Electronic Amplifiers

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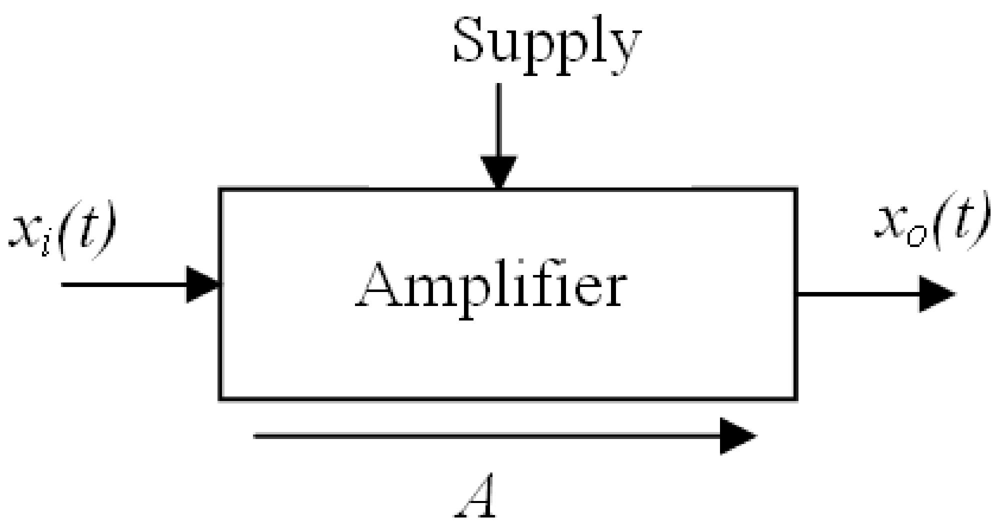
Amplifier: activ three-port network that delivers to the output a signal $x_o(t)$ (voltage or current) with **the same shape** as the input signal $x_i(t)$ and can provide **greater power** on an adequated load.



A – amplification, gain

$$x_o(t) = Ax_i(t)$$

- Linear circuit:

