Lecture 7 – Feedback Amplifier
Part II

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Outline of this Lecture

- Previously on ELCN 201
- Shunt-Shunt Feedback Topology
- Shunt-Series Feedback Topology

Previously on ELCN 201

Feedback Amplifier

Amplifiers are usually classified into two groups: open-loop amplifiers and closed-loop (feedback) amplifiers

In amplifier design, feedback is usually applied to achieve one or more of the following goals:

- Make the value of the gain less sensitive to variations in the values of circuit components.
- Extend the Bandwidth
- Modify the input and output resistances

Previously on ELCN 201

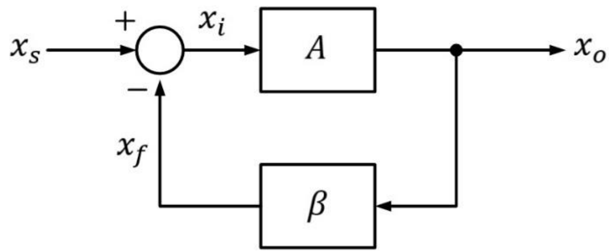
General Feedback Structure

The closed-loop gain of the feedback amplifier A_f, is given by

$$A_f = \frac{x_o}{x_i} = \frac{A}{1 + A\beta}$$

The quantity $A\beta$ is called the **loop gain**

The quantity $1 + A\beta$ is called the **amount of feedback**



$$x_o = Ax_i$$

$$x_f = \beta x_o$$

$$x_i = x_s - x_f$$

$$x_o/A = x_s - \beta x_o$$

$$x_o(1 + A\beta) = Ax_s$$

Previously on ELCN 201

Feedback Amplifier Types

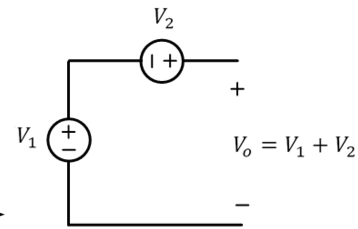
Based on the input signal to be amplified and on the desired form of output signal, feedback amplifiers are classified into four categories:

Amplifier Type	Input signal x_s, x_i, x_f	Output signal x_o
Voltage Amplifier	Voltage	Voltage
Current Amplifier	Current	Current
Transconductance Amplifier	Voltage	Current
Transresistance Amplifier	Current	Voltage

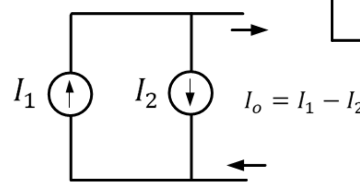
Previously on ELCN 201

Feedback Amplifier Types

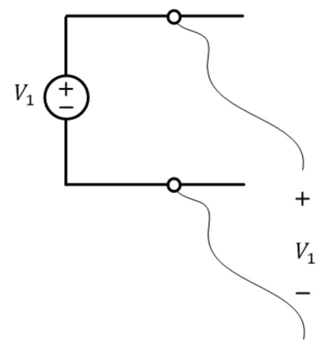
Voltage signals are added or subtracted (mixed) in **series** fashion



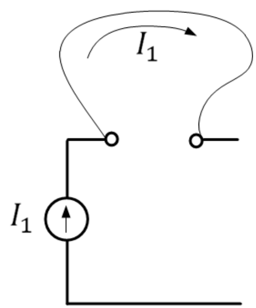
Current signals are mixed in **parallel (shunt)** fashion



Voltage is sampled in a **parallel (shunt)** fashion



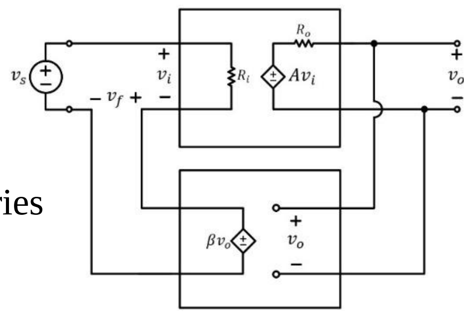
Current is sampled in a **series** fashion



