Structured Electronic Design

EE3C11
Design of low-noise feedback amplifier configurations

Anton J.M. Montagne

Negative feedback: a powerful error reduction technique

With a high-gain controller the static and dynamic transfer are predominantly determined by the feedback network

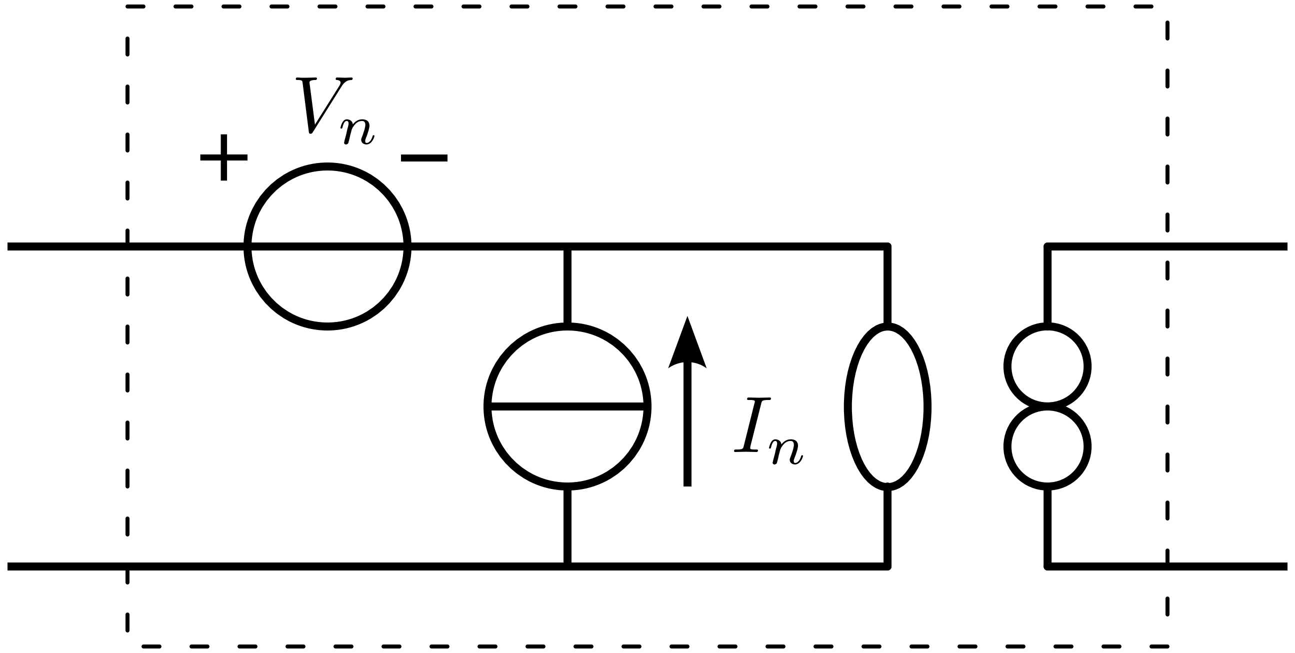
We will show that this is not the case for the noise behavior

- Equivalent input noise sources of the controller should be kept small
- Deterioration of the signal to noise ratio by the feedback network should be kept small

