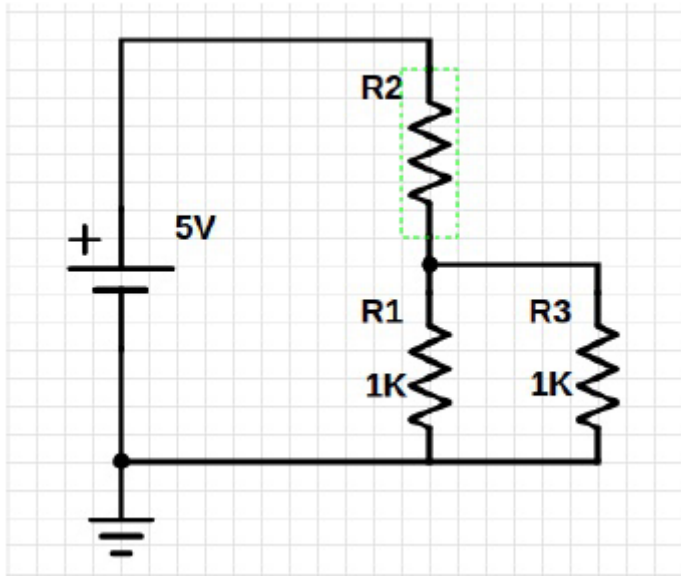


Løsningsforslag

Motstandsnettverk



What is the resistance value of R2, if we get 1V over R3?

$$R_p = R1 \parallel R3 = 1 / (1/(1k) + 1/(1k)) = (1/2)k \text{ (Ohm)}$$

$$V=RI \Rightarrow I \cdot (R_p + R2) = V_{in}, V_{in} = 5V, R_p \cdot I = 1V$$

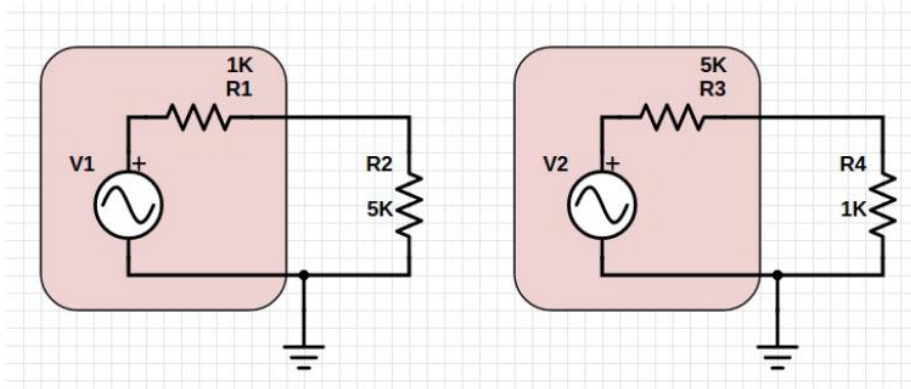
$$\Rightarrow R2 = V_{in}/I - R_p, I = 1V/R_p = 1V/(0.5k\Omega) = 2mA$$

$$\Rightarrow R2 = 5V/2mA - 0.5k\Omega = 2.5k\Omega - 0.5k\Omega = 2k\Omega$$

Impedansmatching

I figuren under ser vi to signalkilder med indre Thevenin motstand representert ved henholdsvis R1 og R3. Lasten er R2 og R4. 1K betyr 1kOhm

Anta at amplituden på V1 og V2 er lik. Hva øker overført effekt fra signalkilden til lasten mest?



$$P = VI, V=RI \Leftrightarrow I = V/R \Rightarrow P = V^2/R$$

$$P_{RX} = V_{RX}^2/RX, \quad X = 2 \text{ eller } 4 \text{ (for } R2, R4)$$

$$V_{RX} = I_{RX} \cdot RX, \quad I_{RX} = V/(RY+RX), \quad Y = 1 \text{ eller } 3$$

$$V_{RX} = RX \cdot V/(RY+RX)$$

$$P_{RX} = (RX \cdot V/(RY+RX))^2/RX = V^2 \cdot RX / ((RY+RX)^2)$$

V er konstant $\Rightarrow$ finne når $RX/((RY+RX)^2)$ er øker mest, $\Rightarrow$ Vi trenger ikke vite amplituden fordi formelen vår er uavhengig av amplituden på spenningskilden.