Previously on ELCN 201

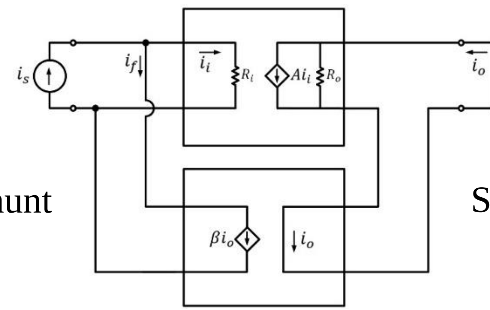
Feedback Amplifier Types

Series



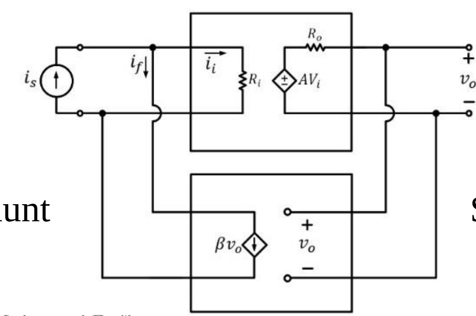
Shunt

Shunt



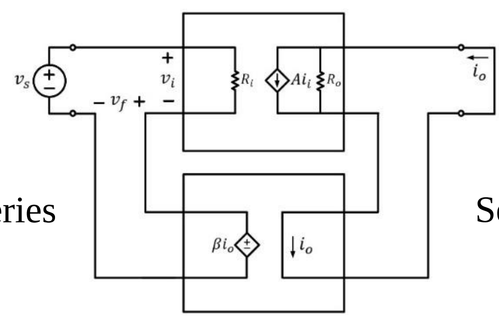
Series

Shunt



Shunt

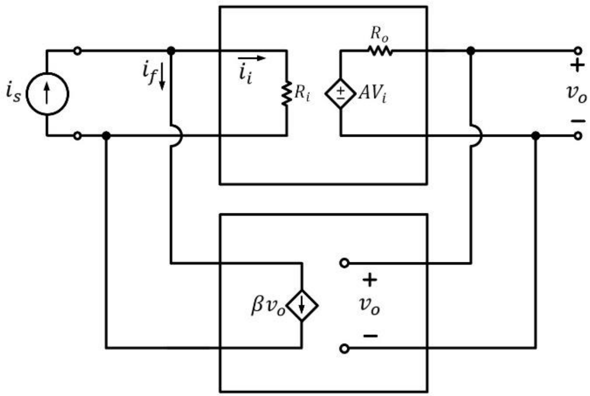
Series

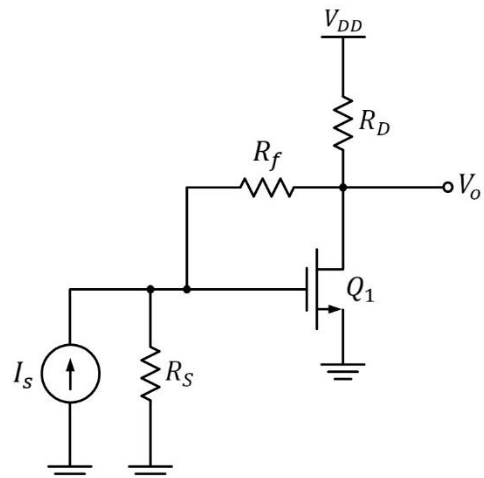


Series

Transresistance Amplifier

Shunt-Shunt Feedback Topology





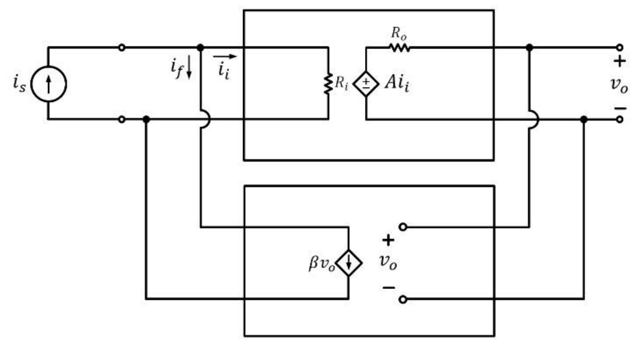
For the feedback to be negative, i_f must be of the **same** polarity as i_s

