



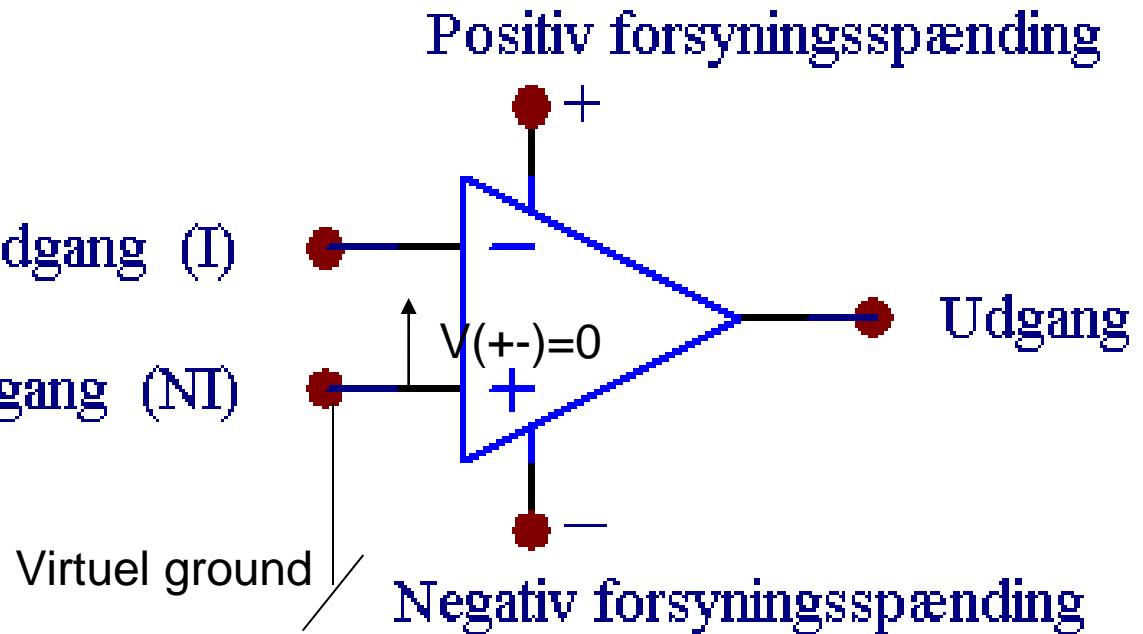
Op-Amp H1

Lkaa
2011

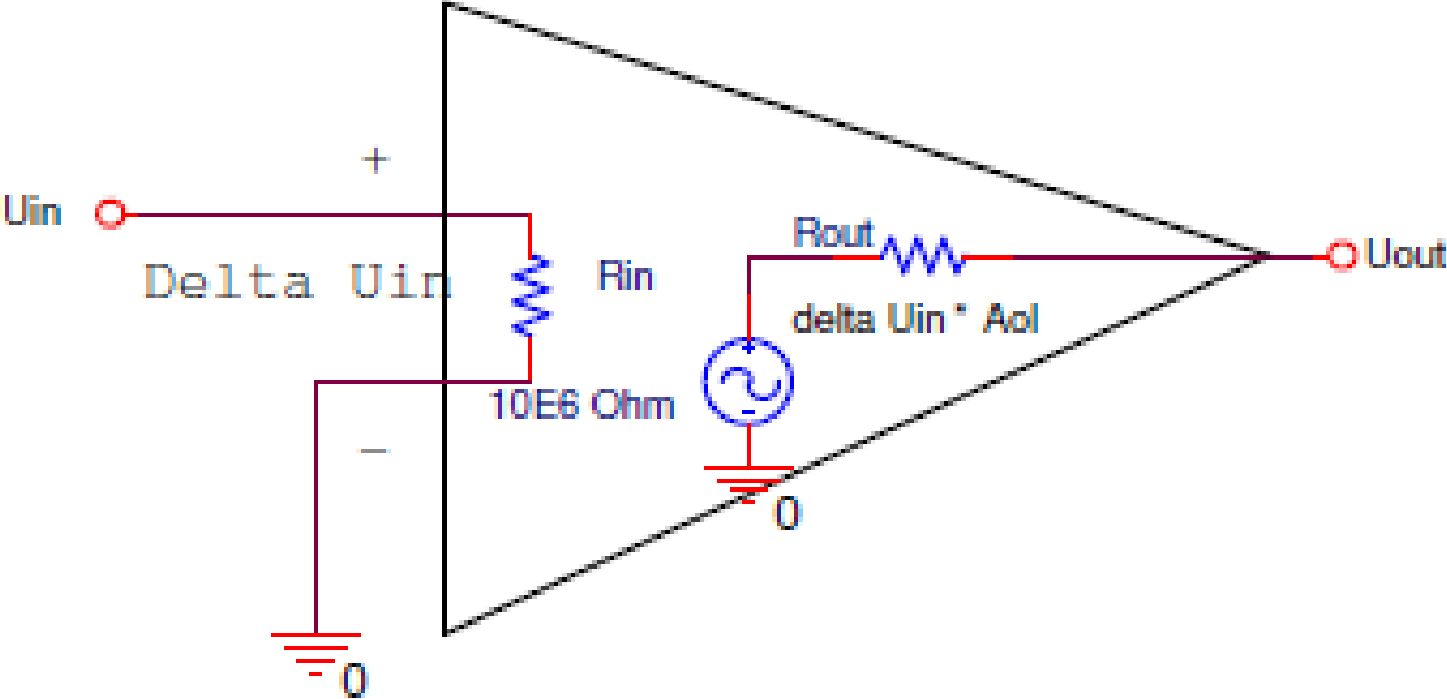


Op-Amp

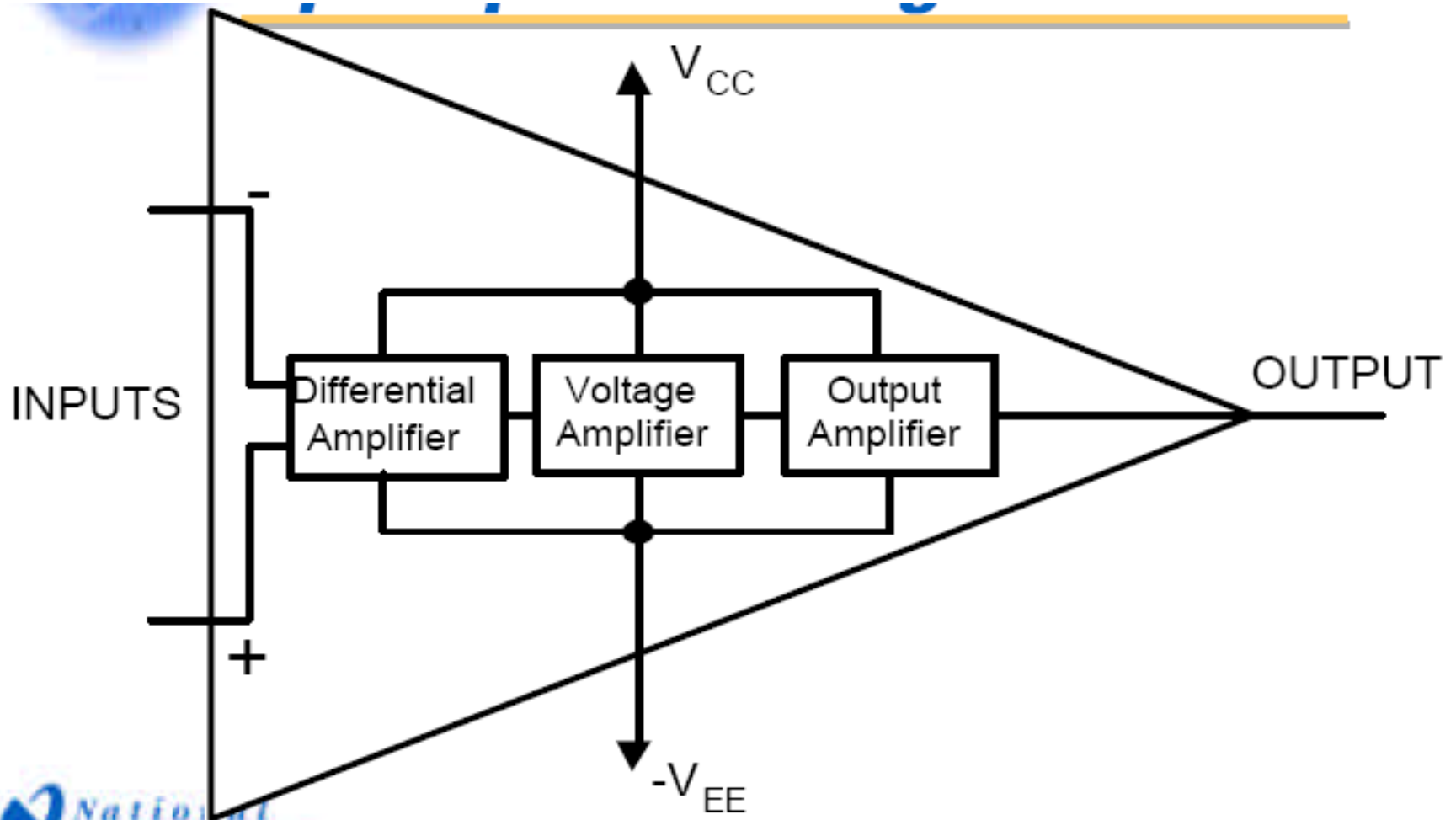
Inverterende indgang (I)
Ikke-inverterende indgang (NI)



