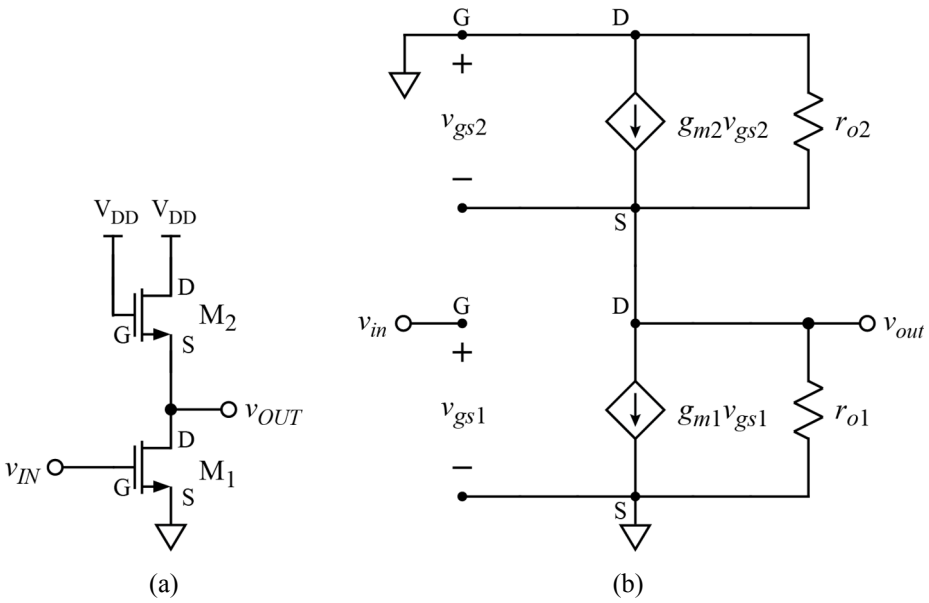

Fig. 3. CS amp with diode load. (a) circuit, (b) AC model.

$$R_{in} = \infty\ \Omega \qquad R_{out} = \frac{1}{g_{m2}} || r_{o1} || r_{o2} \qquad A_v = -g_{m1}\left(\frac{1}{g_{m2}} || r_{o1} || r_{o2}\right)$$

Source Degeneration

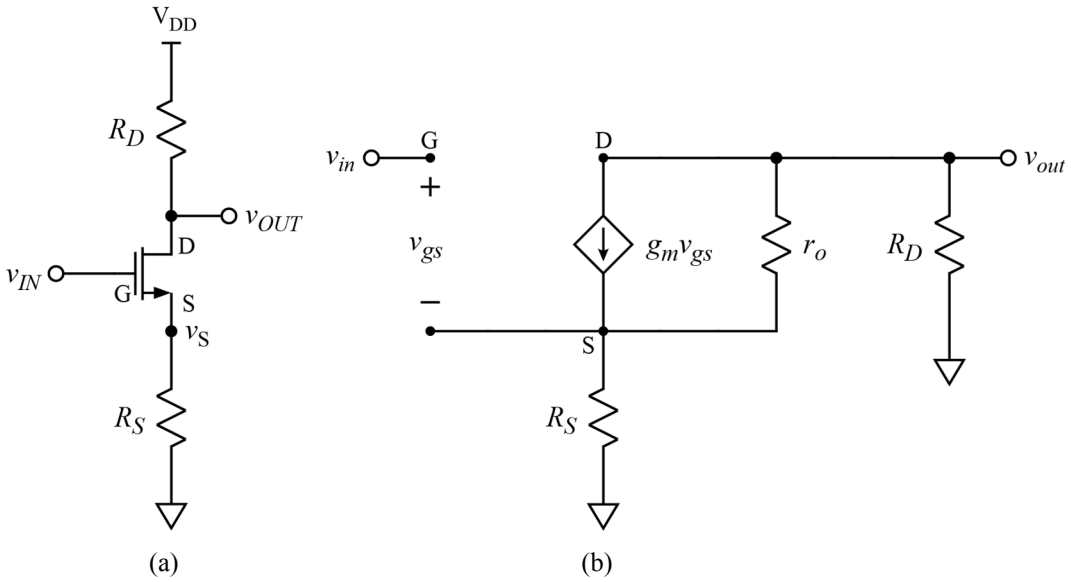

Fig. 4. CS amp with source degeneration. (a) circuit, (b) AC model.