Transresistance Amplifier

Shunt-Shunt Feedback Topology

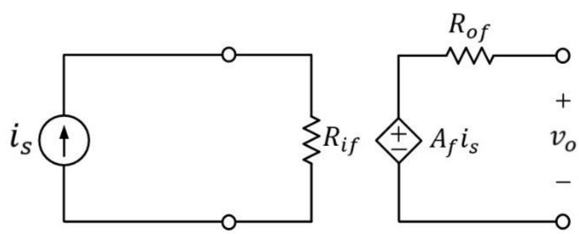
The Ideal Case

In the ideal case, the feedback network has an **infinite** input resistance and **infinite** output resistance



The feedback network **does not** load the basic amplifier

$$A_f = \frac{v_o}{i_s} = \frac{A}{1+\beta A}$$

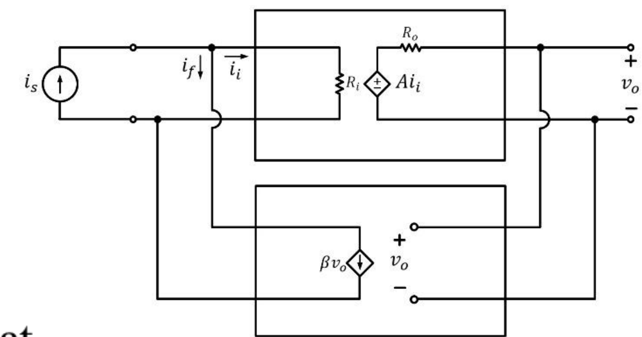


Transresistance Amplifier

Shunt-Shunt Feedback Topology

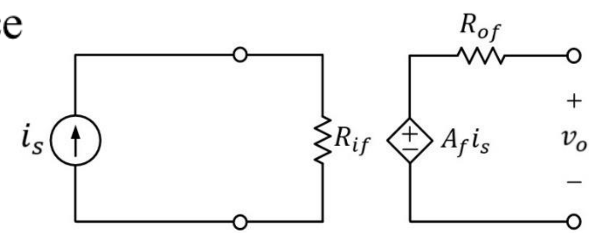
The Ideal Case

Due to the shunt connection at the input, the input resistance is given by



$$R_{if} = \frac{R_i}{1 + A\beta}$$

Due to the shunt connection at the output, the output resistance is given by



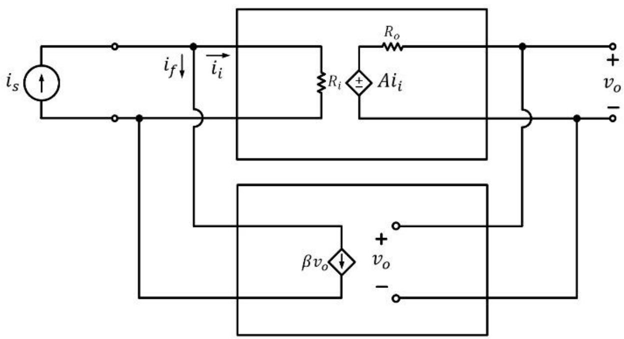
$$R_{of} = \frac{R_o}{1 + A\beta}$$

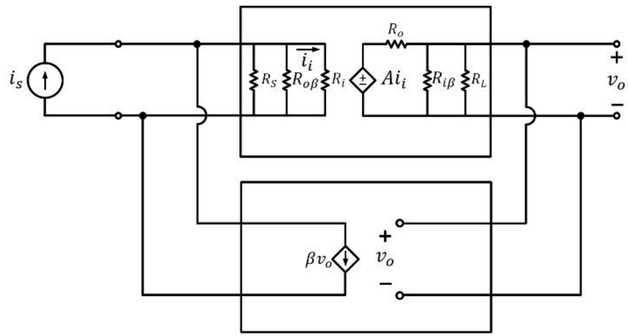
Transresistance Amplifier

Shunt-Shunt Feedback Topology

The Practical Case

In the practical case, the feedback network loads the basic amplifier and affects the values of A, R_i, and R_o.





The finite source and load resistances also affect the values of A, R_i, and R_o.