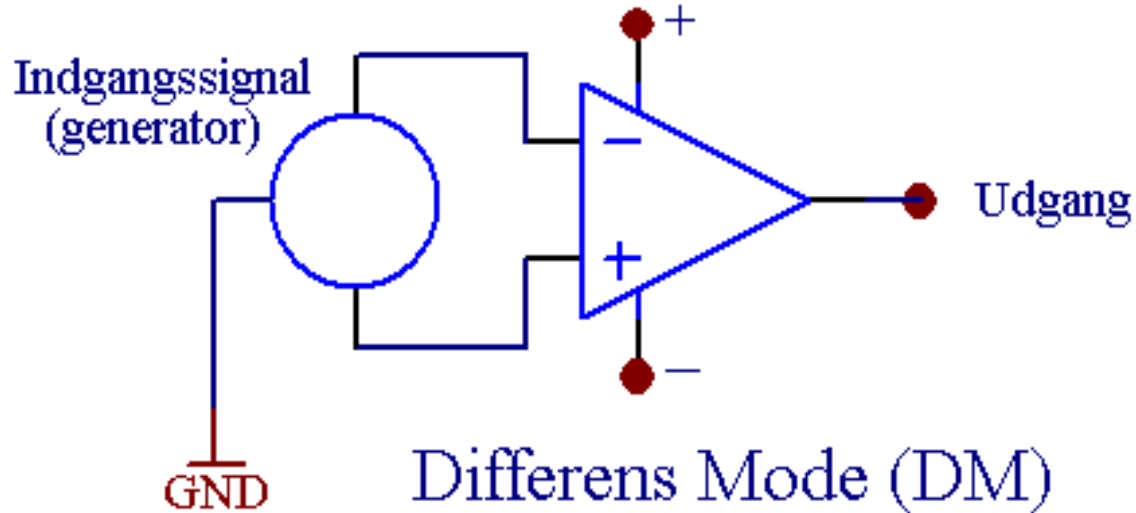
OP-AMP intern



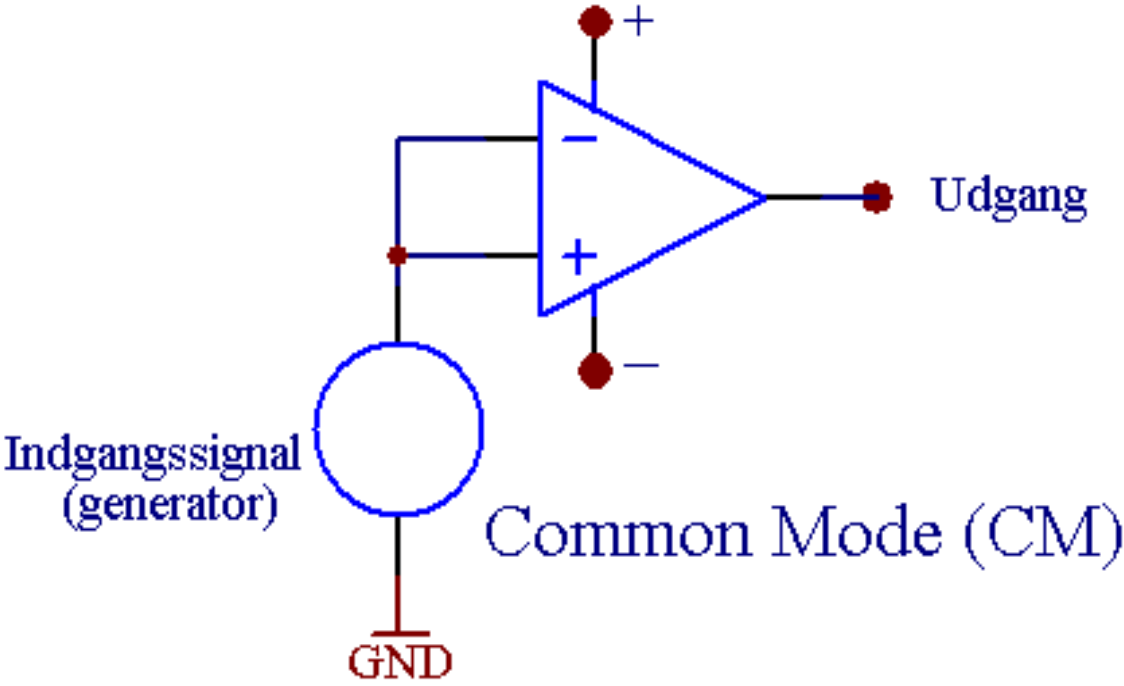
Op-Ampens interne opbygning



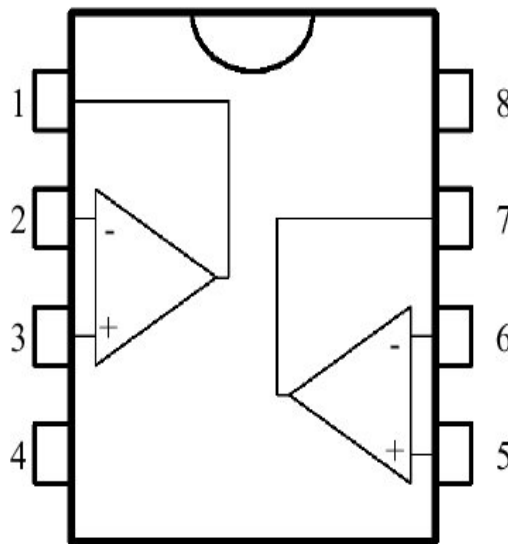
Op-Amp



Op-Amp



Op-Amp LM741 eller UA741



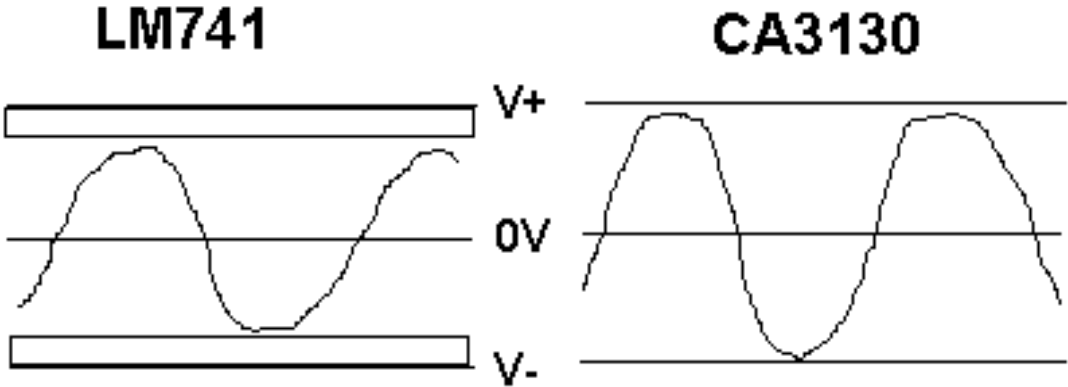
- 1 - Output 1
- 2 - Inverting input 1
- 3 - Non-inverting input 1
- 4 - V_{cc}^-
- 5 - Non-inverting input 2
- 6 - Inverting input 2
- 7 - Output 2
- 8 - V_{cc}^+



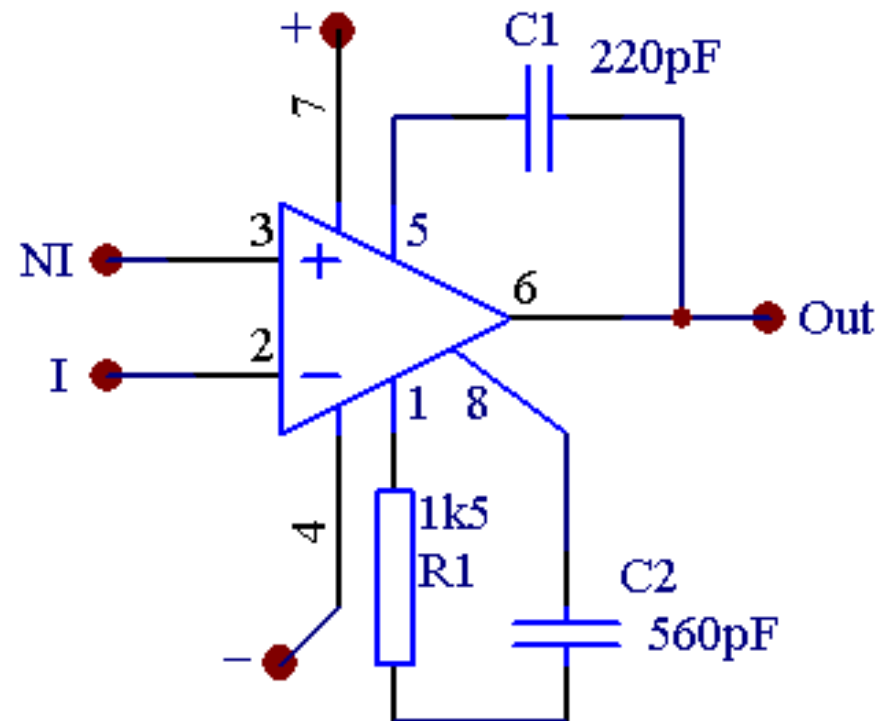
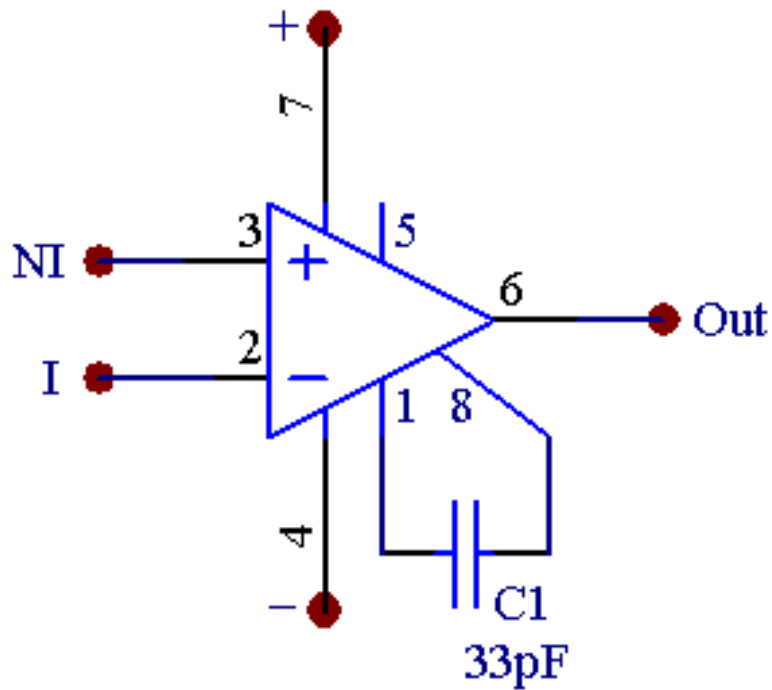
Data

