Lecture 2

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- Current-Amplifier Model

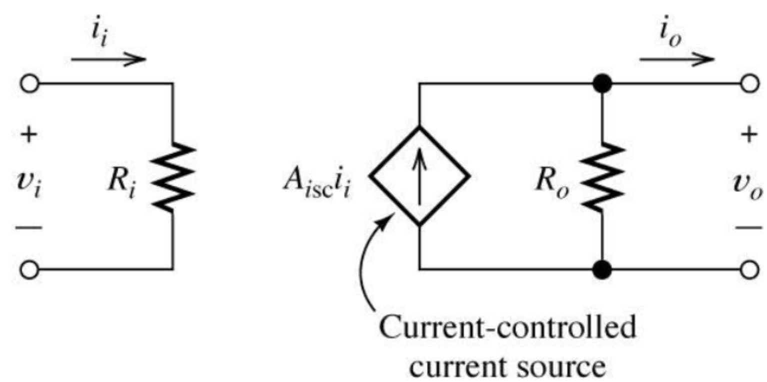

Figure 1: Reference Figure for Current-Amplifier Model

  - Parameters
    - i_i is the input current, which ideally comes from a current source
    - R_i and R_o are the input and output resistances, respectively
    - A_{isc} is the short-circuit current gain
  - Current gain with load impedance at the output: $A_i = i_o/i_i$

- Application of Thévenin to Norton transformation
  - The connection of R_o is changed, but the value remains the same

- $A_{isc} = i_{osc}/i_i$ is obtained with a short-circuit at the output terminals
  - where: $i_{osc} = A_{vo}v_i/R_o$ and $i_i = v_i/R_i$
  - After substituting: $A_{isc} = A_{vo}(R_i/R_o)$

- Transconductance-Amplifier Model

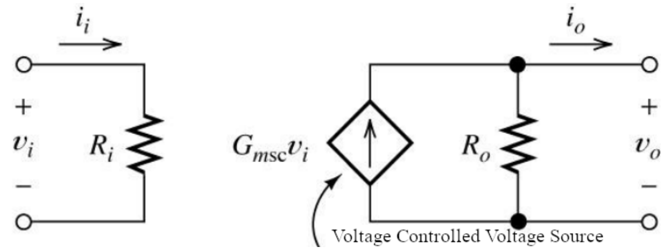

Figure 2: Reference Figure for Transconductance-Amplifier Model

  - Parameters
    - R_i and R_o are the input and output resistances, respectively
    - G_{msc} is the short-circuit transconductance gain
  - Transconductance gain with load impedance: $G_m = i_o/v_i$
  - The units of G_{msc} and G_m are Siemens ($S = A/V$)
  - During model conversions: obtain G_{msc} with the same short-circuit load procedure as outlined for A_{isc}

- Transresistance-Amplifier Model

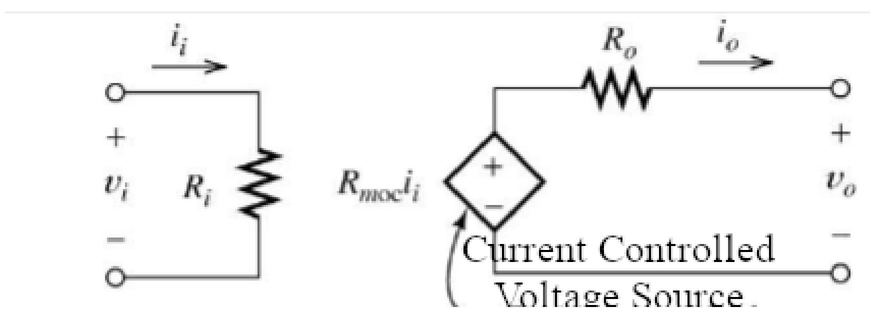

Figure 3: Reference Figure for Transresistance-Amplifier Model

  - Parameters
    - R_i and R_o are the input and output resistances, respectively
    - R_{moc} is the open-circuit transresistance gain
  - Transresistance gain with load impedance: $R_m = v_o/i_i$
  - The units of R_{moc} and R_m are Ohms (Ω)
  - During model conversions from Norton to Thévenin equivalent output stages, analyze the models with open-circuit loads:
    - Transresistance-amplifier: $R_{moc} = v_{ooc}/i_i$
    - Voltage-amplifier: $A_{vo} = v_{ooc}/v_i$, v_{ooc} is the open-circuit output voltage