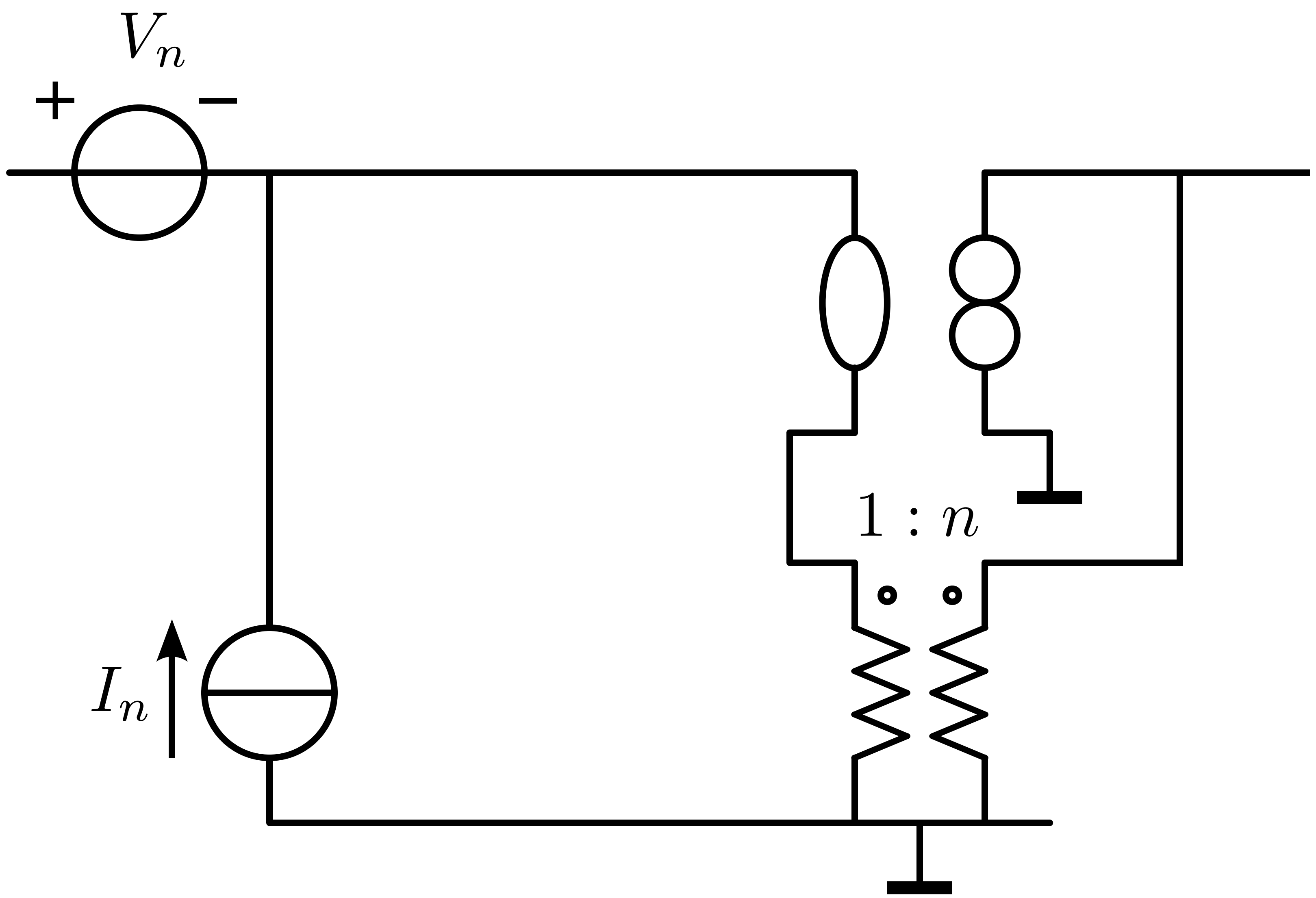
Study the noise behavior of nonenergic and passive feedback amplifiers

- Find rules for low-noise design
- Model the controller as a noisy nullor

  This enables orthogonal design of the noise behavior and of the static and dynamic transfer