	LM741	CA3130
Forsyningsspænding	$\pm 22V$	$\pm 2,5V - \pm 8V$
Spændingsforstærkning	200.000	320.000
Ingangsimpedans	2 M Ω	1,5 T Ω
Input offset-spænding	1 mV	8 mV
Input offset-strøm	500 nA	0,5 pA
Slew-rate(spændingsændring)	0,5V/ μ Sek	30V/ μ Sek
Internt kompenseret	ja	nej
Kortslutningssikker udgang	ja	ja
IC-hus (case)	DIP8	DIP8
Teknik	transistor	MOSFET/CMOS

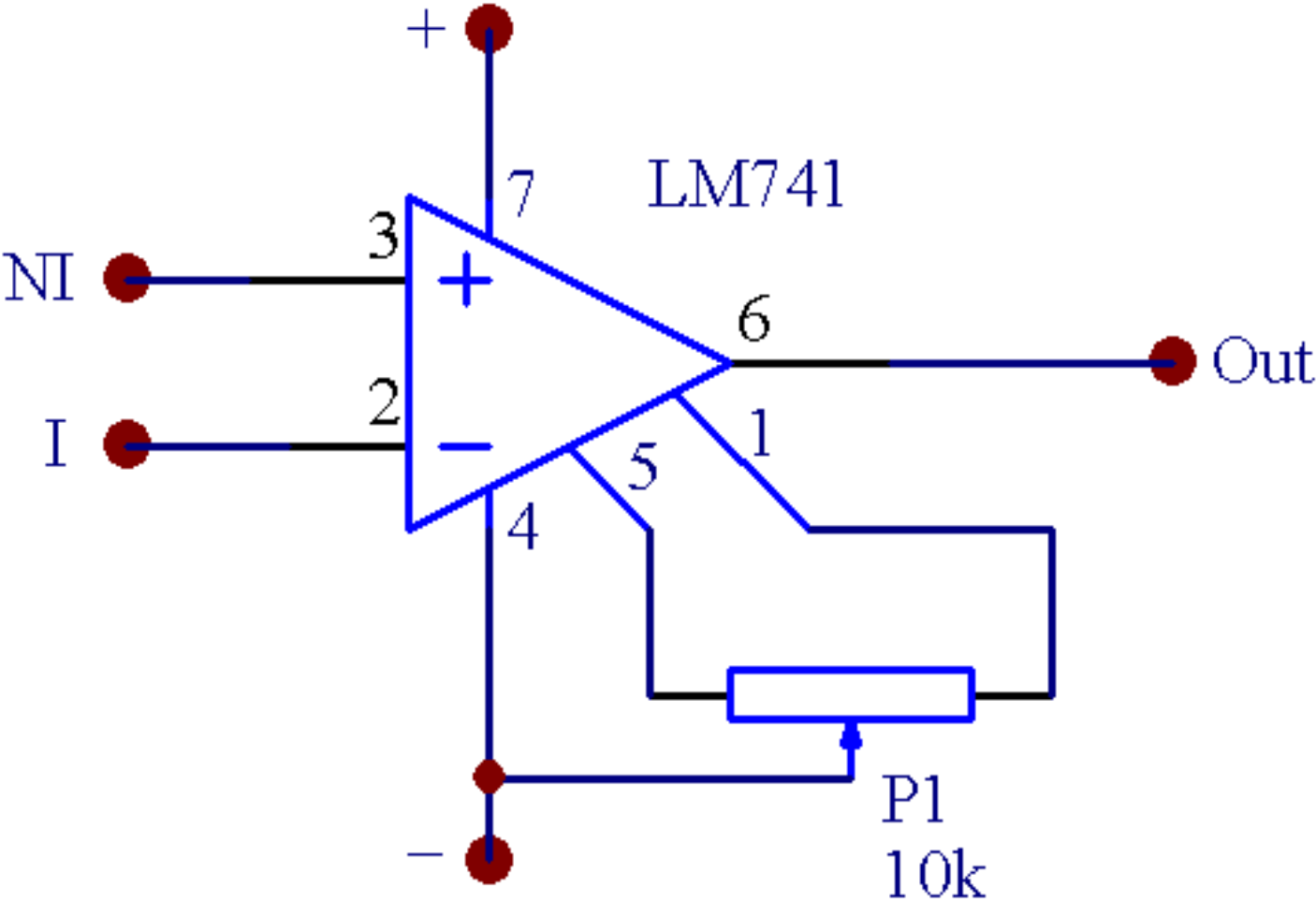
Rail- rail



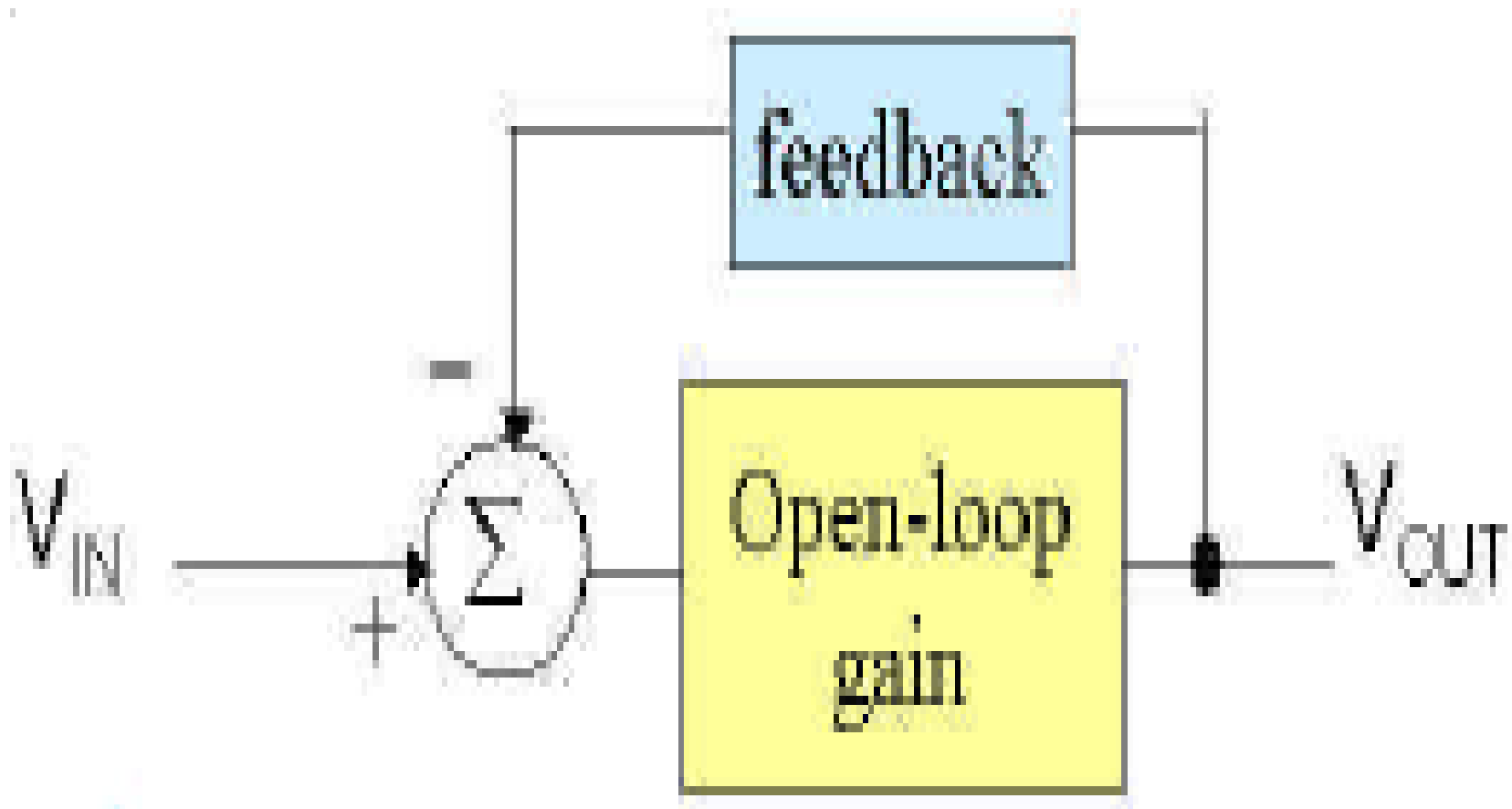
Kompensationskredløb "selvsving"