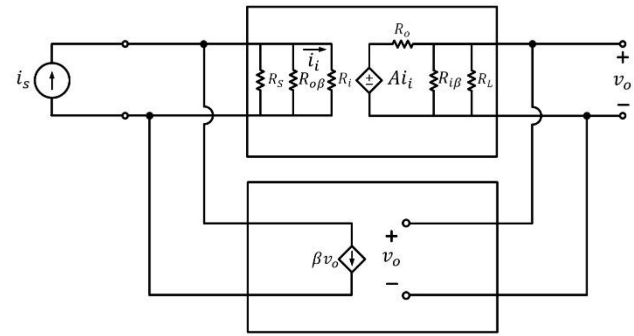
Transresistance Amplifier

Shunt-Shunt Feedback Topology

The Practical Case

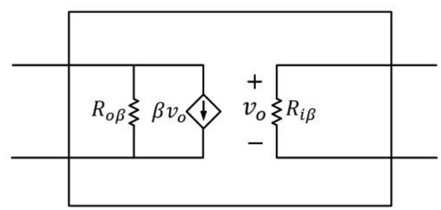
The gain of the feedback network is given by

$$\beta = \left.\frac{i_f}{v_o}\right|_{v_f=0}$$



The input resistance of the feedback network is given by

$$R_{i\beta} = \left.\frac{v_o}{i_o}\right|_{v_f=0}$$



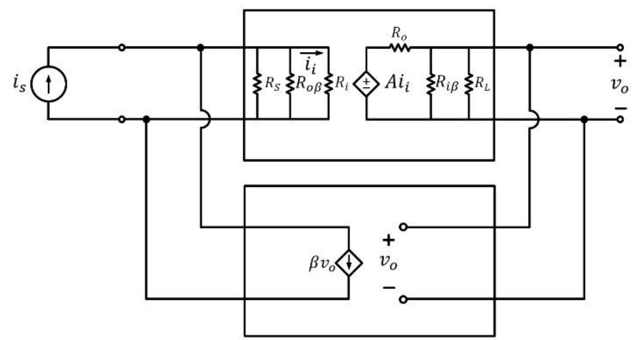
Transresistance Amplifier

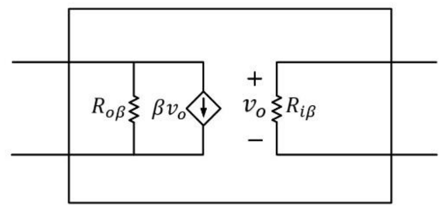
Shunt-Shunt Feedback Topology

The Practical Case

The output resistance of the feedback network is given by

$$R_{o\beta} = \left.\frac{v_x}{i_x}\right|_{v_o=0}$$





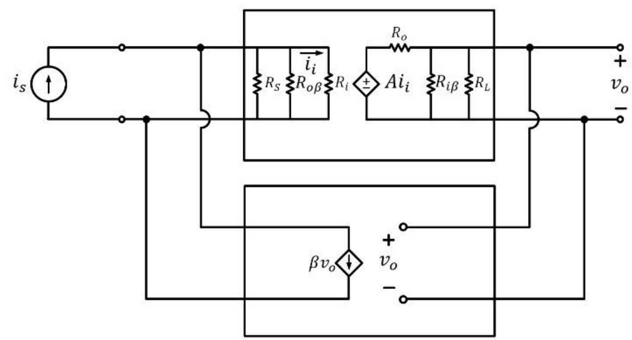
Transresistance Amplifier

Shunt-Shunt Feedback Topology

The Practical Case

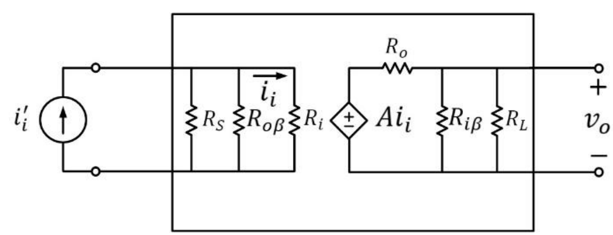
The gain of the modified basic amplifier is given by

$$A_m = \frac{v_o}{i_i'}$$



R_{im} and R_{om} are determined from the modified basic amplifier circuit

$$R_{im} = \frac{v_i}{i_i} \qquad R_{om} = \left.\frac{v_o}{i_o}\right|_{i_i'=0}$$