Hva øker overført effekt fra kilde til last mest?

Utgangspunkt Sys A (tv):

$$RX = 5K, RY = 1K \Rightarrow RX/((RY+RX)^2) = 5K/((1K+5K)^2) = 5m/36 = 0,139m$$

Utgangspunkt Sys B (th):

$$RX = 1K, RY = 5K \Rightarrow 1K/((1K+5K)^2) = 1m/36 = 0,028m$$

SYS A

$$R2 = 5K, R1 = 4K9 \Rightarrow 5m/((5+4,9)^2) = 5m/(98,01) = 0,051m$$

$$\text{Forskjell: } 0,051m - 0,139m = -0,088m \text{ (Går ned i effekt for last)}$$

Sys A

$$R2 = 5K, R1 = 5K1 \Rightarrow 5m/((5+5,1)^2) = 5m/(102,1) = 0,050m$$

$$\text{Forskjell } 0,050m - 0,139m = -0,089m \text{ (Går ned i effekt for last)}$$

Sys B : Eneste som går opp i effekt for lasten

$$R4 = 6K, R3 = 5K \Rightarrow 6m/((6+5)^2) = 6m/(121) = 0,050m$$

$$\text{Forskjell } 0,050m - 0,028m = 0,022m \text{ (Går opp i effekt for last)}$$

Sys B

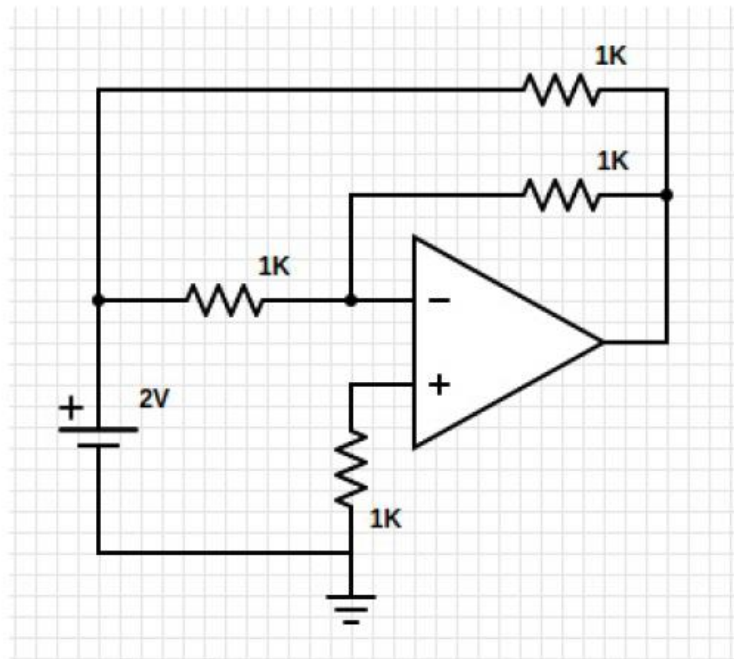
$$R4 = 0K2, R3 = 5K \Rightarrow 0,2m/((5+0,2)^2) = 0,2m/(27,04) = 0,007m$$

$$\text{Forskjell } 0,007m - 0,028m = -0,021m \text{ (Går ned i effekt for last)}$$

Merk: Dette kan løses utelukkende på resonnement. For ideell kjøring bør R_i være så liten som mulig (Lavest mulig tap i strømforsyning), og R_L være lik R_i (evt analyser V^2/R). Forslag som øker R_i kan ikke øke effekt i systemet, forslag som senker R_L fra under R_i vil ikke hjelpe heller.