Off-set



Feedback eller Modkobling

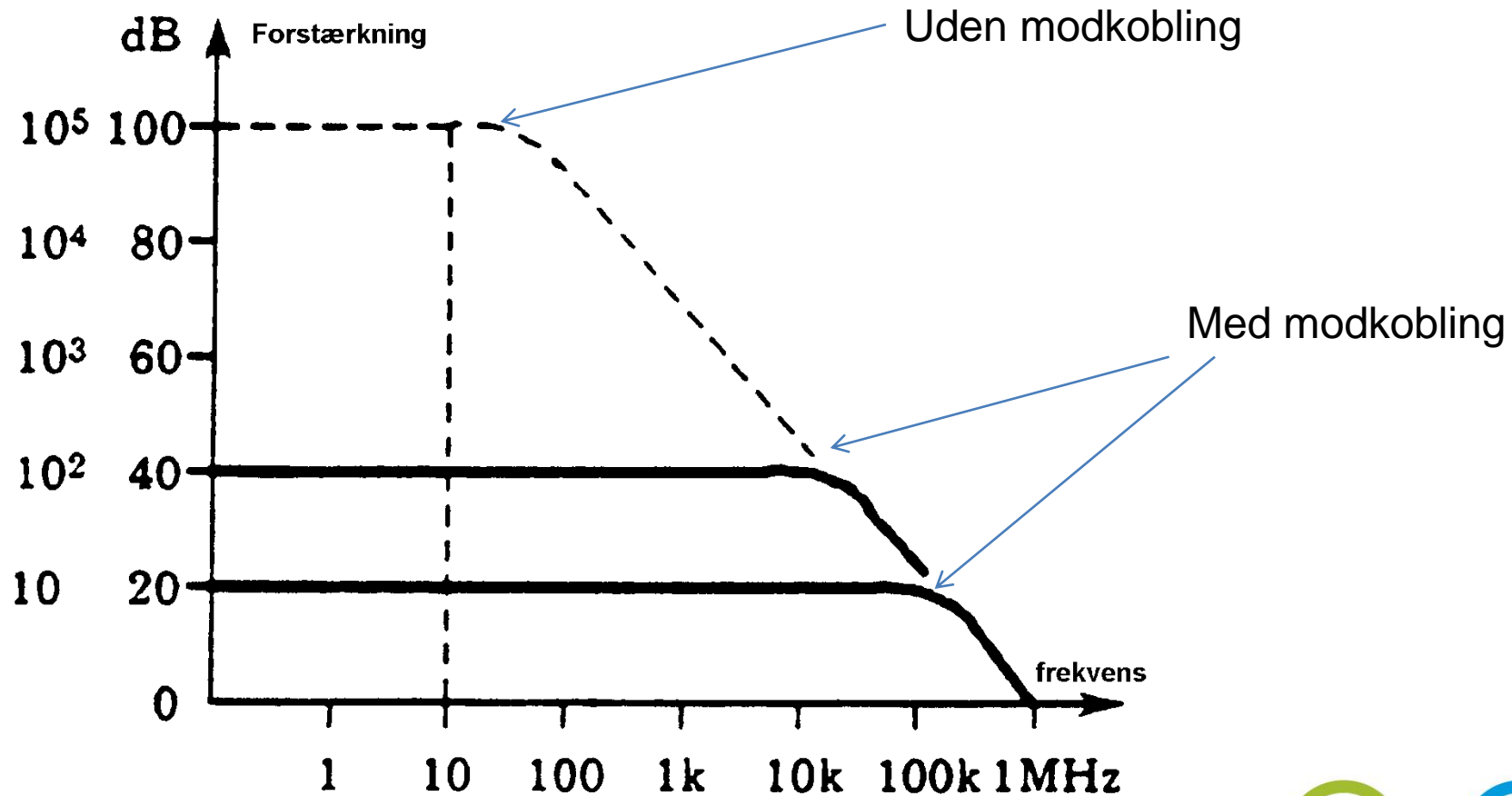


Feedback!

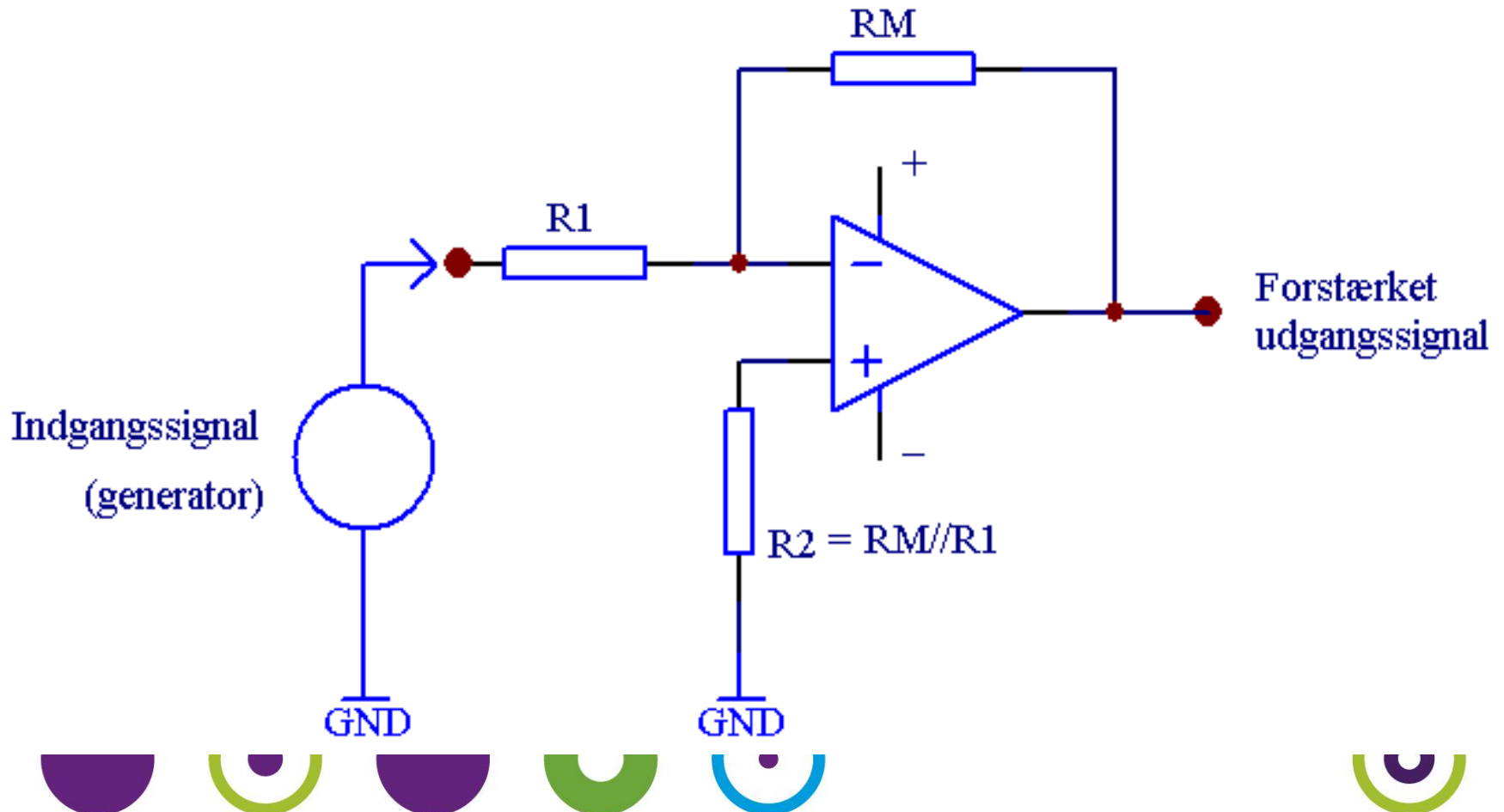
- Reducere forstærkningen
- Båndbredden forøges
- Op-amp'en stabiliseres!
- Lineariteten forbedres!
- Forvrængning reduceres!



Slew-rate & rå forstærkning



Invertende forst.