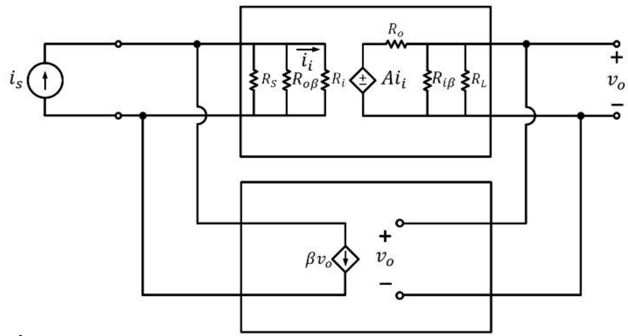
Transresistance Amplifier

Shunt-Shunt Feedback Topology

The Practical Case

The overall gain of the feedback amplifier is given by

$$A_f = \frac{A_m}{1 + A_m\beta}$$



The input resistance with feedback is given by

$$R_{if} = \frac{R_{im}}{1 + A_m\beta}$$

The output resistance with feedback is given by

$$R_{of} = \frac{R_{om}}{1 + A_m\beta}$$

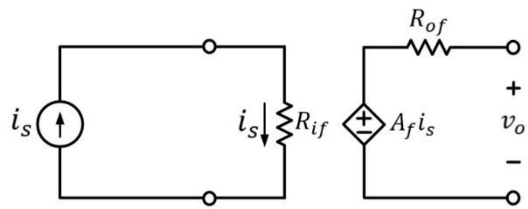
Transresistance Amplifier

Shunt-Shunt Feedback Topology

The Practical Case

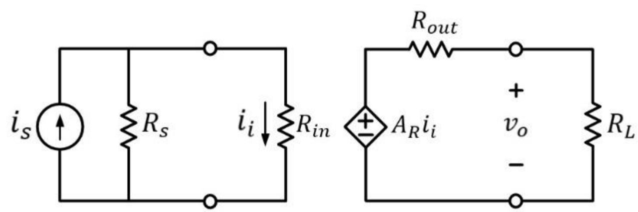
The actual input resistance of the feedback amplifier is given by

$$R_{in} = 1/\left(\frac{1}{R_{if}} - \frac{1}{R_s}\right)$$



The actual output resistance of the feedback amplifier is given by

$$R_{out} = 1/\left(\frac{1}{R_{of}} - \frac{1}{R_L}\right)$$

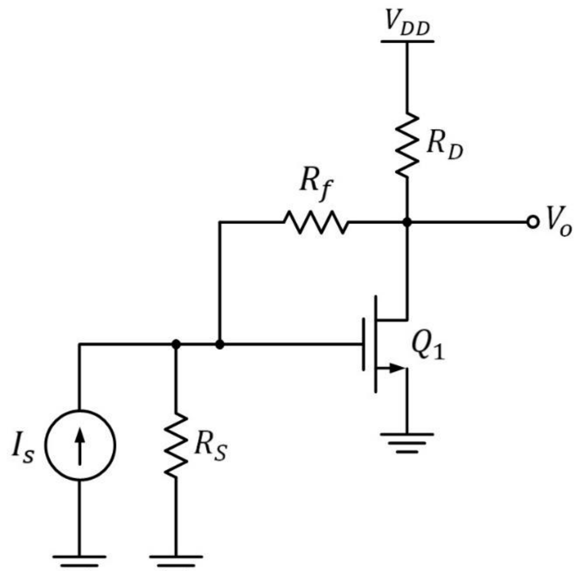


$$R_{of} = R_{out} // R_L$$

Transresistance Amplifier

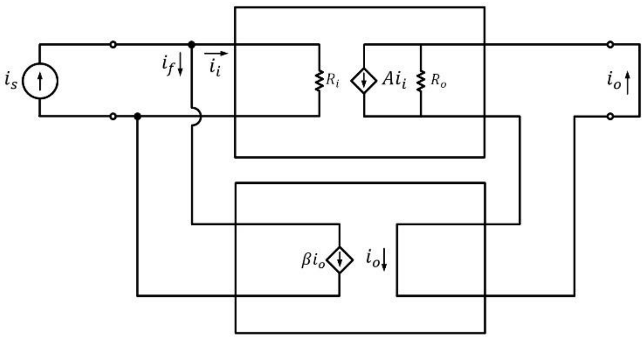
Example (1)