- Conservation of Energy During Amplification

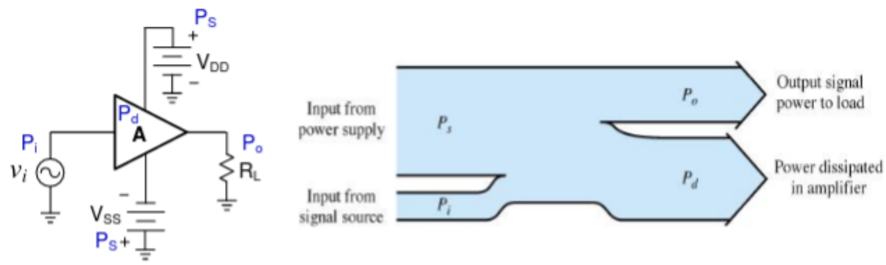

Figure 4: Amplifier Energy Conservation

  - P_i is the available power from the input signal source
  - P_s is the available power from the DC supply/supplies
  - P_o is the output power delivered to the load
  - P_d is the power dissipated in the amplifier (loss)

$$P_i + P_s = P_o + P_d$$

  - Amplifier efficiency:

$$\eta = \frac{P_o}{P_s} \cdot 100\%$$

- Note: for input/output power calculations, RMS values must always be used
- Differential Amplification

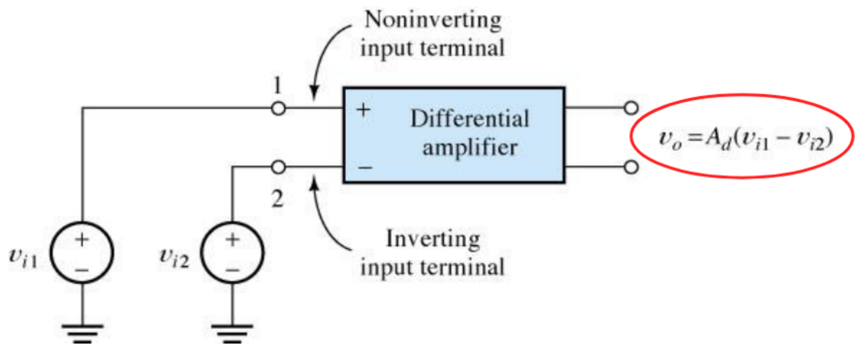

Figure 5: Differential Amplifier Model

  - Differential input signal: $v_{id} = v_{i1} - v_{i2}$
  - Differential voltage gain: A_d
  - $v_o = A_d v_{id}$
  - Common-mode (average) input signal: $v_{icm} = \frac{1}{2}(v_{i1} + v_{i2})$

- Output in the presence of differential and common-mode input signals
  - $v_o = A_d v_{id} + A_{cm} v_{cm}$, where A_{cm} is the common-mode gain
  - In many applications, we want: $A_{cm} = 0$ (ideal case) or $A_{cm} << A_d$

- Common-Mode Rejection

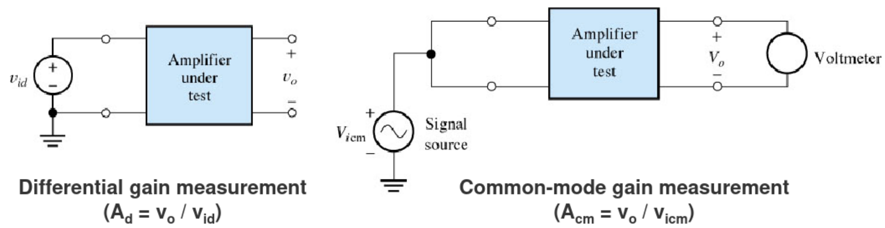

Figure 6: Common-Mode Rejection Calculation

- Common-mode rejection ratio (CMRR) in decibels:

$$CMRR = 20 \log \left(\frac{A_d}{A_{cm}} \right)$$

  - Indicates the capacity of the amplifier to attenuate the common-mode input signal relative to the differential input signal
  - In many applications, a high CMRR is desired → *i.e.*, the amplifier rejects (reduces) the common-mode input signal components