Noise performance of nonenergic feedback amplifiers



Redirect the current noise source via ground

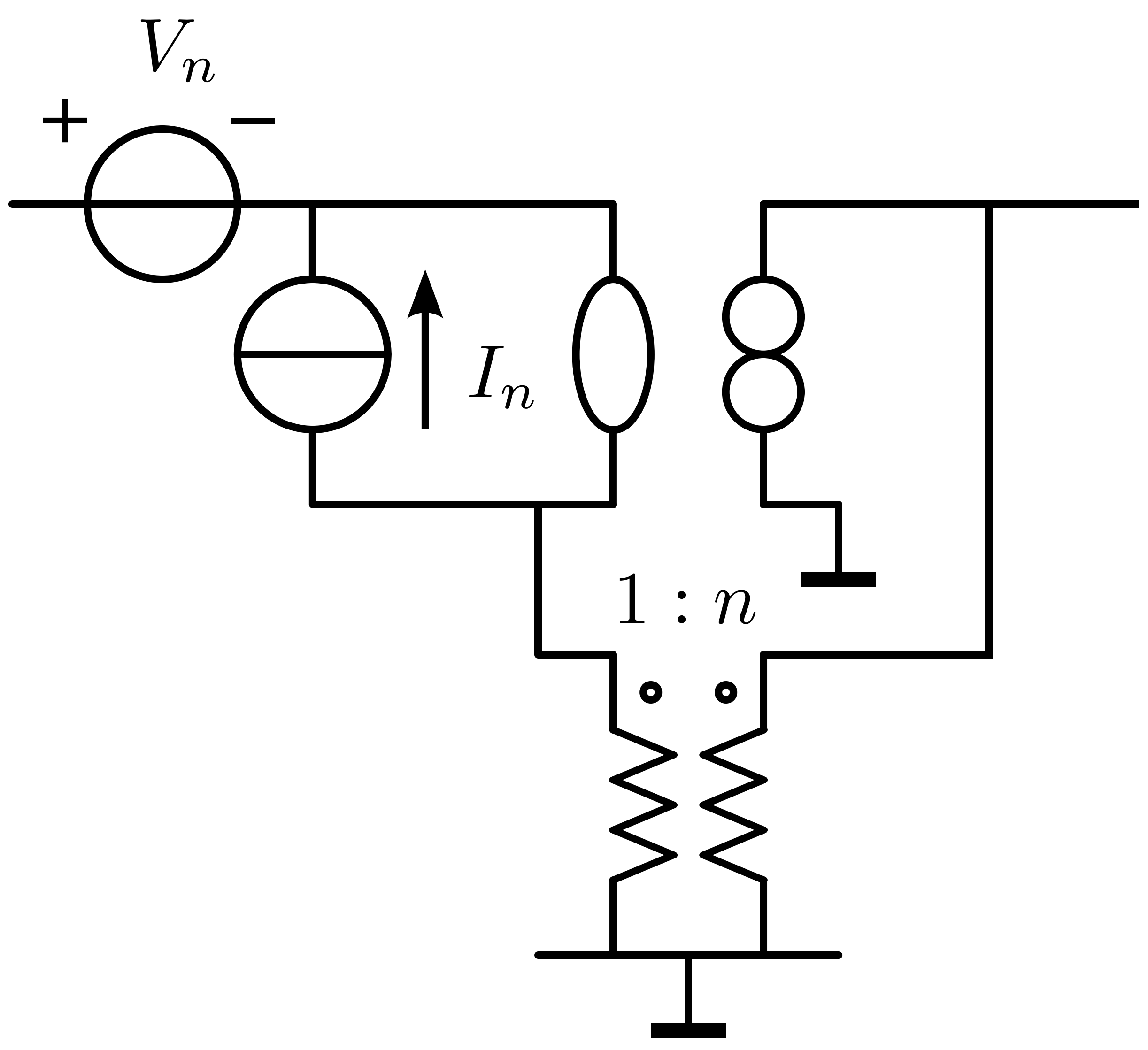
Replace the equivalent input current noise source of the transformer with an equivalent output current noise source; use:

$$AD = 1, B = C = 0$$

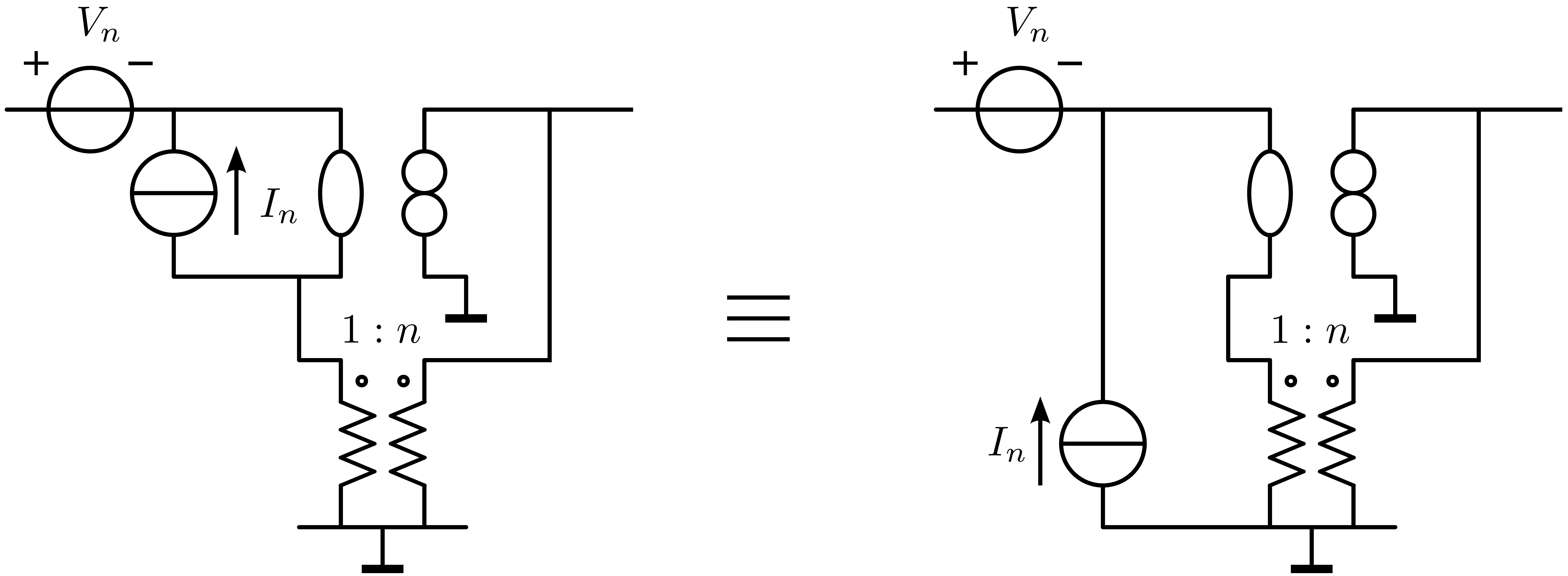
The current source in parallel with the output of the nullor can be ignored. Replacing it with equivalent input sources yields zero because:

$$A = B = C = D = 0$$

Noise performance of nonenergic feedback amplifiers



Noise performance of nonenergic feedback amplifiers

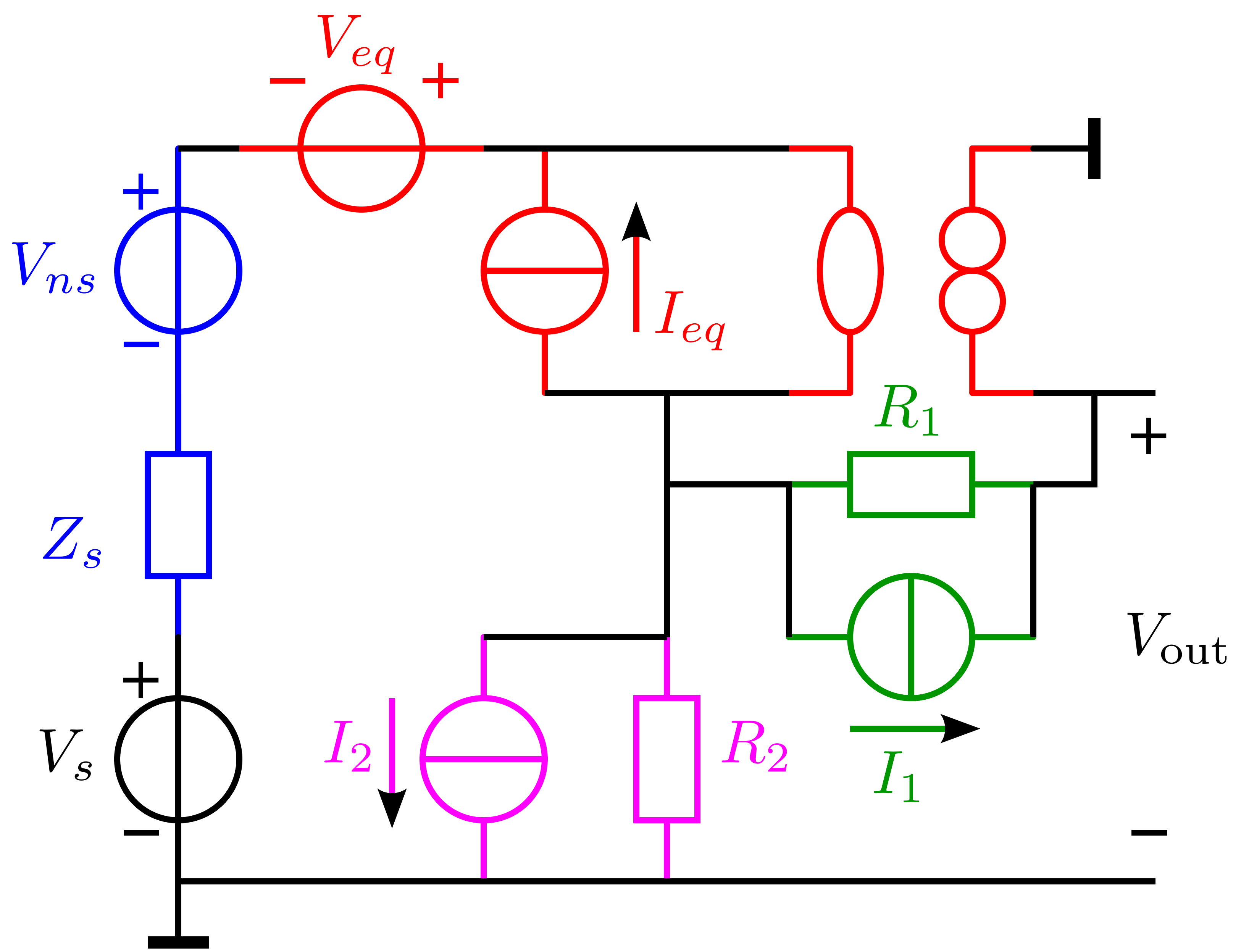


The equivalent input noise sources of a nonenergic feedback amplifier are equal to those of its controller

Noise performance of passive feedback amplifiers

Conclusion:

The influence of the feedback resistors in the passive feedback voltage amplifier can be accounted for as if their parallel connection is in series with the source.



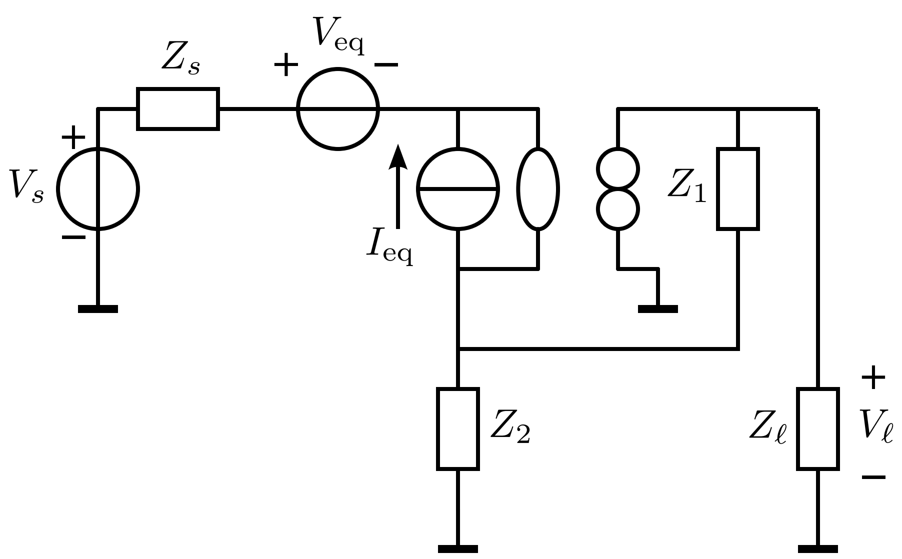
$$S_{V_{\mathrm{out}}} = 4kT\mathrm{Re}(Z_s)\left(\frac{R_1+R_2}{R_2}\right)^2 + S_{V_{eq}}\left(\frac{R_1+R_2}{R_2}\right)^2 + S_{I_{eq}}\left(\frac{R_1+R_2}{R_2}\right)^2\left(Z_s+\frac{R_1R_2}{R_1+R_2}\right)^2 + 4kT\frac{R_1^2}{R_2} + 4kTR_1$$