Opamp, negativ tilbakekobling

Hva blir spenningen ut av opampen? (1K betyr 1 kOhm)



Skriv et tall: (-2.1 - -1.9)volt

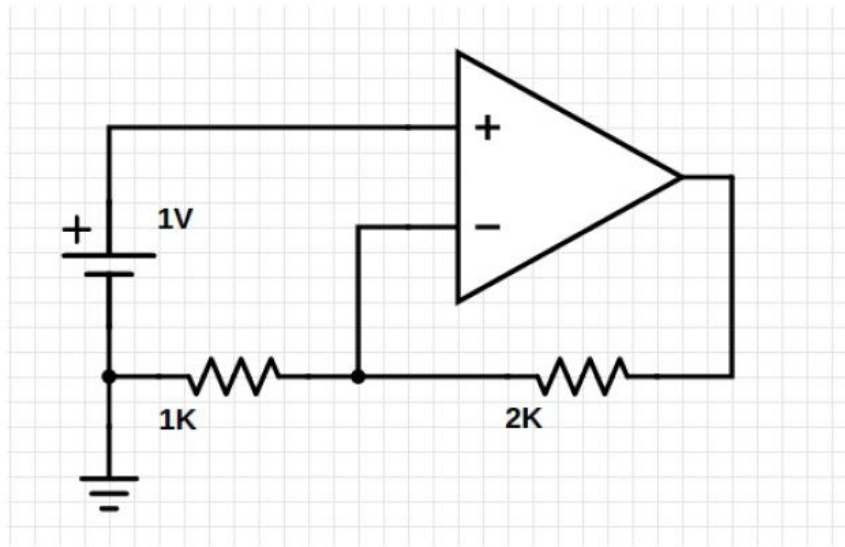
Vi ser at vi har negativ tilbakekobling $\Rightarrow V_+ = V_-$.

Ideell opamp $\Rightarrow I_{\text{inn}} = 0 \Rightarrow V_+ = 0V \Rightarrow V_- = 0V$

Kirchoff + Ideell opamp gir oss at strømmen gjennom (og følgelig spenningsfallet over) R_+ og R_f er like (NB: Feedbackmotstanden er kun den med node på minusinngangen). $\Rightarrow V_{\text{out}} = 0 - 2V = -2V$.

Opamp

What is the output voltage of the opamp? (1K betyr 1 kOhm)



Skriv et tall: (2.5 - 3.5)volt

Negativ feedback => $V_+ = V_-$

Ideell opamp => 0 strøm mellom + og - terminal.

=> V_- må være 1V, All strøm gjennom 1K motstand må gjennom 2K motstand =>

$I \cdot 1\text{k}\Omega = 1\text{V} \Leftrightarrow I = 1\text{mA}$, $1\text{V} + 1\text{mA} \cdot 2\text{k}\Omega = 3\text{V}$

Ideal electromotor

Given a DC motor with a coil resistance (R) of 0.5 Ohm and a motor constant (k) of 80 mNm/A. Without load, the motor runs at stable at 400 rad/s.

a) What will the dc voltage of the voltage source have to be under this condition?

Write your answer here: (31,9 - 32,2)Volt

Vi har $V = IR + k\omega$. For No load har vi $I = 0$

$\Rightarrow V = k\omega \Rightarrow V = 80\text{mNm/A} \cdot 400\text{rad/s} \Rightarrow V = 32\text{V}$

The supply voltage is now set to 20 v) What will the rotational speed be in this case?

Write your answer here: (249 - 251)rad/s

$20\text{V} = k\omega \Rightarrow \omega = 20\text{V}/k = 20\text{V}/(80\text{mNm/A}) = 250/\text{s} \text{ (rad/s)}$

The motor is set to do a job which reduces its speed to 10 rad/s. The supply voltage remains constant (20v)

c) What will be the current consumption under this condition?

