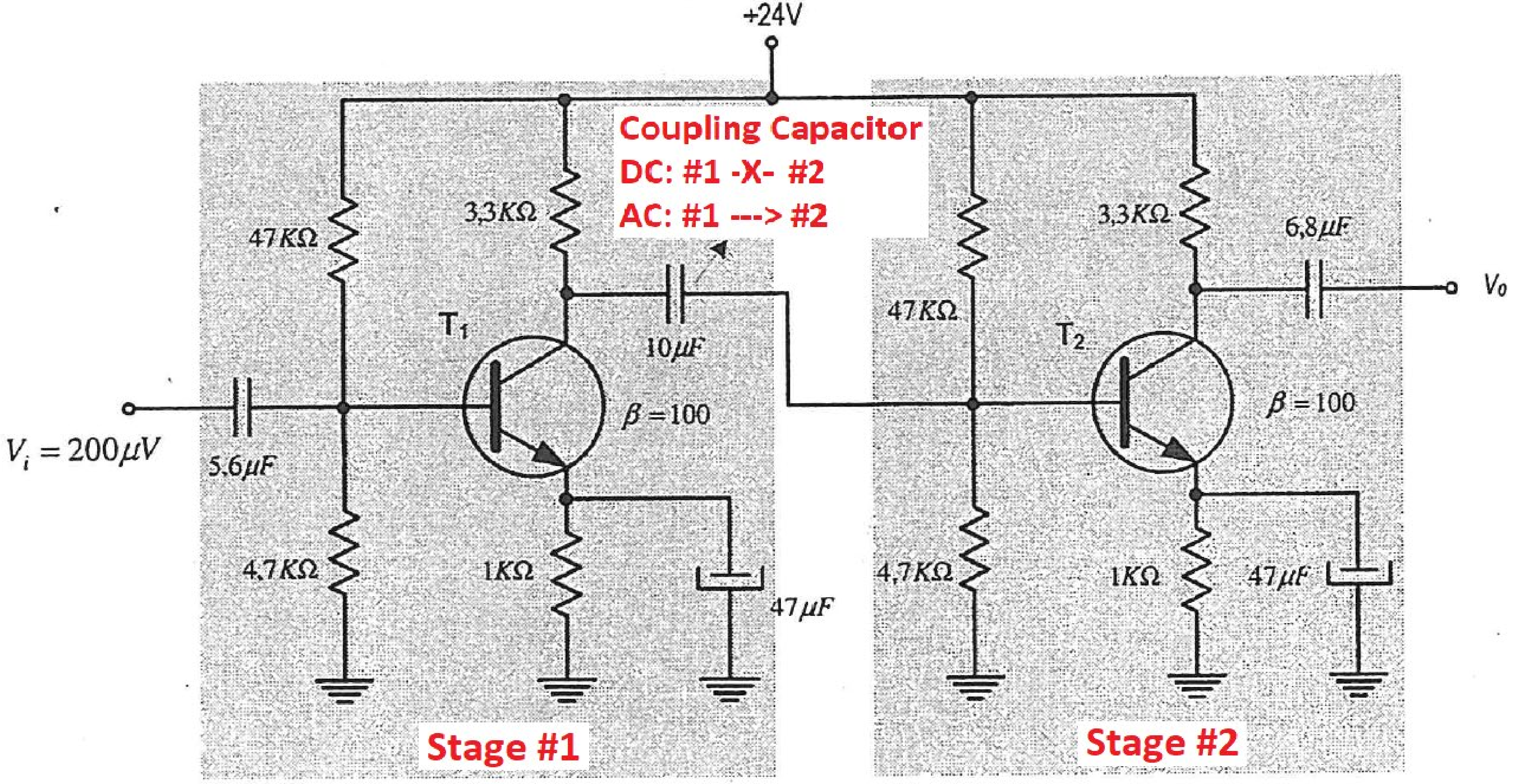