$$S_{V_s} = 4kT\mathrm{Re}(Z_s) + S_{V_{eq}} + S_{I_{eq}}\left(Z_s+\frac{R_1R_2}{R_1+R_2}\right)^2 + 4kT\frac{R_1^2R_2}{(R_1+R_2)^2} + 4kT\frac{R_1R_2^2}{(R_1+R_2)^2} \rightarrow +4kT\frac{R_1R_2}{R_1+R_2}$$

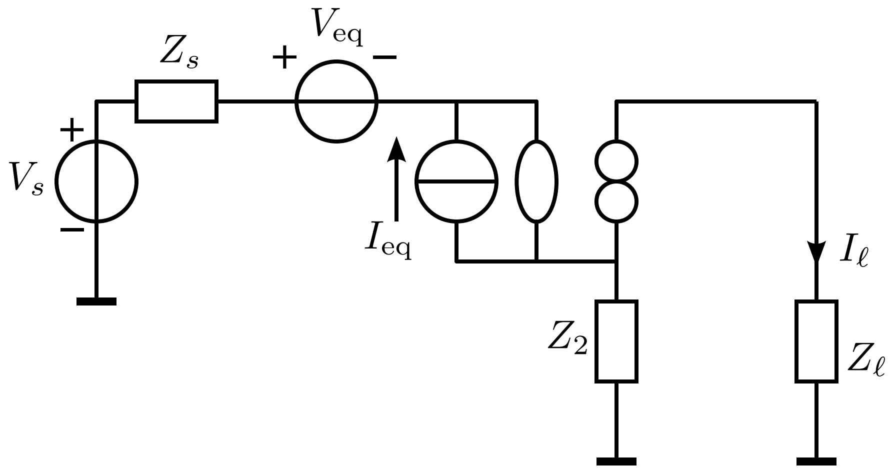
Conclusions noise performance of passive feedback amplifiers