- A_o = Råforstærkning uden modkobling
- A' = Forstærkning med modkobling
- M = Modkoblingsfaktoren
- Z_{in} = Indgangs impedance
- Z_{out} = Udgangsimpedance



Beregning

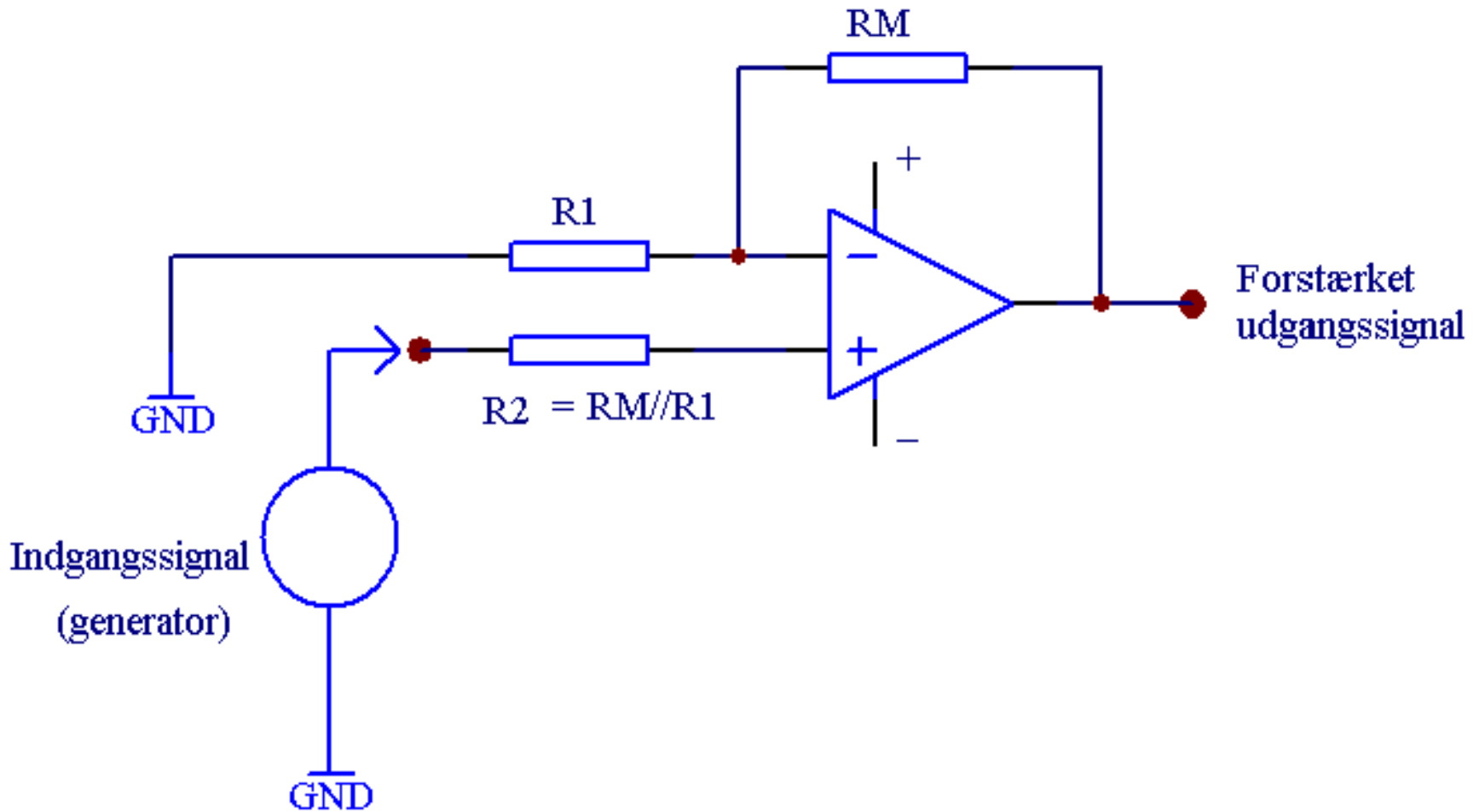
- $A' = -R_M/R_1$
- $Z_{out} \rightarrow 0 \text{ Ohm}$ (Belastning skal være større end 2K Ohm!!)

- $M = \text{modkoblingsfaktoren}$
- $M = A_o/A'$
- $A_o = \text{råforstærkning}$

- $Z_{in} = R_1$

- $Z'_{out} = Z_{out}/M$

Ikke-invertende forst.

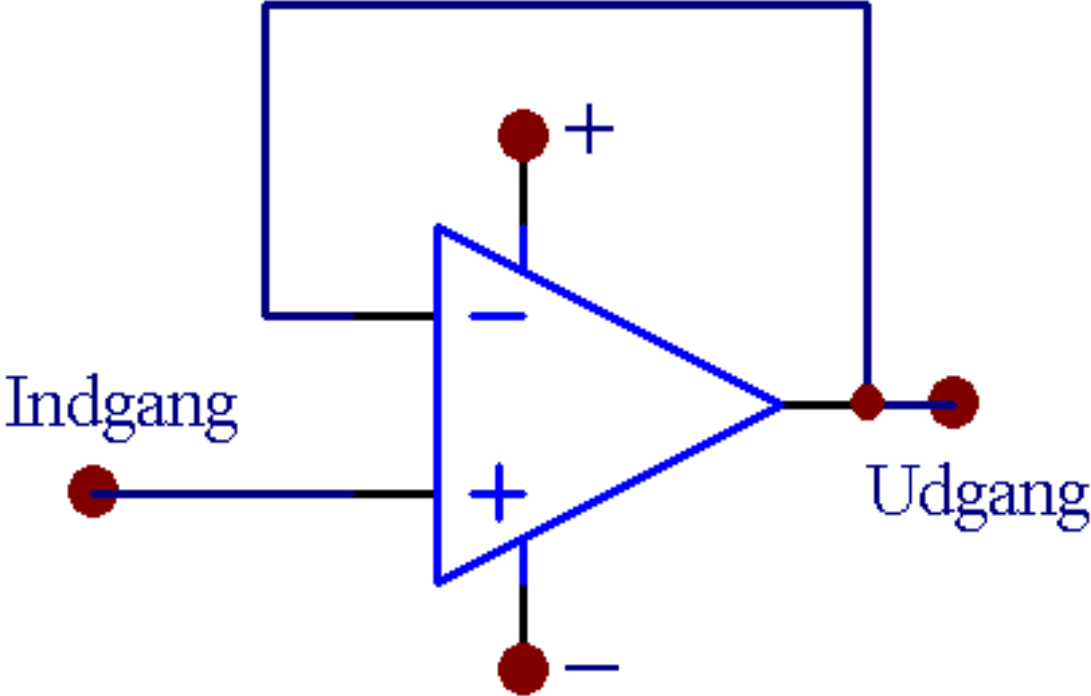


Beregning

- $A' = (R_M/R_1) + 1$
- $Z_{out} \rightarrow 0 \text{ Ohm}$ (Belastning skal være større end 2K Ohm!!)
- $Z'_{out} = Z_{out}/M$:
M=modkoblingsfaktoren



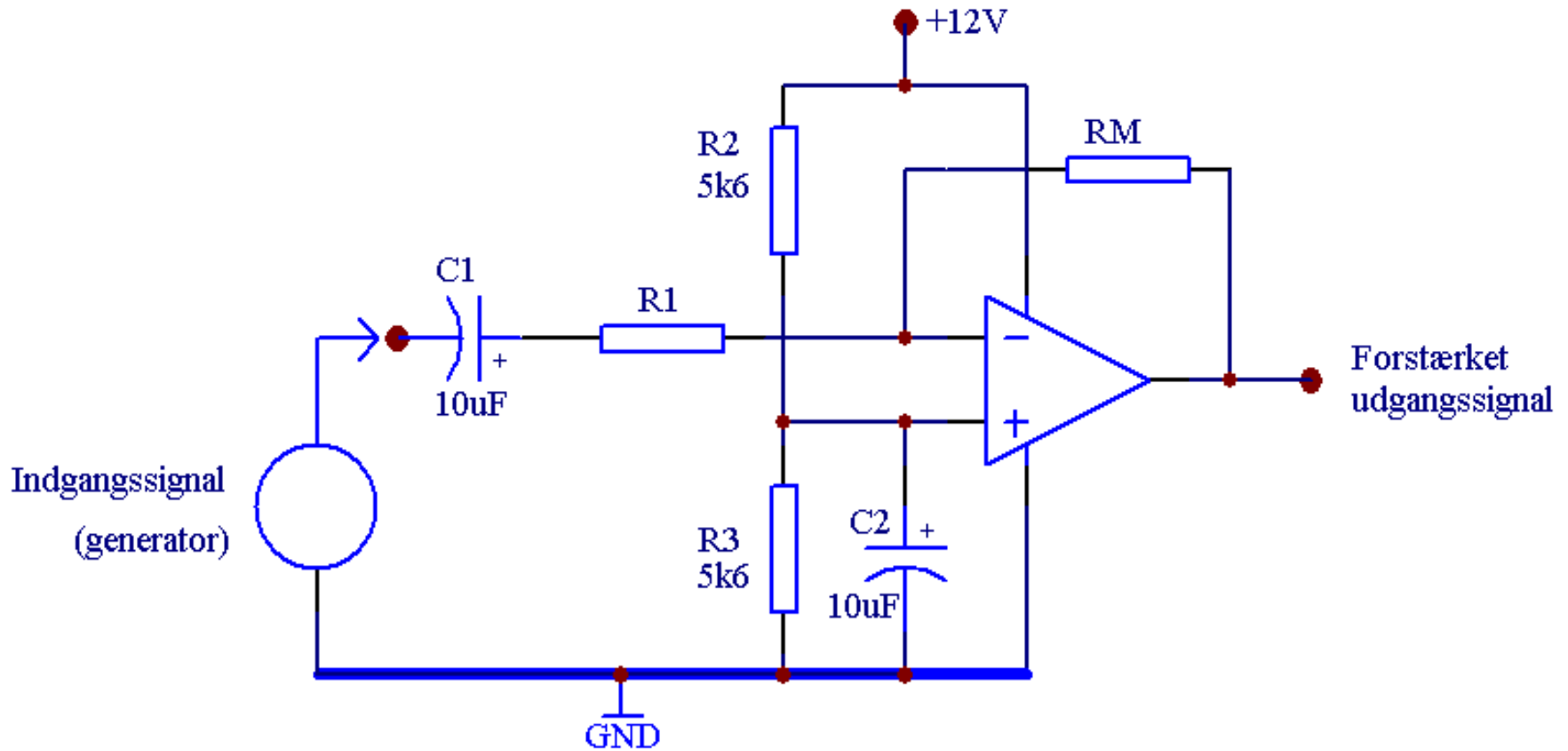
Unity-gain forst. (buffer)