$$R_{in} = \infty\ \Omega \qquad R_{out} = [r_o + (1 + g_m r_o)R_S]\,||R_D$$

$$A_v = -\frac{g_m r_o R_D}{r_o + (1 + g_m r_o)R_S + R_D}$$

Source Degeneration with PMOS diode

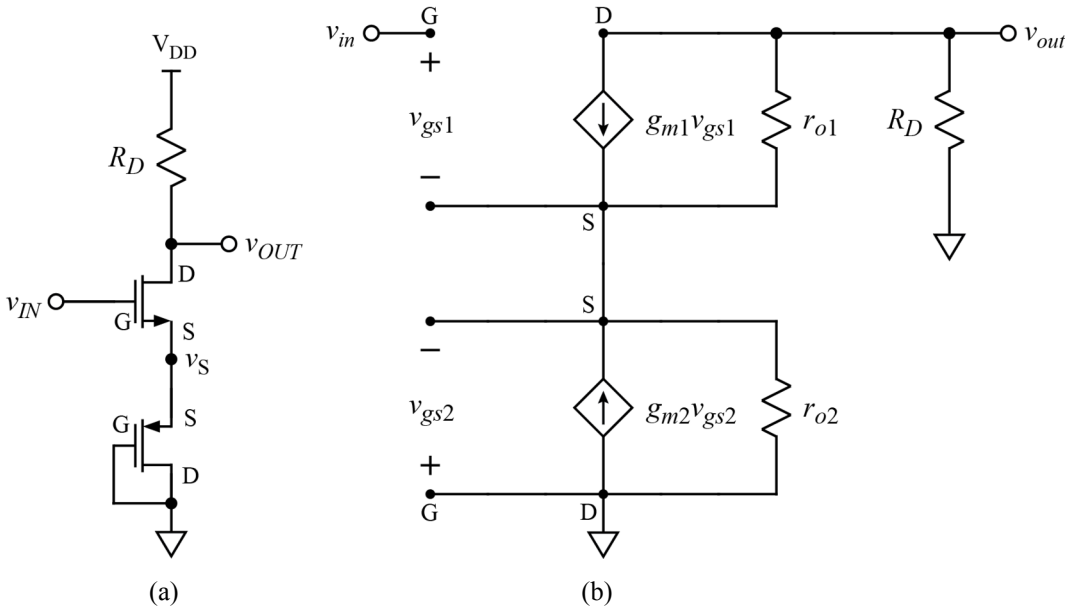

Fig. 5. CS amp with source degeneration PMOS diode. (a) circuit, (b) AC model.

$$R_{in} = \infty\ \Omega \qquad R_{out} = \left[r_{o1} + (1 + g_{m1} r_{o1}) \frac{1}{g_{m2}} || r_{o2} \right] || R_D$$

$$A_v = - \frac{g_{m1} r_{o1} R_D}{r_{o1} + (1 + g_{m1} r_{o1}) \dfrac{1}{g_{m2}} || r_{o2} + R_D}$$

Source Degeneration with NMOS diode

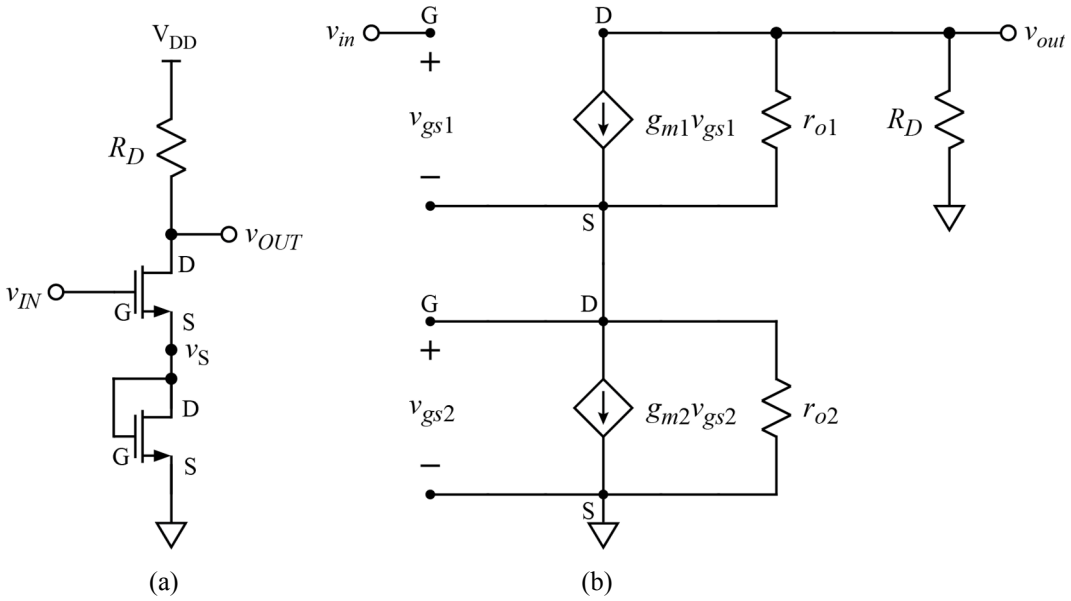

Fig. 6. CS amp with source degeneration NMOS diode. (a) circuit, (b) AC model.

$$R_{in} = \infty\ \Omega \qquad R_{out} = \left[r_{o1} + \left(1 + g_{m1} r_{o1} \cdot \frac{1}{g_{m2}} || r_{o2} \right) \right] || R_D$$

$$A_v = -\frac{g_{m1} r_{o1} R_D}{r_{o1} + (1 + g_{m1} r_{o1}) \dfrac{1}{g_{m2}} || r_{o2} + R_D}$$

REF: Behzad Razavi, *Fundamentals of Microelectronics with Robotics and Bioengineering Applications, 3rd Ed., Enhanced eText,* New York, NY: Wiley, 2021. ISBN: 9781119694397