Conclusions noise performance of passive feedback amplifiers

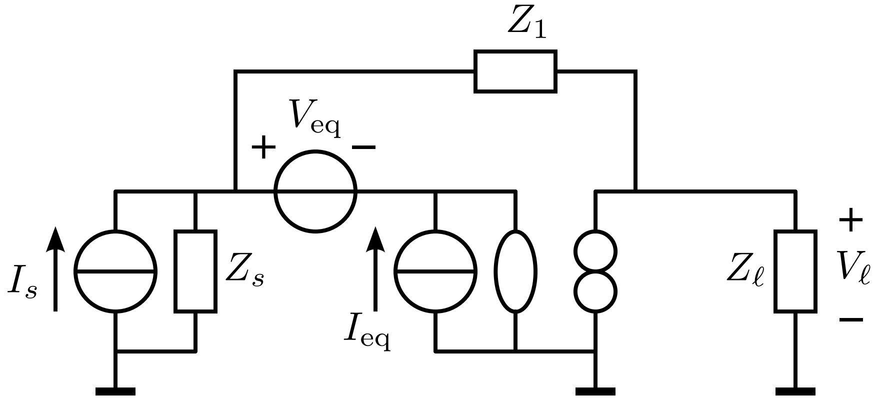
A
Voltage amplifier



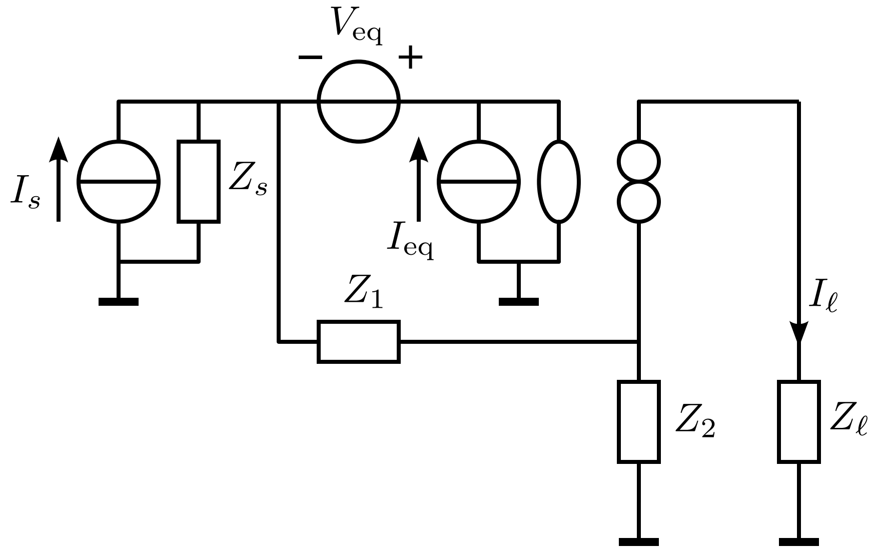
B
Transadmittance



C
Transimpedance

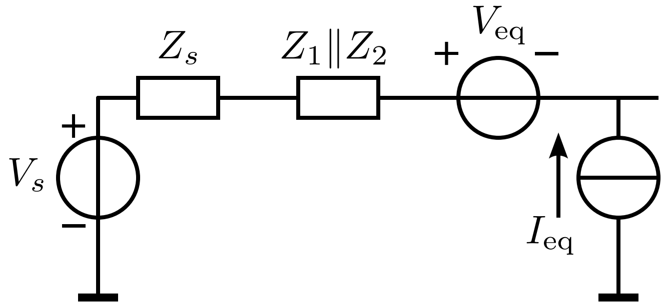


D
Current amplifier

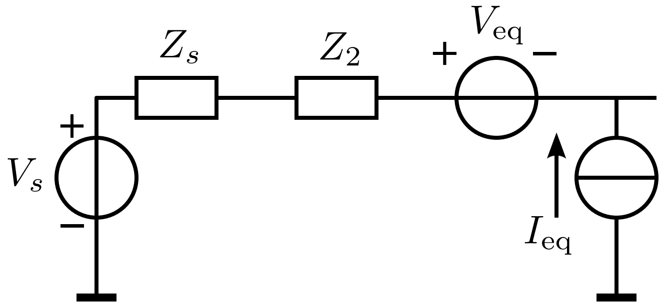


The noise contribution of the feedback impedances and their influence on the contribution of the equivalent input noise sources of the controller can be found:

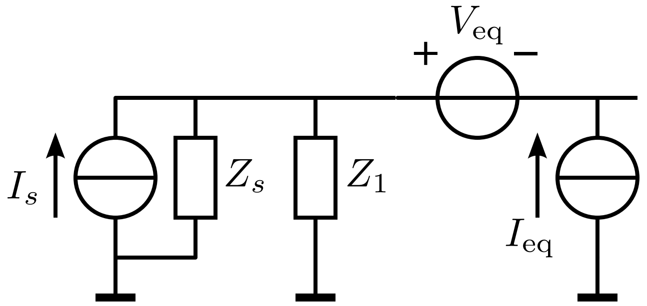
As if the parallel connection of the feedback impedances is in series with the source



As if the feedback impedance is in series with the source



As if the feedback impedance is in parallel with the source



As if the series connection of the feedback impedances is in series with the source