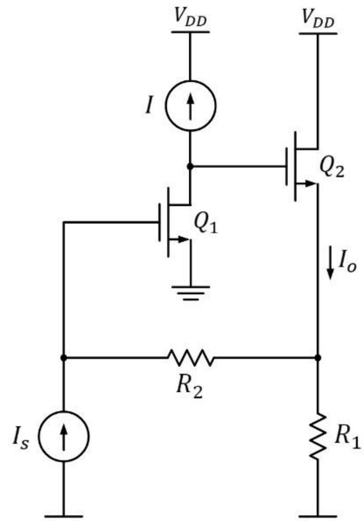
Analyze the shown amplifier obtain its gain, input resistance, and output resistance. Assume $R_s \gg R_f$



Current Amplifier

Shunt-Series Feedback Topology





For the feedback to be negative, i_f must be of the **same** polarity as i_s

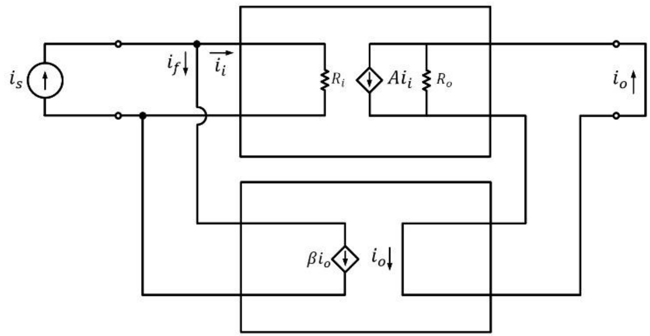
Current Amplifier

Shunt-Series Feedback Topology

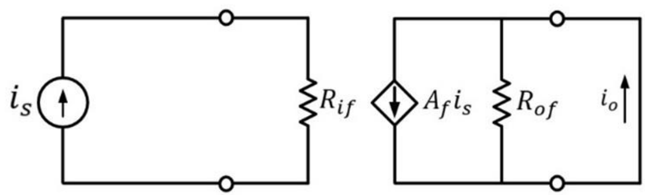
The Ideal Case

In the ideal case, the feedback network has an **zero** input resistance and **infinite** output resistance

The feedback network **does not** load the basic amplifier



$$A_f = \frac{i_o}{i_s} = \frac{A}{1 + \beta A}$$



Current Amplifier

Shunt-Series Feedback Topology

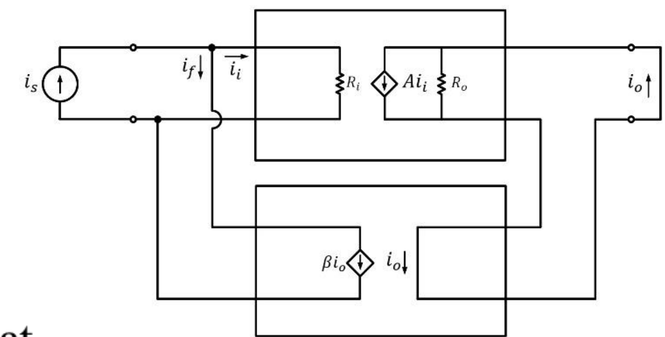
The Ideal Case

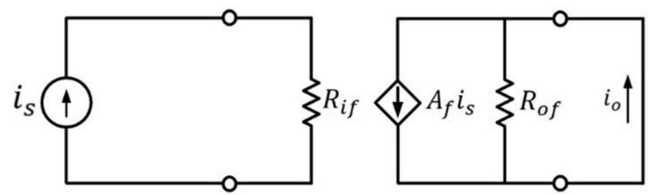
Due to the shunt connection at the input, the input resistance is given by