  x_0 proportional with x_i

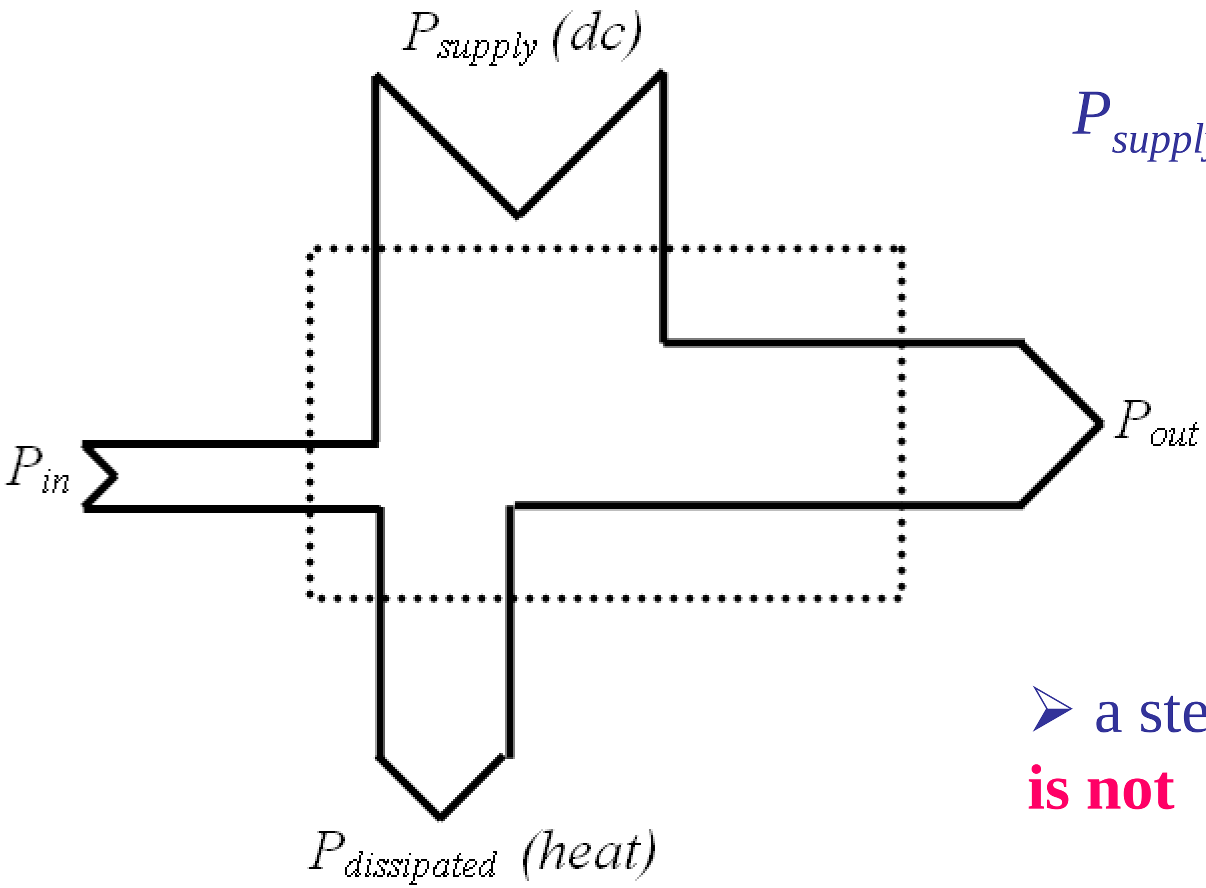
$A < 0$ *inverting*

$A > 0$ *non-inverting*

Power transfer and power balance

- the average power of the output signal P_{out} is greater than the average power of the input signal P_{in}.

- the excess of the output power is taken from the supply sources



$$P_{supply} + P_{in} = P_{out} + P_{dissip}$$

$$P_{supply} \approx P_{out} + P_{dissip}$$

- efficiency

$$\eta = P_{out} / P_{supply}$$

- a step up transformer **is not** an amplifier

Amplifier models

➢ two-port network: it consider explicitly only the behavior to the input and output ports and input-output transfer for the signal

➢ valid, irrespective of the internal complexity of the amplifiers

➢ valid in the bandpass frequency domain

Linear controlled sources

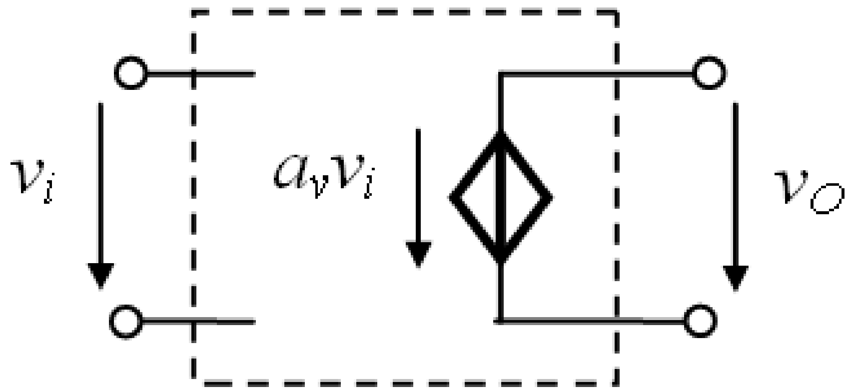
➢ active two-port network – only one finite, non-zero parameter: forward transfer parameter (gain)

➢ the output signal (voltage - v_o) is **controlled** by the input signal (voltage - v_i)