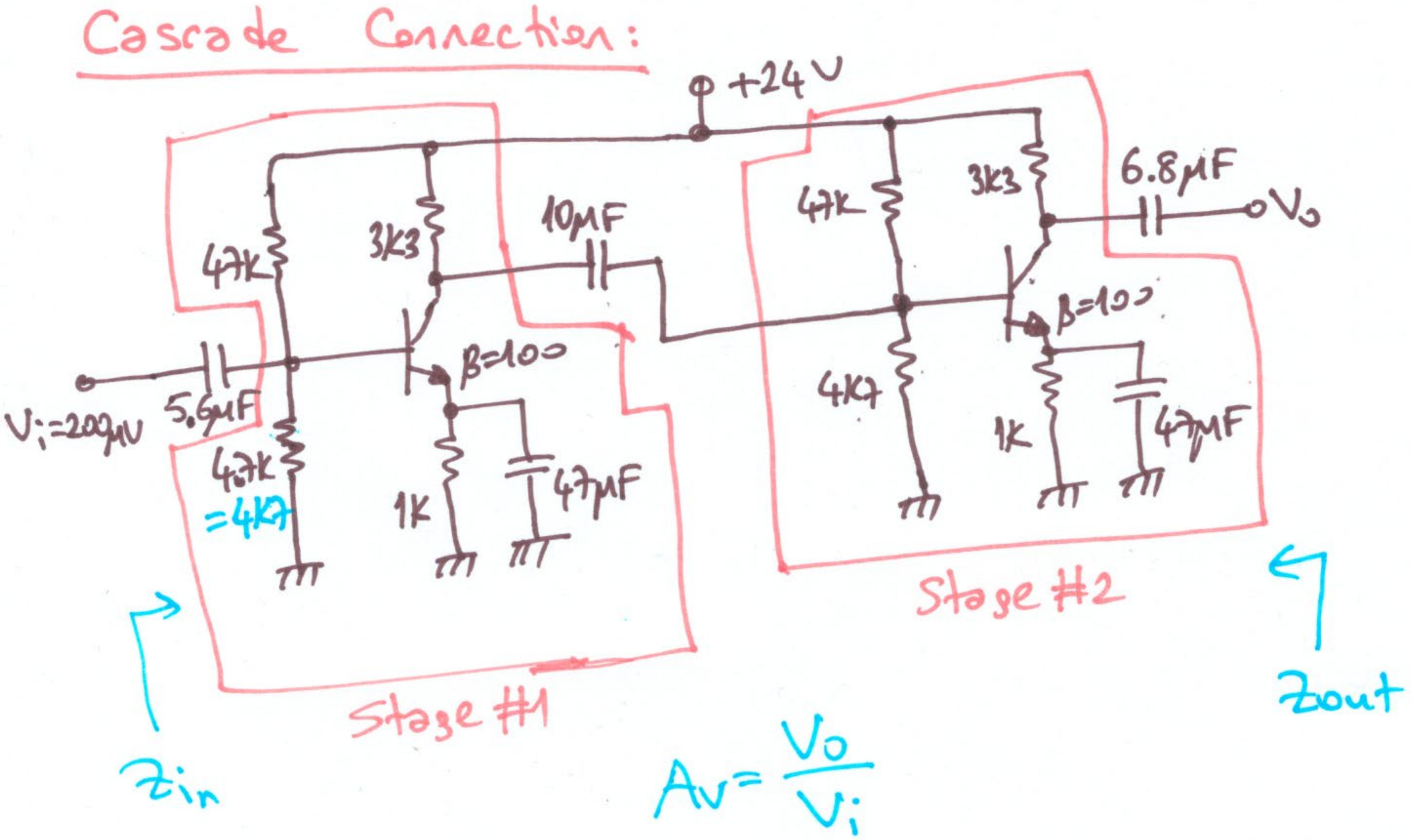
# Electronic Circuits