$$R_{if} = \frac{R_i}{1 + A\beta}$$

Due to the series connection at the output, the output resistanc is given by

$$R_{of} = R_o(1 + A\beta)$$



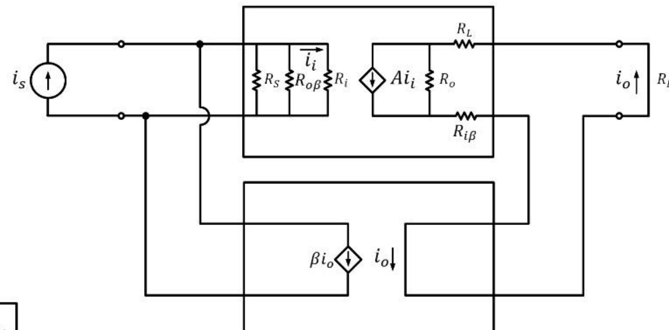


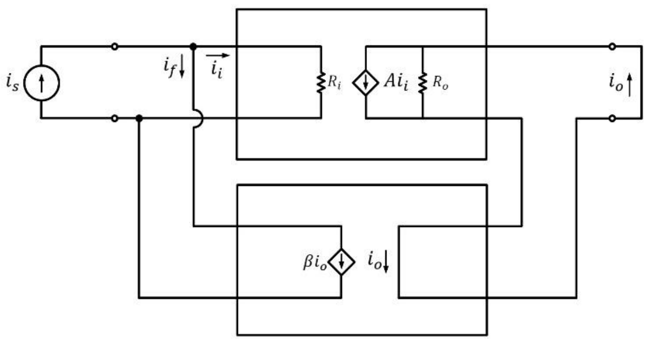
Current Amplifier

Shunt-Series Feedback Topology

The Practical Case

In the practical case, the feedback network loads the basic amplifier and affects the values of A, R_i, and R_o.





The finite source and load resistances also affect the values of A, R_i, and R_o.

Current Amplifier

Shunt-Series Feedback Topology

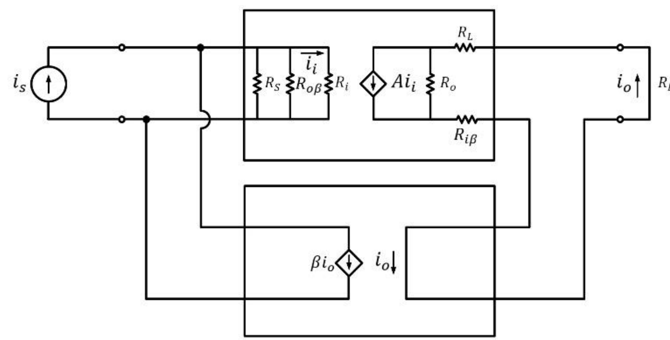
The Practical Case

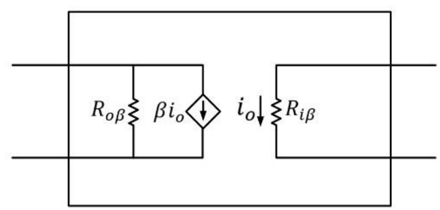
The gain of the feedback network is given by