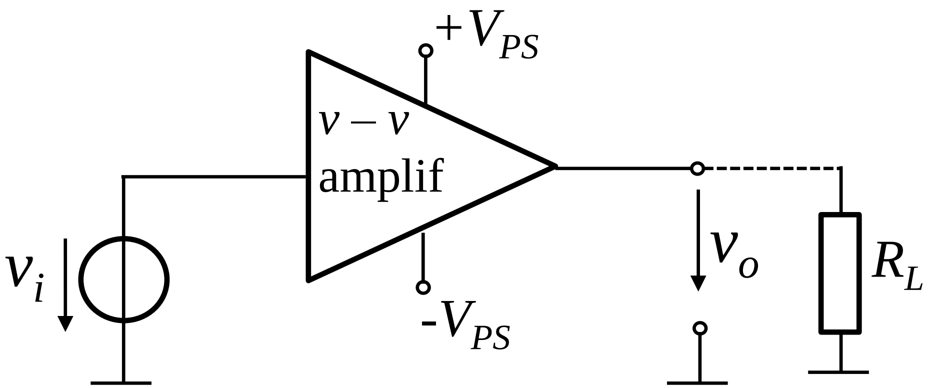
➢ pseudo-sources

Example: VCVS

$$v_O = a_v v_i$$



Noninverting amplifier, symmetric differential supply



$$A_v > 0$$

$$v_O = A_v v_i$$

- general-purpose op-amp

$$v_O \in (-V_{PS} + 1\text{V}\ldots 2\text{V};\ +V_{PS} - 1\text{V}\ldots 2\text{V})$$

- rail-to-rail op amp:

$$v_O \in (-V_{PS}; +V_{PS})$$

VTC for the voltage-to-voltage, noninverting amplifier, symmetric differential supply

- amplification (active) region:

$$v_I \in \left(\frac{V_{OL}}{A_v} ; \frac{V_{OH}}{A_v} \right);$$

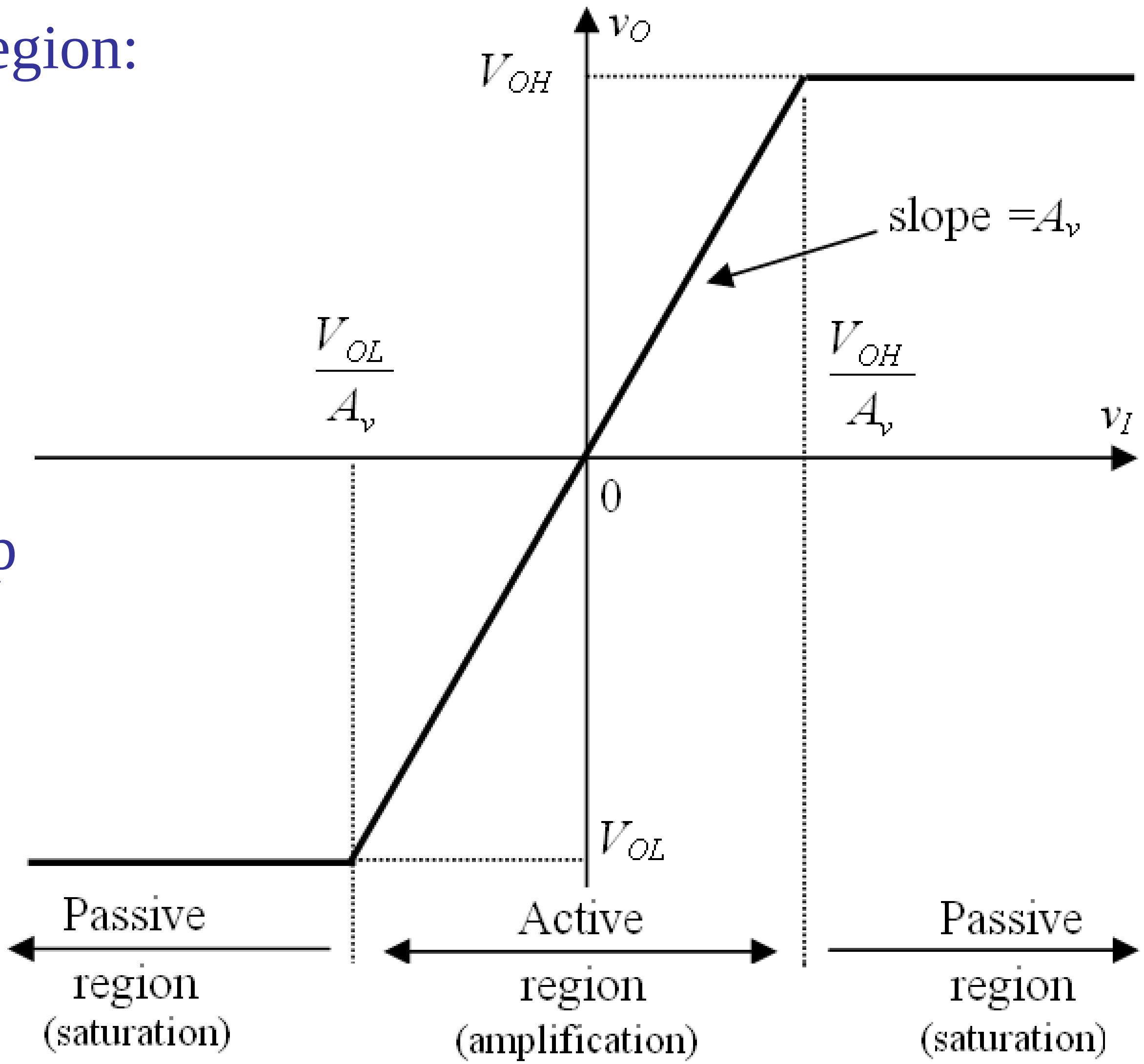
$$v_O \in \left(V_{OL} ; V_{OH} \right)$$