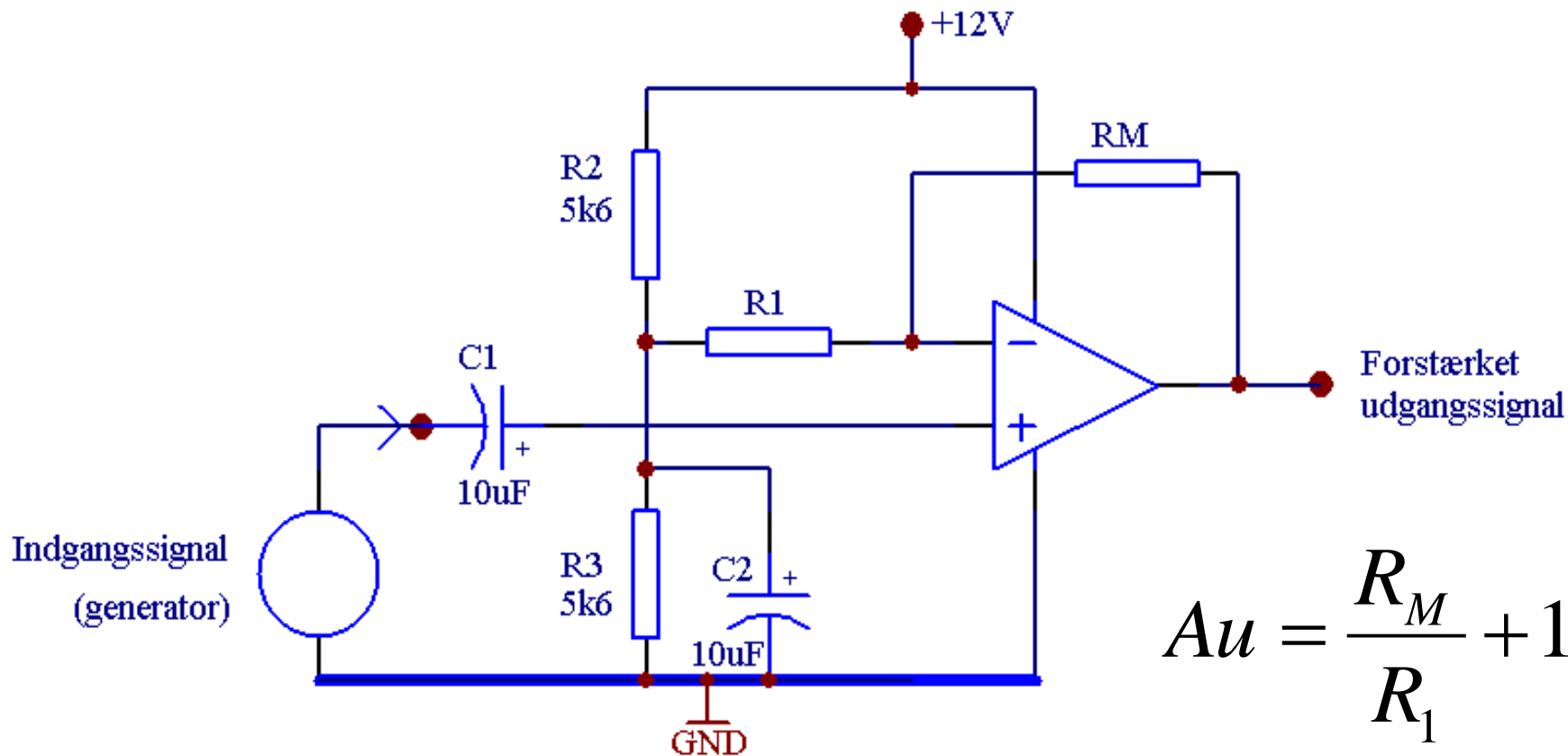
- Forstærkning: $A_u = \frac{0\Omega}{\infty\Omega} + 1 = 1$ ganges forst.
- Fordele: Høj indgangsimpedans, $Z_{IN} \rightarrow \infty\Omega$
- Lav udgangsimpedans, $Z_{OUT} \rightarrow 0\Omega$
- Op-amp = diff. I indgangen og effekt forstærker i udgangen



OP-amp med enkelt strømfor- syning, Inverterende



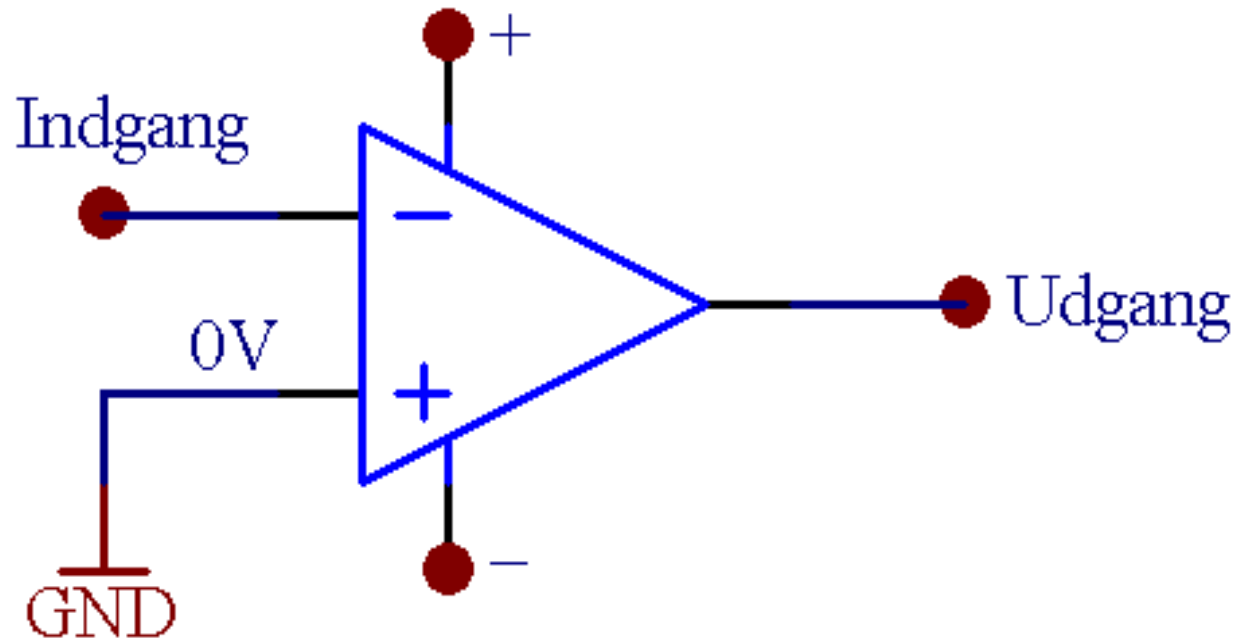
Enkelt strømforstyrning, Ikke-Inverterende



$$Au = \frac{R_M}{R_1} + 1$$

OP-amp som Komparator

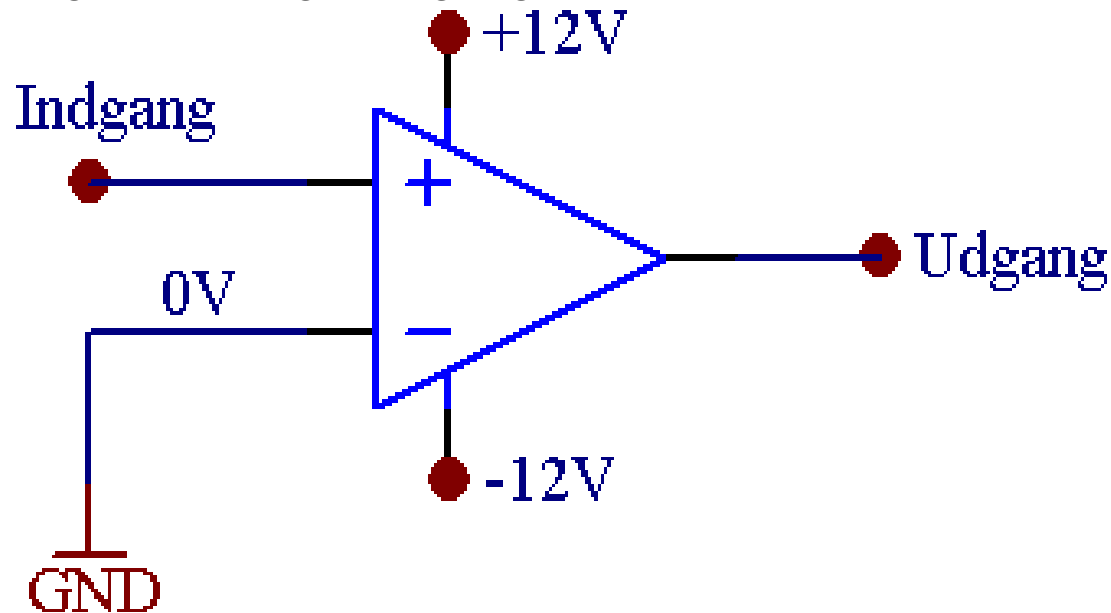
Er indgangssignalet $>0V$ går udgangen $\rightarrow -12V$
Er indgangssignalet $<0V$ går udgangen $\rightarrow +12V$