$$\beta = \frac{i_f}{i_o}\bigg|_{v_f=0}$$

The input resistance of the feedback network is given by

$$R_{i\beta} = \frac{v_o}{i_o}\bigg|_{v_f=0}$$





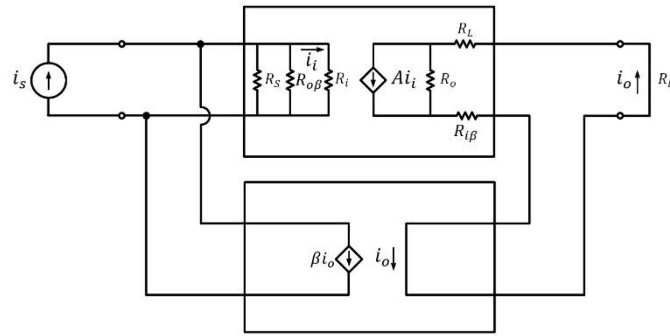
Current Amplifier

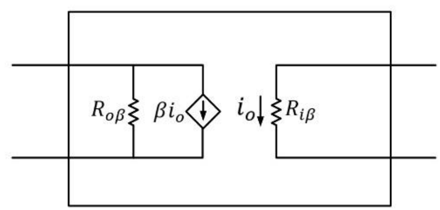
Shunt-Series Feedback Topology

The Practical Case

The output resistance of the feedback network is given by

$$R_{o\beta} = \left.\frac{v_f}{i_f}\right|_{i_o=0}$$





Current Amplifier

Shunt-Series Feedback Topology

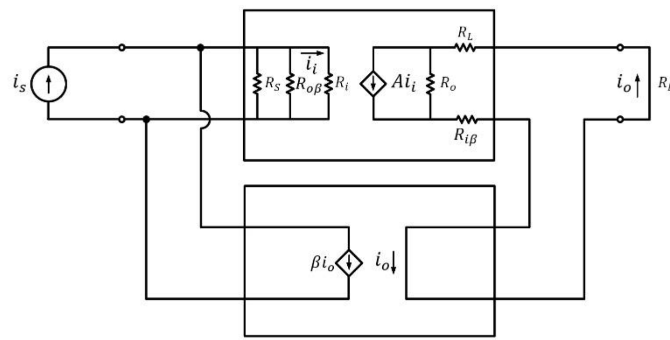
The Practical Case

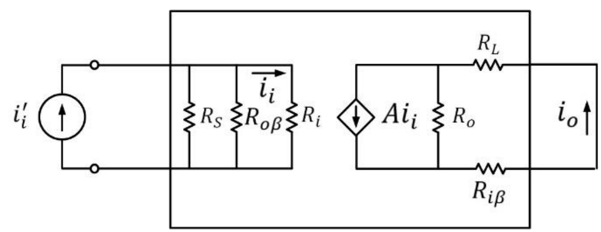
The gain of the modified basic amplifier is given by

$$A_m = \frac{i_o}{i_i'}$$

R_{im} and R_{om} are determined from the modified basic amplifier circuit

$$R_{im} = \frac{v_i}{i_i'} \qquad R_{om} = \left.\frac{v_o}{i_o}\right|_{i_i'=0}$$





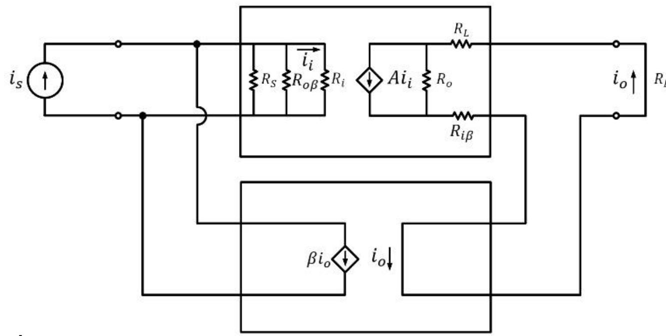
Current Amplifier

Shunt-Series Feedback Topology

The Practical Case

The overall gain of the feedback amplifier is given by

$$A_f = \frac{A_m}{1 + A_m\beta}$$



The input resistance with feedback is given by

$$R_{if} = \frac{R_{im}}{1 + A_m\beta}$$

The output resistance with feedback is given by

$$R_{of} = R_{om}(1 + A_m\beta)$$

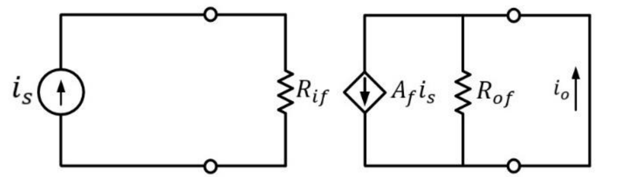
Current Amplifier

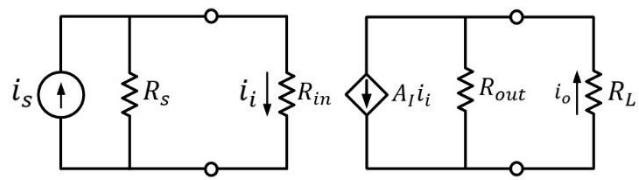
Shunt-Series Feedback Topology

The Practical Case

The actual input resistance of the feedback amplifier is given by

$$R_{in} = 1/\left(\frac{1}{R_{if}} - \frac{1}{R_s}\right)$$





The actual output resistance of the feedback amplifier is given by

$$R_{out} = R_{of} - R_L$$

$$R_{of} = R_{out} + R_L$$

Current Amplifier

Example (2)

Analyze the shown amplifier obtain its gain, input resistance, and output resistance.