- general-purpose op-amp

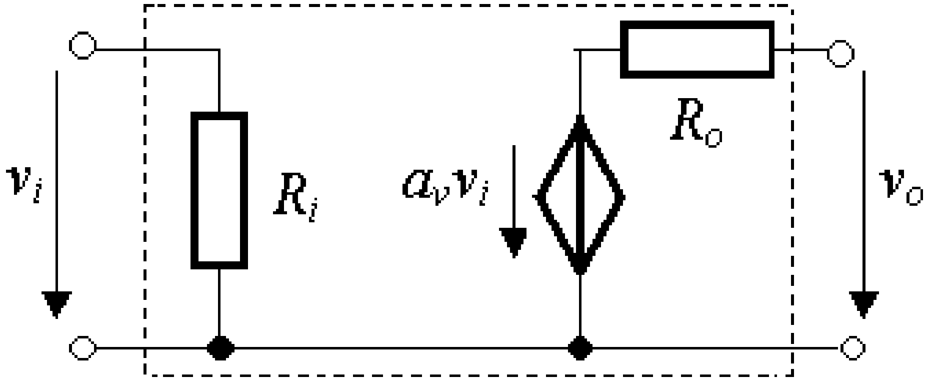
$$v_O \in (-V_{PS} + 1\text{V}...2\text{V}; \quad +V_{PS} - 1\text{V}...2\text{V})$$

- rail-to-rail OA:

$$v_O \in \left(-V_{PS} ; +V_{PS} \right)$$



Modeling the voltage amplifier

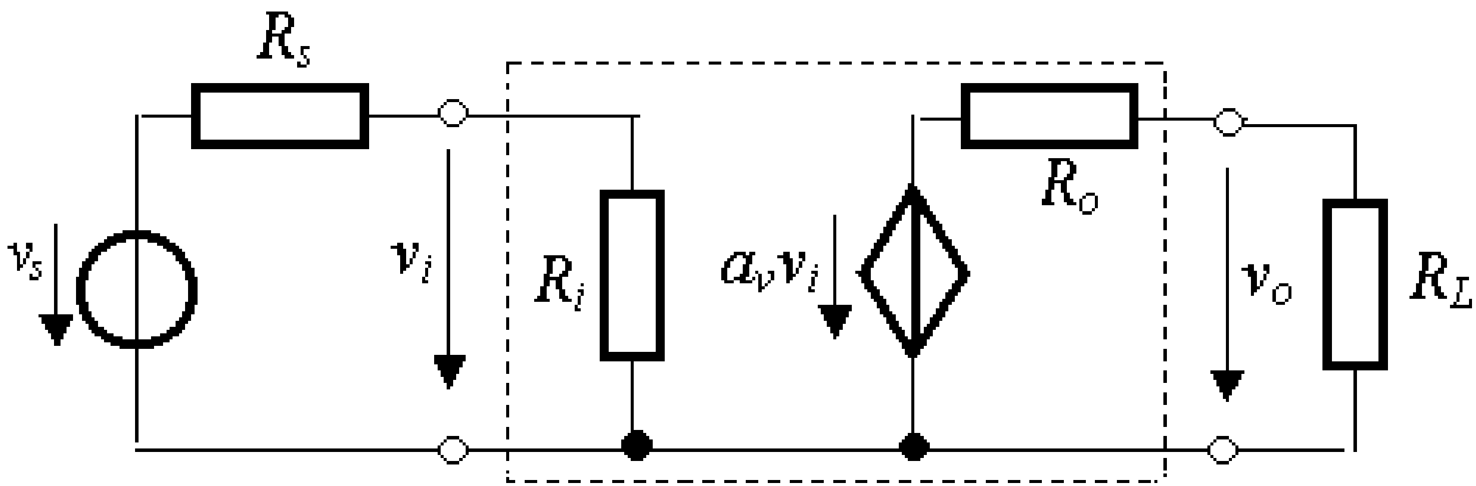


$$a_v = \frac{v_o}{v_i}$$

R_i – draws current from the input signal source

R_o – deteriorates the output voltage in the presence of load (voltage divider)

Amplifier connected with a signal source and a load resistance



$$v_i = \frac{R_i}{R_i + R_s} v_s \qquad v_o = \frac{R_L}{R_L + R_o} a_v v_i$$

ideal

voltage amplifier $\boldsymbol{R_i = \infty;}$ $\boldsymbol{R_o = 0}$

$$v_i = v_s \qquad v_o = a_v v_i$$

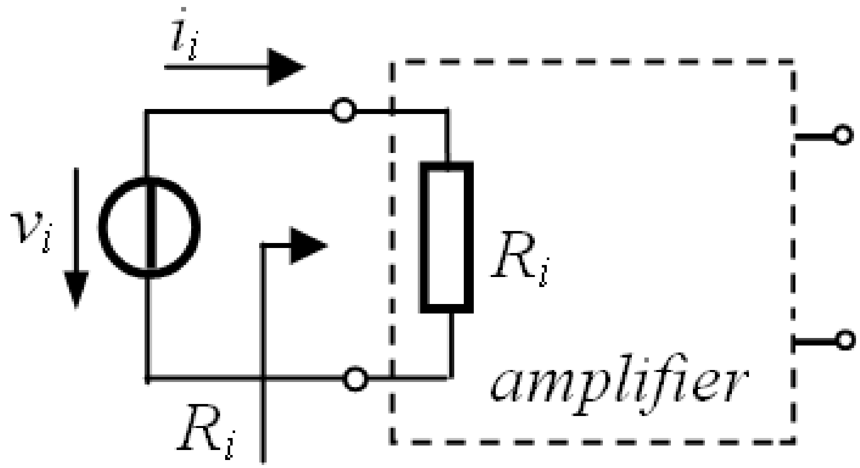
Determining the amplifier performances

- gain (forward transfer factor)
- input resistance
- output resistance

Gain

- analysis of the circuit using theorems and electrical circuit relations (Kirchhoff, Ohm, etc.) and equations describing the operation of the active devices
- express the output signal as a function of the input signal and compute the gain