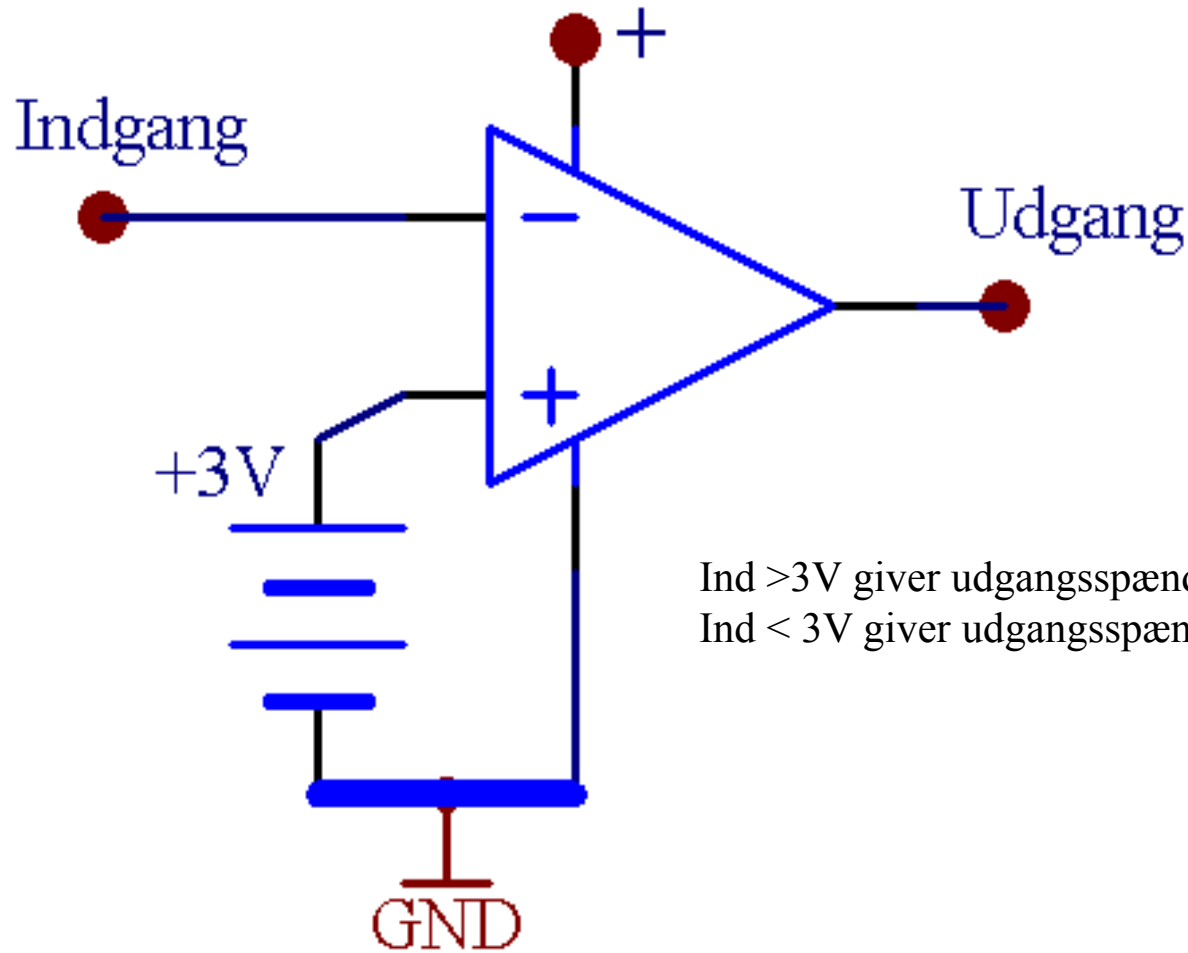
OP-amp som Komparator

Er indgangssignalet $> 0V$ går udgangen $\rightarrow +12V$

Er indgangssignalet $< 0V$ går udgangen $\rightarrow -12V$

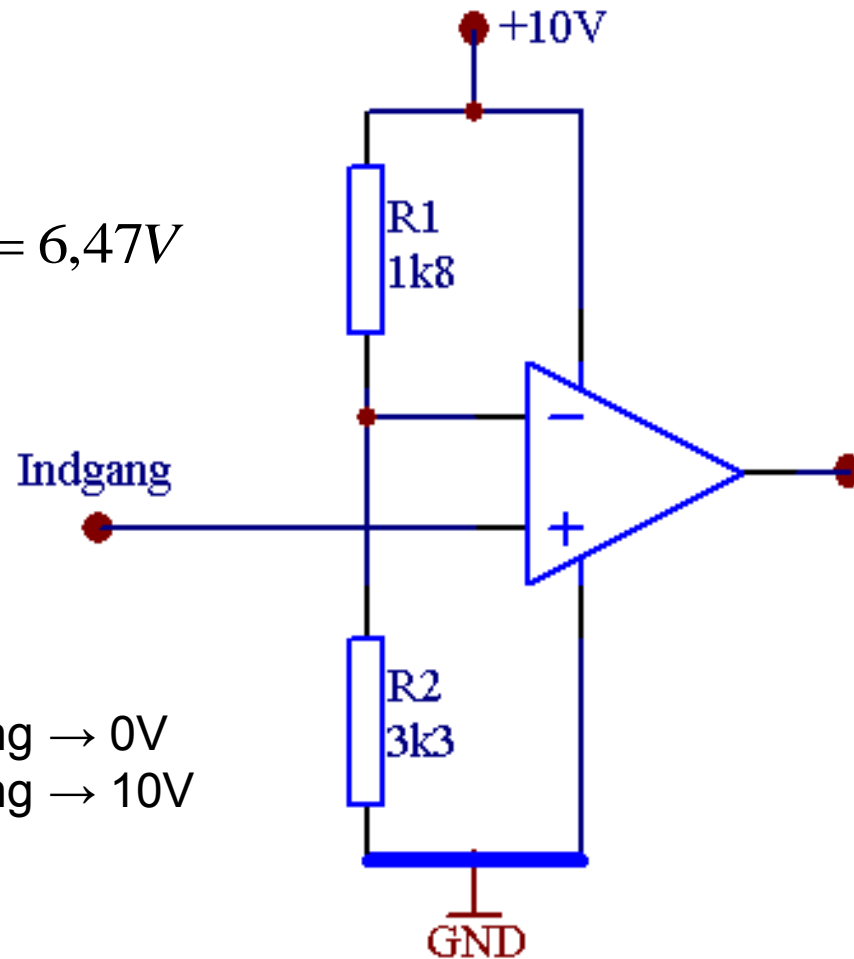


OP-amp som Komparator



OP-amp som Komparator

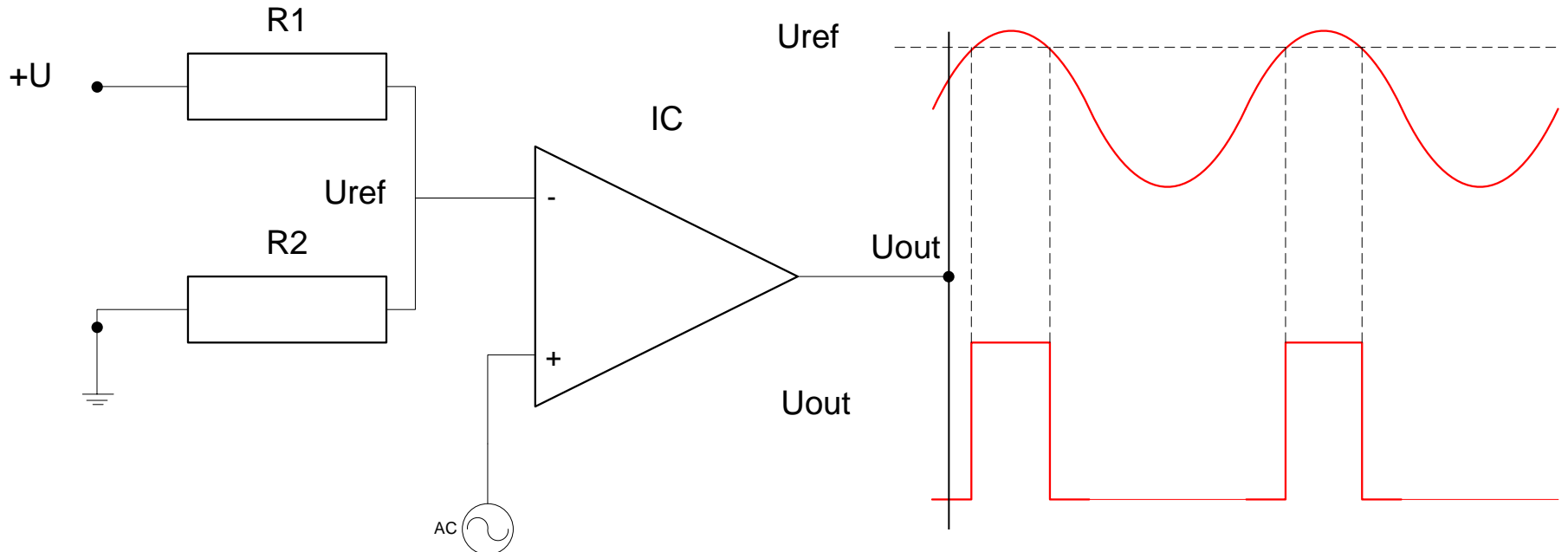
$$U_{REF} = U_{R2} = 10V \cdot \frac{3,3k}{3,3k + 1,8k} = 6,47V$$



