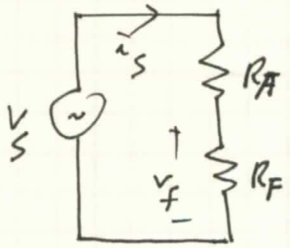
Feedback Basics

⊛ 2-resistor feedback (series)



i) Without R_F, i_s will be developed as

$$i_s = \frac{V_s}{R_A}.$$

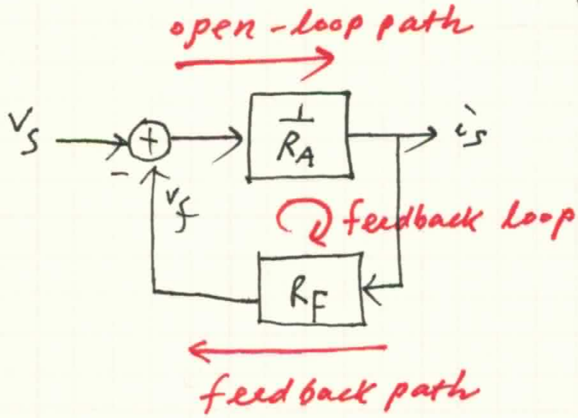
ii) When R_F included,
R_F will detect i_s and develop V_f.
And the V_f will be subtracted from V_s.
The resultant $i_s = \frac{V_s - V_f}{R_A}$. — (A)

equivalent feedback system

$\Rightarrow V_f = i_s R_F$ apply to (A)

$$\Rightarrow \quad i_s R_A = V_s - V_f = V_s - i_s R_F$$

$$\therefore i_s = \frac{V_s}{R_A + R_F} = \frac{V_s}{R_A} \frac{1}{\left(1 + \frac{R_F}{R_A}\right)}$$



open loop gain, $A_{op} = \frac{1}{R_A}$
feedback factor, $f = R_F$
loop gain, $T = A_{op} \cdot f = \frac{R_F}{R_A}$

closed-loop gain (A_s)

$$= \frac{i_s}{V_s} = \frac{A_{op}}{1+T} = \frac{A_{op}}{1+A_{op}f}$$

$$= \frac{\frac{1}{R_A}}{1+\frac{R_F}{R_A}} = \frac{1}{R_A + R_F}$$

⇒ Without R_F, $Z_{in} = R_A$

With R_F, $Z_{in} = R_A + R_F = R_A\left(1 + \frac{R_F}{R_A}\right)$

$= R_A(1+T)$

Z_{in} increases by a factor of $(1+T)$. (why?)

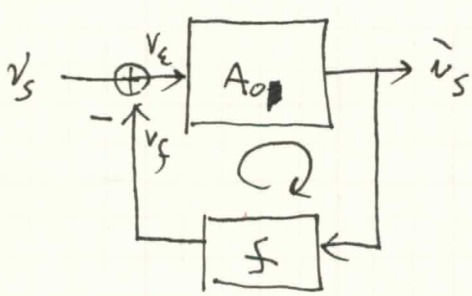
⇒ without R_F, $Z_{out} = R_A$

with R_F, $Z_{out} = R_A + R_F = R_A\left(1 + \frac{R_F}{R_A}\right)$

$= R_A(1+T)$

Z_{out} increases by a factor of $(1+T)$. (why?)

⟨ Generalization ⟩



$v_s - v_f = v_\varepsilon$

$= \frac{1}{1+T} \times v_s$

NOTE: input is Voltage, output is Current

① Loop gain $= T = A_{op} \cdot f$

② closed loop gain $= A_f = \frac{A_{op}}{1+T} = \frac{A_{op}}{1 + A_{op} f}$

$= \frac{1}{f}\left(\frac{1}{1 + \frac{1}{A_{op} f}}\right) = \frac{1}{f}\left(\frac{1}{1 + \frac{1}{T}}\right)$

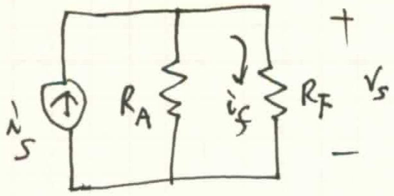
1'st-order approximation: $\approx \frac{1}{f}\left(1 - \frac{1}{T}\right)$ (if) $T \gg 1$

2nd-order approximation: $\approx \frac{1}{f}$ (if) $T \gg 1$

③ $Z_{inf} = Z_{in}(1+T)$ ← makes more ideal voltage driving.

④ $Z_{out} = Z_{out}(1+T)$

⊛ 2-resistor feedback (parallel)



i) Without R_F, V_S will be developed as

$$V_S = i_S R_A.$$

ii) when R_F paralleled,
R_F will detect V_S and generate i_f.
And the i_f will be subtracted from i_S.

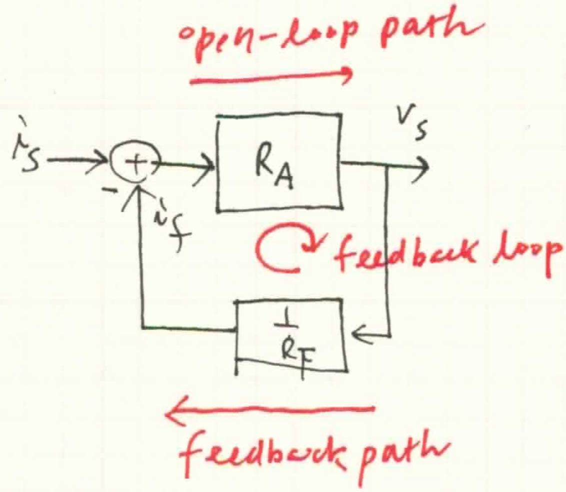
The resultant $V_S = (i_S - i_f) R_A$ — Ⓐ