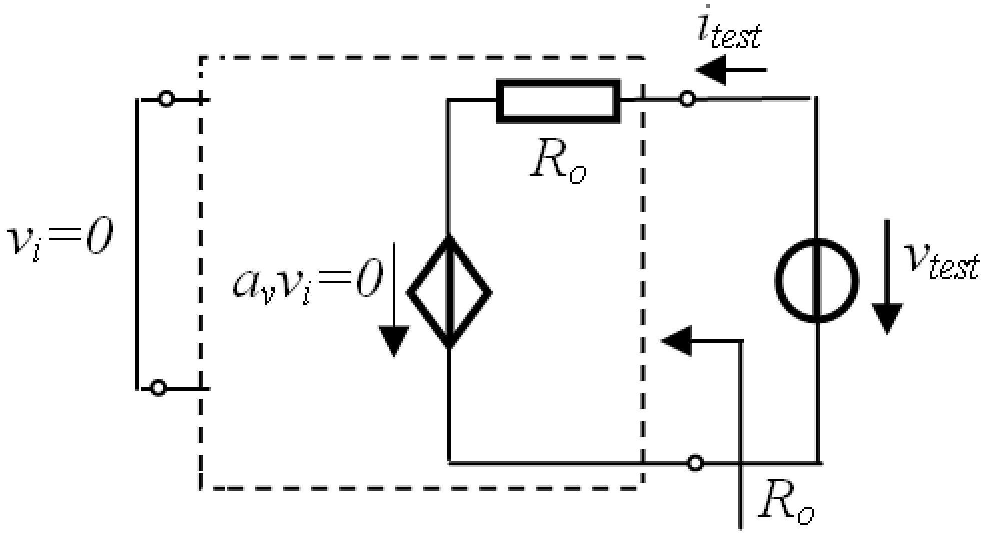
Input resistance



$$R_i = \frac{v_i}{i_i}$$

➢ **The resistance seen by the signal source when it looks to the circuit**

Output resistance



- Set the input signal source to zero
- Connect a test source to the output

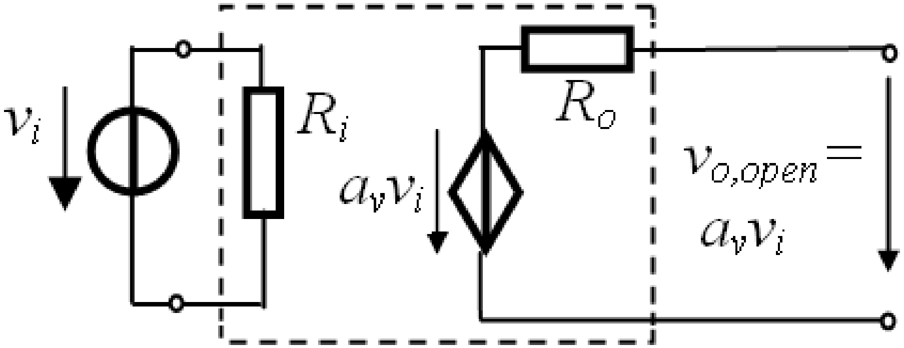
$$R_o = \frac{v_{test}}{i_{test}}$$

- **The resistance seen by the load when it looks back to the circuit and input signal source is set to zero**

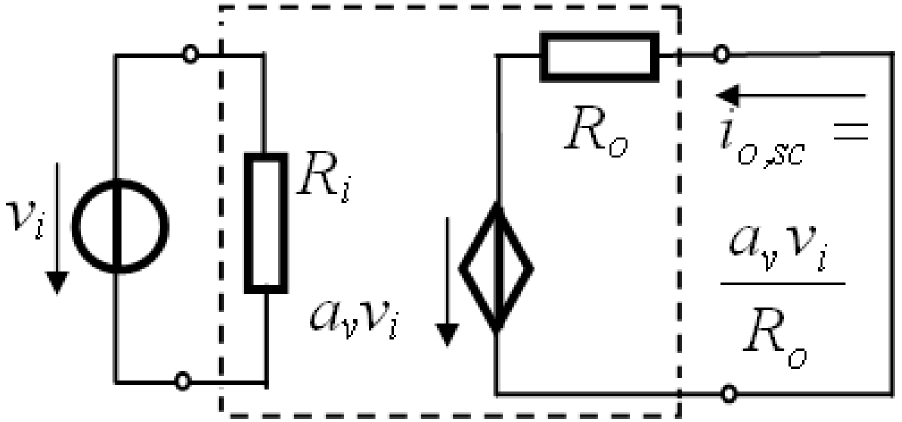
Output resistance – alternative method

Optional

open



short-circuit



$$R_o = \frac{v_{o,open}}{i_{o,sc}}$$