Write your answer here: (37,9 - 38,5)A

$V = IR + k\omega \Rightarrow I = (V - k\omega)/R, \Rightarrow I = (20\text{V} - 80\text{mNm/A} \cdot 10\text{rad/s})/0,5\Omega = 2 \cdot 19,2\text{V} = 38,4\text{A}$

d) What is the torque of the motor? (The load and supply voltage remain the same as in c)

Write your answer here: (3,0 – 3,1)Nm

$\tau = kI, 38,4 \cdot 80\text{mNm/A} = 3,072\text{Nm}$

This motor will be used to lift a basket with beverages up one floor in a restaurant. It is connected to a drum with a 10 cm radius which winds up a rope lifting the basket. **The speed of the motor shall not exceed 100 rad/s.** The supply voltage will be 40 V DC. The chef gives the basket a little push as he sends the goods up one floor where the guests are. We ignore the weight of the basket and the rope, as well as friction and the diameter of the rope.

e) What is the maximum weight of the cargo which can be sent in the basket?

Write your answer here: (6 - 7)kg

Ve have max Torque at $\omega = 0$ (can be used with a slight push for start). Thus $\tau_{\max} = kI_{\max}$,

$I_{\max} = V/R$ ($V = IR + k\omega$, der $\omega = 0$) $\Rightarrow \tau_{\max} = kV/R = 80\text{mNm} \cdot 40\text{V}/0,5\Omega = 6,4\text{Nm}$

$\tau = r \times F$, r er normal på F $\Rightarrow F = \tau/r$, $r = 0,1\text{m} \Rightarrow F = 64\text{N}$

$F = mg$, $g = 9,81\text{m/s}^2 \Rightarrow m = F/g = 64\text{N}/9,81\text{m/s}^2 = 6,53\text{kg}$

f) What is the minimum weight of the cargo which can be sent in the basket without causing too high speed?

Write your answer here: (4,9 - 5,5)kg

$V = IR + k\omega \Rightarrow I = (V - k\omega)/R, \Rightarrow I = (40\text{V} - 80\text{mNm/A} \cdot 100\text{rad/s})/0,5\Omega = 2 \cdot 32\text{V} = 64\text{A}$

$\tau = kI = 80\text{mNm/A} \cdot 64\text{A} = 5,12\text{Nm}$

$\tau = r \times F$, r is perpendicular to F $\Rightarrow F = \tau/r$, $r = 0,1\text{m} \Rightarrow F = 51,2\text{N}$

$F = mg$, $g = 9,81\text{m/s}^2 \Rightarrow m = F/g = 51,2\text{N}/9,81\text{m/s}^2 = 5,22\text{kg}$

AD conversion

Assume a 3.3V AD converter with 10-bit precision with a dynamic area rail-to-rail, i.e from 0V til 3.3V. The sampling speed is 1 MHz.

a) How many levels can the AD converter distinguish between?

Write your answer here: 1023,1024 levels.

$$2^{10} = 1024$$

b) What is the minimum voltage difference between to levels? (Assume linearity over the whole area of operation).

Write your answer here: 3,3,5 mV

$$3,3V / 1024 = 3,22mV$$

The AD converter is embedded in a microcontroller and it is used in two ways. Either it samples the input at the highest frequency or it samples all eight inputs A0 to A7 in a fixed sequence. The actual sampling is done at the same fixed frequency.

We wish to connect five sensors to the AD converter.

c) What is the maximum frequency of any input signal of the five sensors without experiencing aliasing?

Write your answer here: 62,63 kHz

$$f_{AD} = 1MHz, f_{input} = f_{AD}/8 = 125kHz. f_{input} \text{ must be at least } 2 \times f_{signal} \Rightarrow f_{signal} = f_{input}/2 = 125kHz/2 = 62,5kHz$$

Imagine an input signal with -40dB noise and assume that the signal uses the whole dynamic area.

d) How many levels of the AD converter does the noise maximally correspond to?

$$-40dB \text{ (Level) er } 20 \log(V2/V1)$$

$$-2 = \log(V2/V1)$$

$$0,01 = V2/V1$$

$$V2 = 0,01 \cdot V1$$

$$V1 = 3,3V$$

$$V2 = 0,033V$$

$$V_{nivå} = 3,3/1024 \text{ (Alt } V1/1024)$$

$$V2/V_{nivå} = 0,033 \cdot 1024 / 3,3 = 10,24 \text{ (Alt } 0,01V1/(V1/1024) = 1024 \cdot 0,01 = 10,24)$$

(Både 10 og 11 godtas)