Lecture 5.2: Cascade Connection

# Cascade Connection

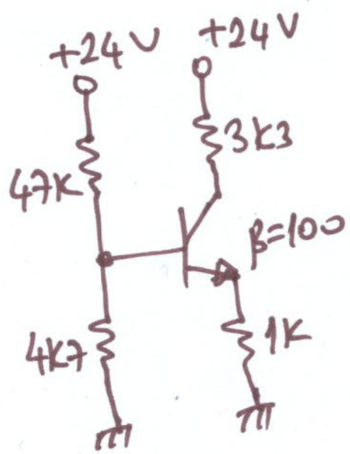


# Cascade Connection Example (1)



# Cascade Connection Example (2)

#1: DC Analysis: Both stages are same, so single DC analysis is enough ☺




$$R_{B1} = R_{B2} = \frac{47K \cdot 4K7}{47K + 4K7} = 4{,}27K\Omega$$

$$V_{B1} = V_{B2} = \frac{4K7}{4K7 + 47K} \cdot (+24V) = 2{,}17V$$

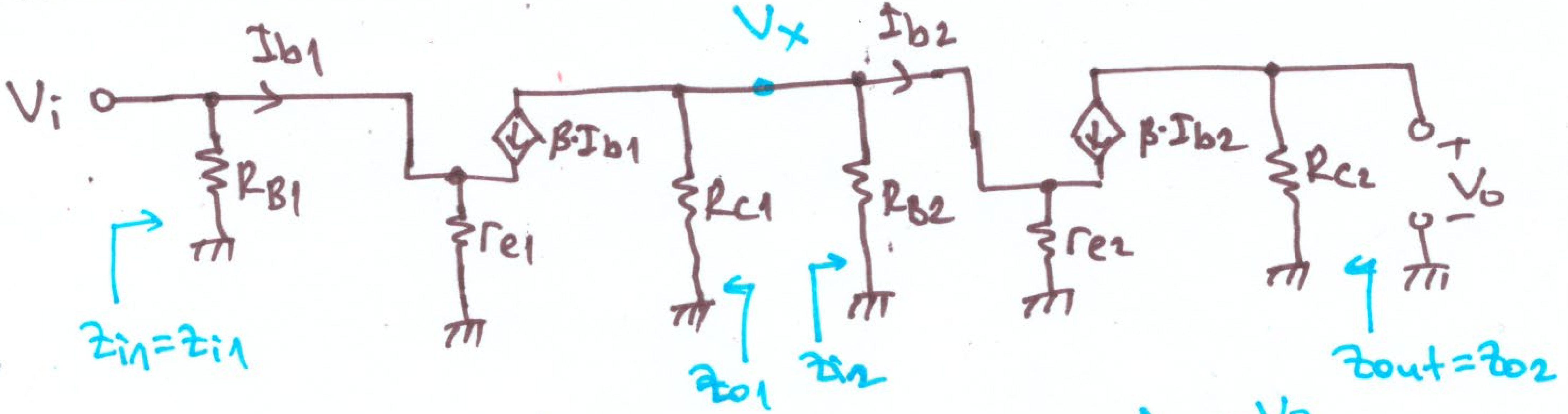
$$I_{B1} = I_{B2} = \frac{2{,}17V - 0{,}7V}{4{,}27K + (\beta+1) \cdot 1K} = 14\mu A$$

$$I_{E1} = I_{E2} = (\beta+1) \cdot I_{B1} = 101 \cdot 14\mu A = 1{,}41mA$$

$$r_e = r_{e1} = r_{e2} = \frac{26mV}{1{,}41mA} = 18{,}44\Omega$$

# Cascade Connection Example (3)

## #2: AC Analysis:




$$A_{v1} = \frac{V_x}{V_i}$$

$$A_{v2} = \frac{V_o}{V_x}$$

$$A_v = \frac{V_o}{V_i}$$

# Cascade Connection Example (4)

$$z_{i1} = R_{B1} // ((\beta+1) \cdot r_{e1}) = 1{,}29\ k\Omega \Rightarrow z_{in} = z_{i1} = 1{,}29\ k\Omega$$

$$z_{o1} = R_{C1} = 3{,}3\ k\Omega$$

$$z_{i2} = R_{B2} // ((\beta+1) \cdot r_{e2}) = 1{,}29\ k\Omega$$

$$z_{o2} = R_{C2} = 3{,}3\ k\Omega \Rightarrow z_{out} = z_{o2} = 3{,}3\ k\Omega$$

! $z_{i2}$ is the load resistor of the stage #1.

# Cascade Connection Example (5)

$$I_{b1} = \frac{v_i}{(\beta+1)\cdot r_{e1}} \quad \text{and} \quad V_x = -(z_{o1} // z_{i2})\cdot \beta \cdot I_{b1}$$

$$\text{So,} \quad \frac{V_x}{V_i} = A_{v1} = -\frac{(3K3 // 1K29)\cdot 100}{101 \cdot 18{,}44} = -43{,}8$$

$$I_{b2} = \frac{V_x}{(\beta+1)\cdot r_{e2}} \quad \text{and} \quad V_o = -z_{o2}\cdot \beta \cdot I_{b2}$$

$$\text{So,} \quad \frac{V_o}{V_x} = A_{v2} = -\frac{3K3 \cdot 100}{101 \cdot 18{,}44} = -177{,}19$$