$\Rightarrow i_f = \dfrac{V_S}{R_F}$ ↗ apply to Ⓐ

$\Rightarrow V_S = \left(i_S - \dfrac{V_S}{R_F}\right) R_A$

$$\therefore V_S = \frac{i_S R_A}{1 + \frac{R_A}{R_F}}$$

↓ equivalent feedback system.



open loop gain, $A_o = R_A$
feed back factor, $f = \frac{1}{R_F}$
loop gain, $T = A_o f$
$= R_A / R_F$

Closed loop gain (A_f)

$$= \frac{V_S}{i_S} = \frac{A_o}{1+T} = \frac{R_A}{1 + \frac{R_A}{R_F}}$$

$$= \frac{R_A \cdot R_F}{R_A + R_F} = R_A \parallel R_F$$

⇒ without R_F, $Z_{in} = R_A$

with R_F, $Z_{in} = R_A \parallel R_F = \frac{R_A \cdot R_F}{R_A + R_F} = \frac{R_A}{1 + \frac{R_A}{R_F}}$

$= \frac{R_A}{1+T}$

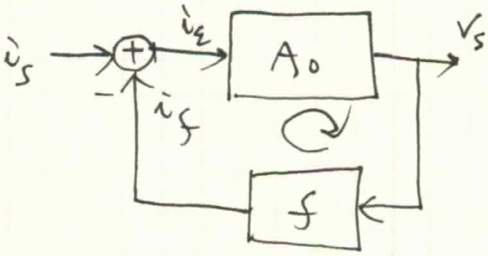
Z_{in} decreases by a factor of $(1+T)$. (why?)

⇒ without R_F, $Z_{out} = R_A$

with R_F, $Z_{out} = R_A \parallel R_F = \frac{R_A}{1 + \frac{R_A}{R_F}} = \frac{R_A}{1+T}$

Z_{in} decreases by a factor of $(1+T)$. (why?)

< generalization >



$i_s - i_f = i_\varepsilon = \frac{1}{1+T} \times i_s$

NOTE: Input is current, output is voltage

① loop gain, $T = A_o f$

② Closed loop gain, $A_f = \frac{A_o}{1+T} = \frac{A_o}{1+A_o f}$

$= \frac{1}{f}\left(\frac{1}{1+\frac{1}{A_o f}}\right) = \frac{1}{f}\left(\frac{1}{1+\frac{1}{T}}\right)$

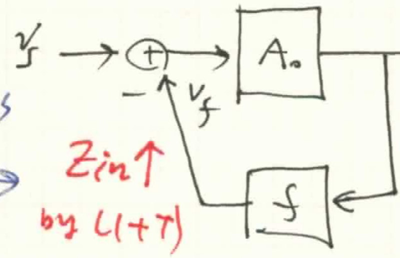
$\approx \frac{1}{f}\left(1 - \frac{1}{T}\right)$ (if) $T \gg 1$

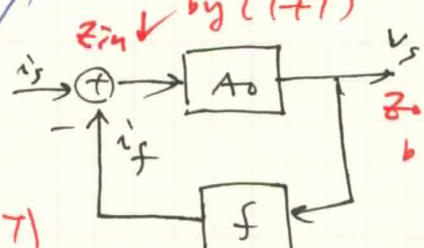
$\approx \frac{1}{f}$

③ $Z_{inf} = Z_{in} \frac{1}{1+T}$ ← makes more ideal current driving.

④ $Z_{outf} = Z_{out} \frac{1}{1+T}$

(*) feedback configurations





This makes better voltage driving for previous stage. → Zin ↑ by (1+T)

→ this makes better current mode driving to next stage. (Zout ↑ by (1+T))

→ This makes better current mode driving for previous stage. (Zin ↓ by (1+T))

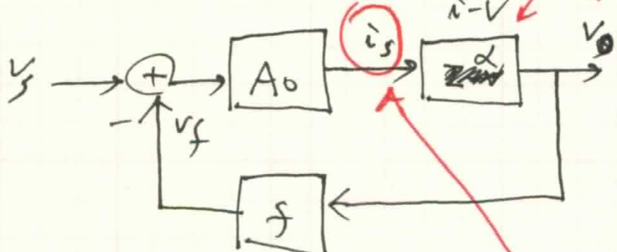
↓ This makes better voltage mode driving to next stage. (Zout ↓ by (1+T))

⇒ These are two basic configuations

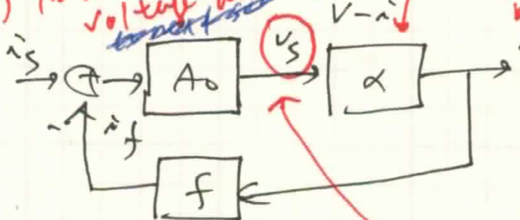
⇒ driving source should be either voltage or current.

⇒ if driving source is voltage, immediate output response is current, which is first case.

⇒ if driving source is current, immediate output response is voltage, which is the second case.



why do we need this? A) To make better voltage driving to next stage



why do we need this? A) To make better current driving to next stage

⇒ i-V converter can be used to convert i_s to v_o.

⇒ But, still the point of feedback operation is to decrease i_s.

⇒ decreasing i_s results in decreasing v_o.

⇒ Zin ↑ ×(1+T)
Zout ↓ ×(1+T)

⇒ V-i converter can be used to convert v_s to i_o

⇒ But, still the point of feedback operation is to decrease v_s.

⇒ decreasing v_s results in decreasing i_o.

⇒ Zin ↓ ×(1+T)
Zout ↑ ×(1+T)