Ind < 6,47V giver udgangsspænding → 0V
Ind > 6,47V giver udgangsspænding → 10V



Inverterende komparator



$$U_{ref} := U_{cc} \cdot \frac{R2}{R1 + R2}$$

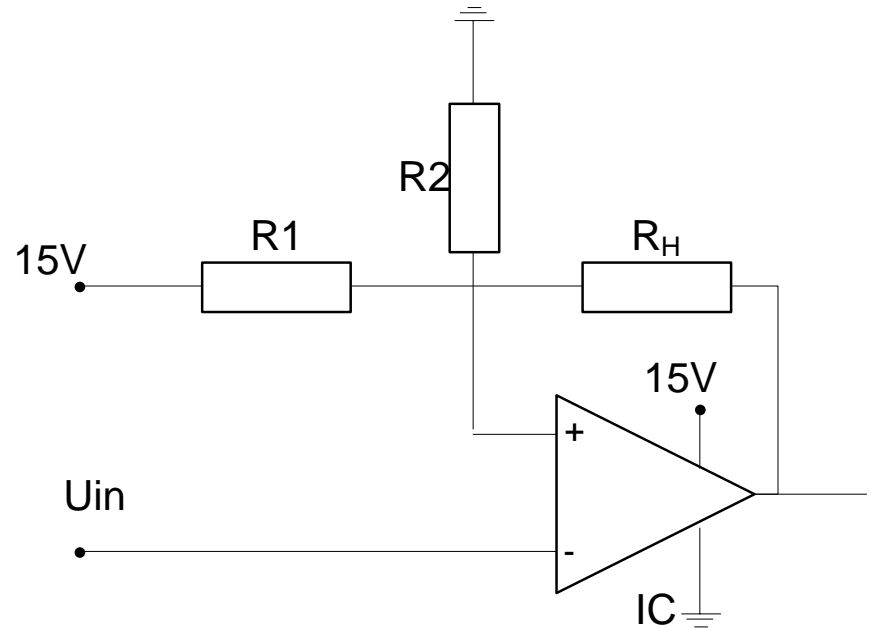
Hysteresis

- Lower level trigger

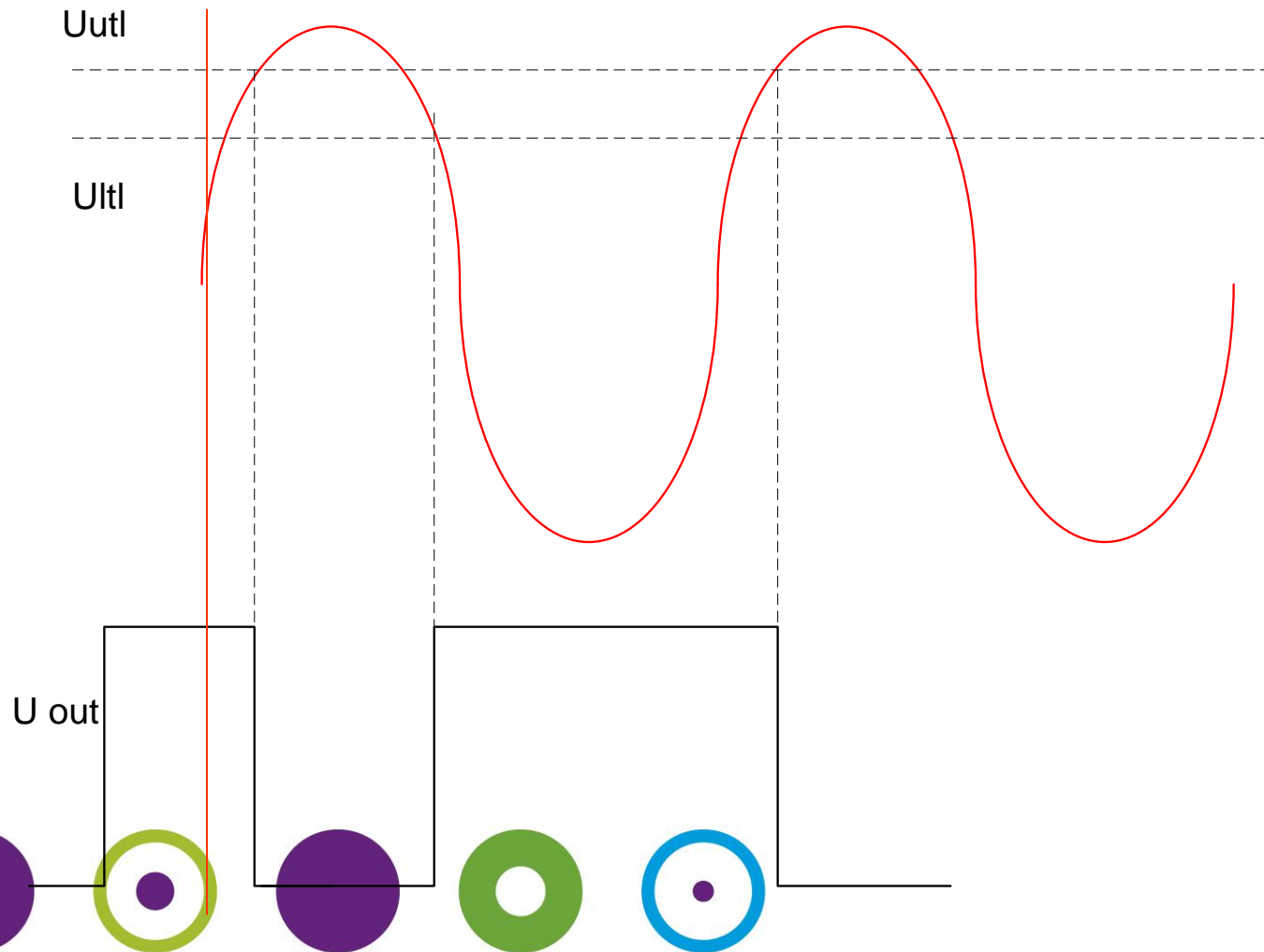
$$U_{\text{tlt}} = U_{\text{cc}} \cdot \frac{R_2 // R_H}{(R_2 // R_H) + R_1}$$

- Upper level trigger

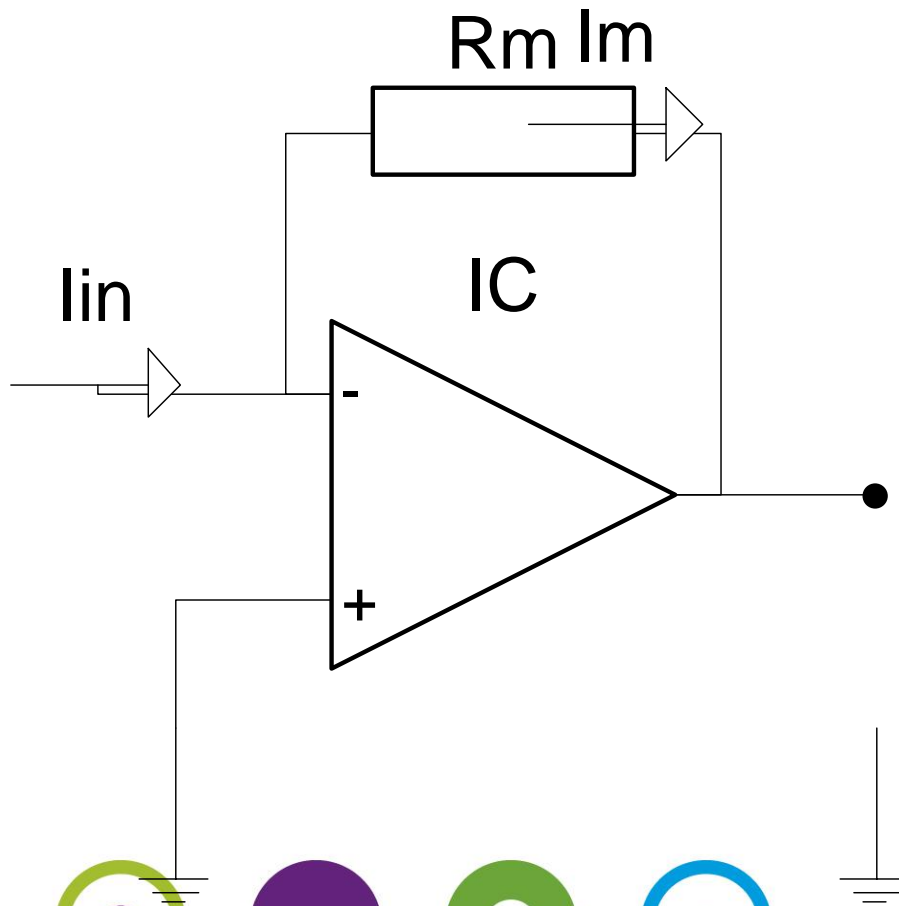
$$U_{\text{ult}} = U_{\text{cc}} \cdot \frac{R_2 // R_H}{(R_1 // R_H) + R_2}$$



Trigger level



Strøm til Spænding



$$U_{out} = -I_{in} \cdot R_m$$