$$A_v = \frac{V_o}{V_i} = (-177{,}19)\cdot(-43{,}8) = \underline{8824}$$

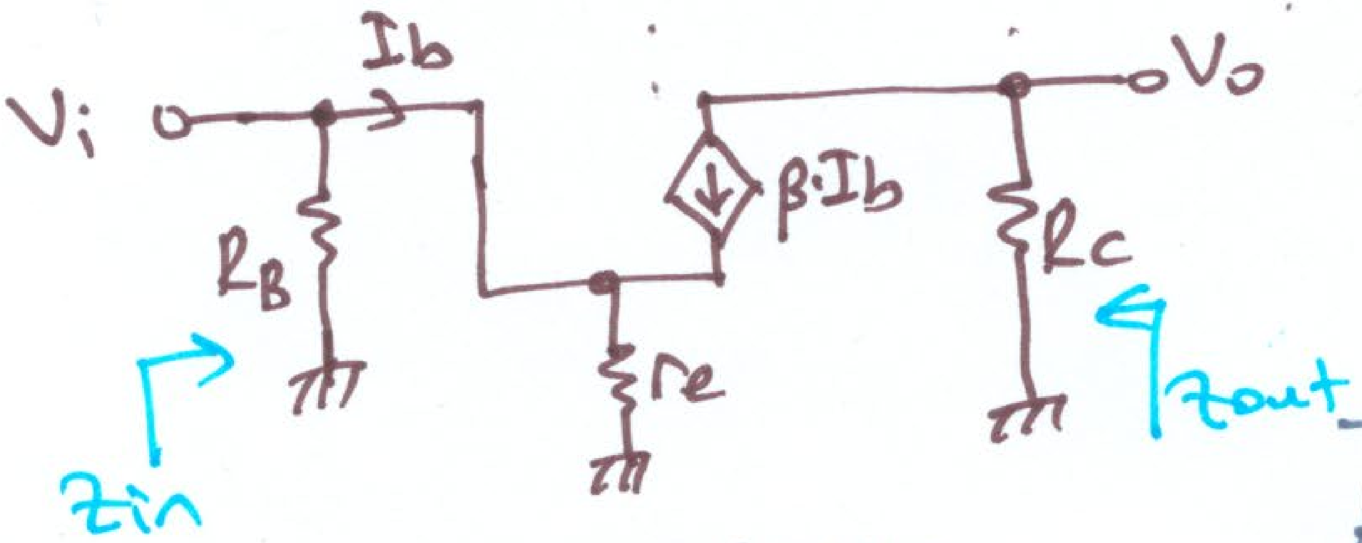
# Cascade Connection Example (6)

ALTERNATIVELY, Block Analysis:

After DC analysis, we found $r_e = 18.44\,\Omega$

# Cascade Connection Example (7)

## #2 AC Analysis of a single stage:




$$I_b = \frac{V_i}{(\beta+1)\cdot r_e}$$

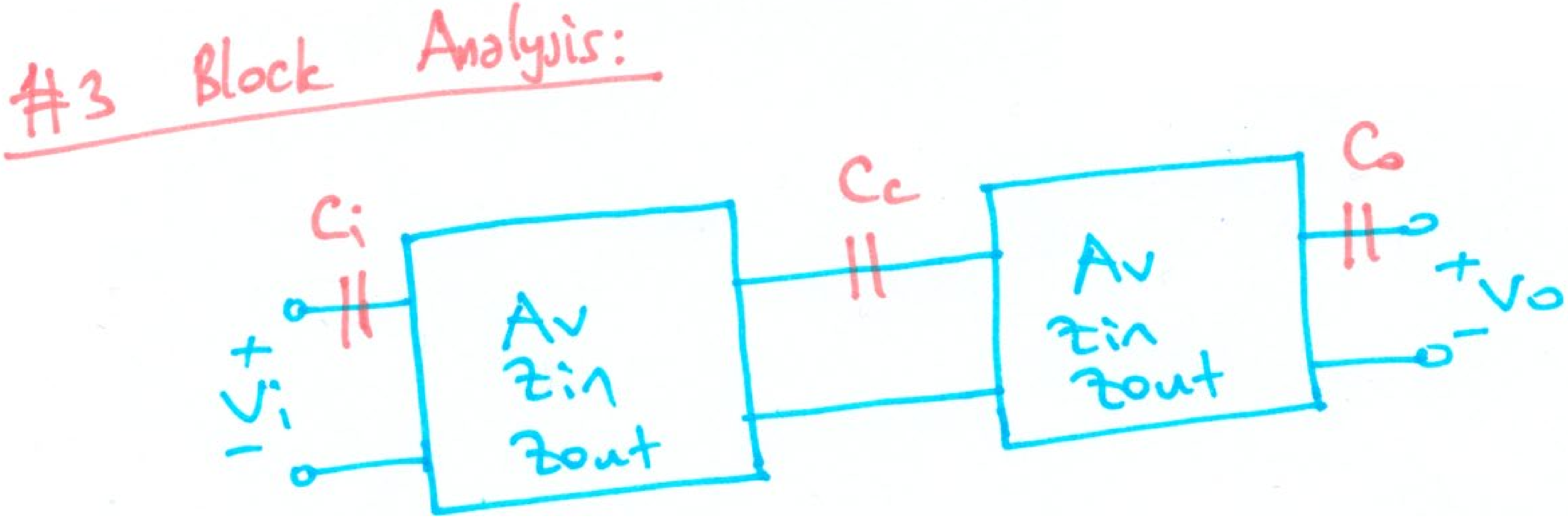
$$V_o = -R_C \cdot \beta \cdot I_b$$

$$A_v = \frac{V_o}{V_i} = -\frac{\beta \cdot R_C}{(\beta+1)\cdot r_e} = -177{,}19$$

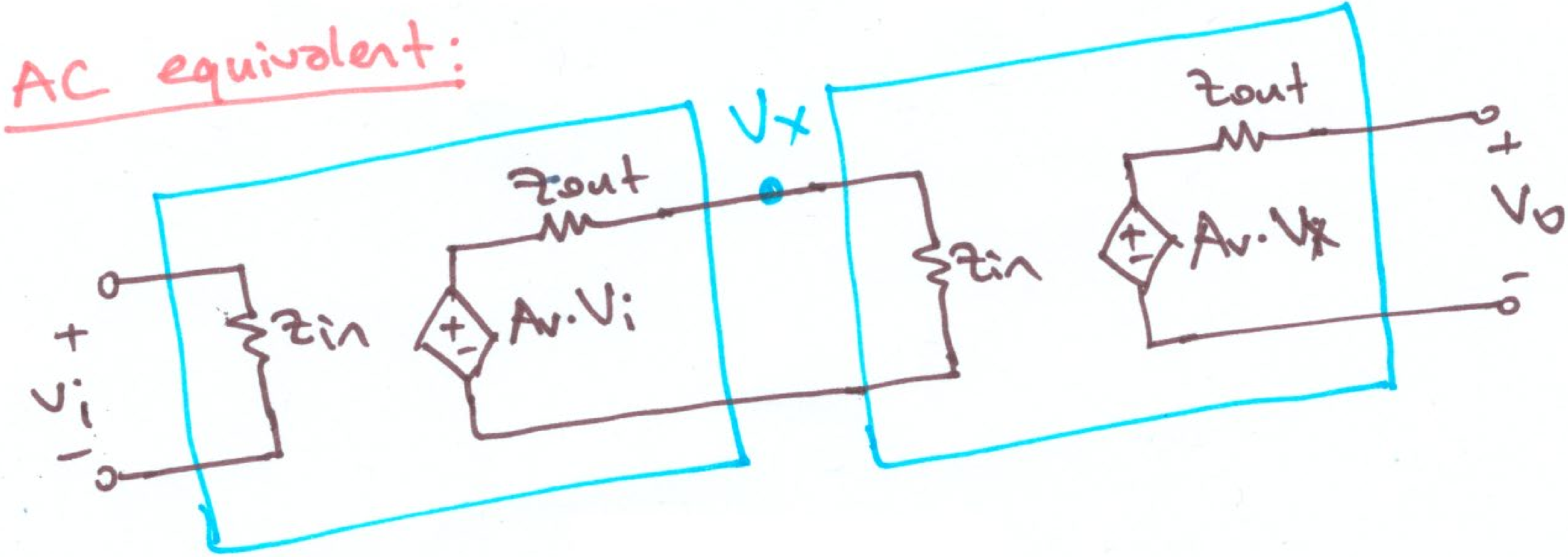
$$Z_{in} = R_B \,//\, ((\beta+1)\cdot r_e) = 1{,}29\,k\Omega$$

$$Z_{out} = R_C = 3{,}3\,k\Omega$$

# Cascade Connection Example (8)



# Cascade Connection Example (9)



# Cascade Connection Example (10)

$$V_x = \frac{Z_{in}}{Z_{in} + Z_{out}} \cdot A_v \cdot V_i$$

$$V_o = A_v \cdot V_x = A_v \cdot A_v \cdot \frac{Z_{in}}{Z_{in} + Z_{out}} \cdot V_i$$

$$A_v = \frac{V_o}{V_i} = (-177{,}19) \cdot (-177{,}19) \cdot \frac{1{,}29K}{1{,}29K + 3{,}3K} \cong 8824$$

As a result, if you know $Z_{in}$, $Z_{out}$, and $A_v$ characteristics of an amplifier, you can reach simple calculations at all.

# Thanks for listening ☺

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