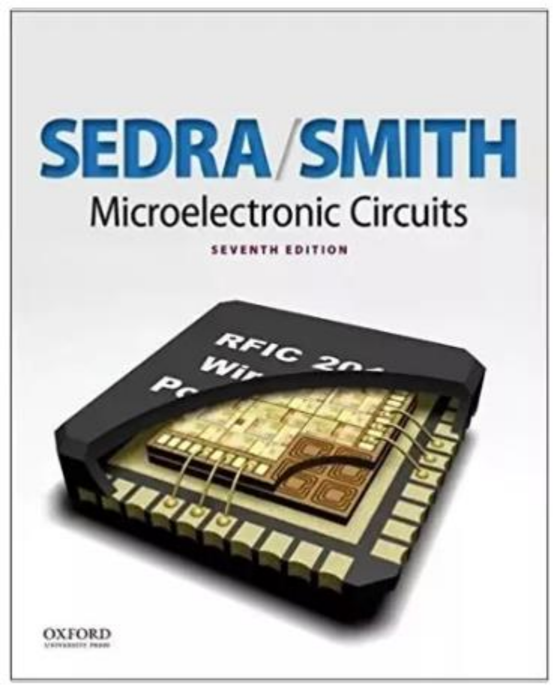
Lista Exercício 1 (Amp Op)



Oxford University Press
2015, 7th Edition

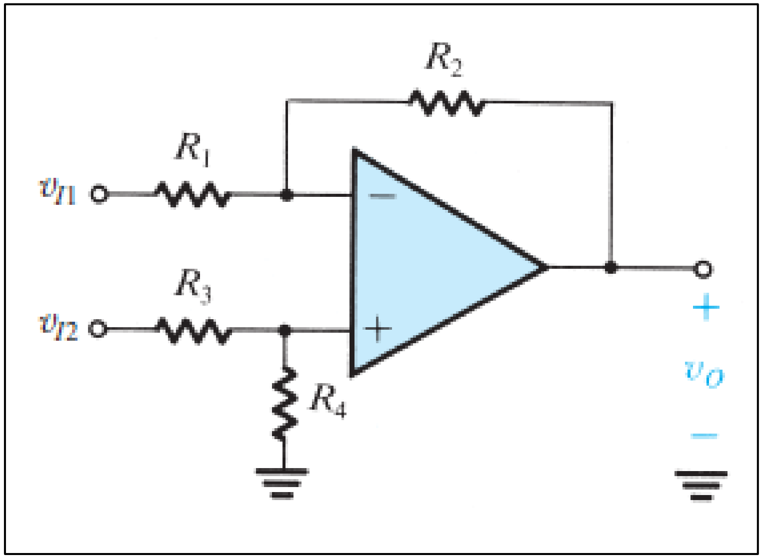
Exercício 1

Consider the single op-amp difference-amplifier circuit for the case R_1=R_3=2kΩ and R_2= R_4=200 kΩ. The resistors have 1% tolerance.

a) Find the interval value of the differential gain A_d.

b) Find the interval values of the differential input resistance R_{id} and the output resistance R_o.

c) The best-case and worst-case common-mode gain A_{cm} and the corresponding value of CMRR.



$$A_d = \frac{R_2}{R_1}$$

$$R_{id} = 2\,R_1$$

$$A_{cm} = \frac{R_4}{R_4 + R_3}\left(1 - \frac{R_2}{R_1}\frac{R_3}{R_4}\right)$$

a) Find the interval value of the differential gain A_d.

$R_1=R_3=2\text{k}\Omega$ e $R_2= R_4=200\ \text{k}\Omega$

1% tolerância

$$A_d = \frac{R_2}{R_1}$$

$$A_{d(max)} = \frac{R_2}{R_1} = \frac{200k \times 1.01}{2k \times 0.99} \cong 101,01$$

$$A_{d(min)} = \frac{R_2}{R_1} = \frac{200k \times 0.99}{2k \times 1.01} \cong 98,02$$

$$98,02 < A_d < 101,01$$

b) Find the interval values of the differential input resistance R_{id} and the output resistance R_o.

$$R_{id} = 2\ R_1$$

$$R_{id(max)} = 2\ x\ (2k \times 1.01) = 4.04K\Omega$$

$$R_{id(min)} = 2\ x\ (2k \times 0.99) = 3.96K\Omega$$

$$3.96K\Omega < R_{id} < 4.04K\Omega$$

$$A_{cm} = \frac{R_4}{R_4 + R_3}\left(1 - \frac{R_2}{R_1}\frac{R_3}{R_4}\right)$$

R_1=R_3=2kΩ e R_2= R_4=200 kΩ
(1% tolerância)

c) Melhor e pior caso:

Pior caso: maior A_{cm}

Melhor caso: menor A_{cm}

Não é trivial determinar quais valores de R_1, R_2, R_3, R_4 maximizam A_{cm} e quais valores minimizam A_{cm} utilizando=se a tolerância dos resistores. Nesta solução o valor de A_{cm} foi determinado para o máximo e mínimo valor de $(R_2R_3)/(R_1R_4)$.

- Cálculo de A_{cm} quando $(R_2R_3)/(R_1R_4)$ é máximo, optando por maximizar o segundo termo do produto:

$$A_{cm} = \frac{(200k \times 1.01)}{(200k \times 1.01)+(2k \times 0{,}99)}\left(1 - \frac{(200k \times 0.99) \times (2k \times 0.99)}{(2k \times 1.01)(200k \times 1.01}\right) \cong 0{,}03883$$

$|A_{cm}| = 0{,}03883$ → $|CMRR_{(max)}| = \frac{101{,}01}{0.03883}$ = 68.30dB

- Cálculo de A_{cm} quando $(R_2R_3)/(R_1R_4)$ é mínimo, optando por minimizar o segundo termo do produto: :

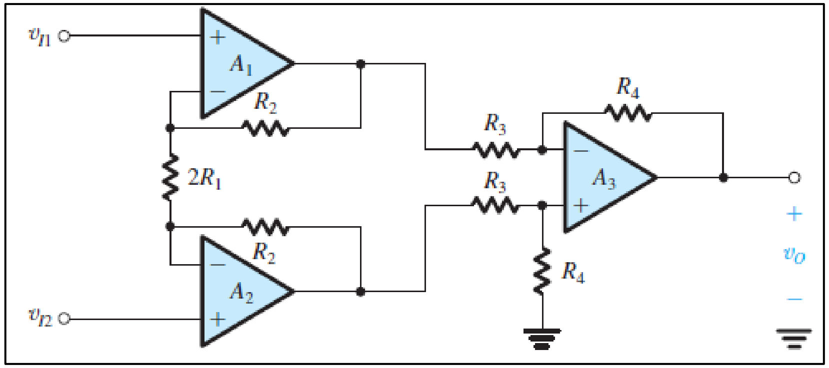
$$A_{cm} = \frac{(200k \times 0.99)}{(200k \times 0.99) + (2k \times 1.01)}\left(1 - \frac{(200k \times 1.01)(2k \times 1.01)}{(2k \times 0.99)(200k \times 0.99)}\right) \cong -0{,}03999$$

$|A_{cm}| = 0{,}03999$ → $|CMRR_{(min)}| = \frac{98.92}{0{,}03999}$ = 67.87dB

→ $67{,}87 \leq CMRR \leq 68{,}39$

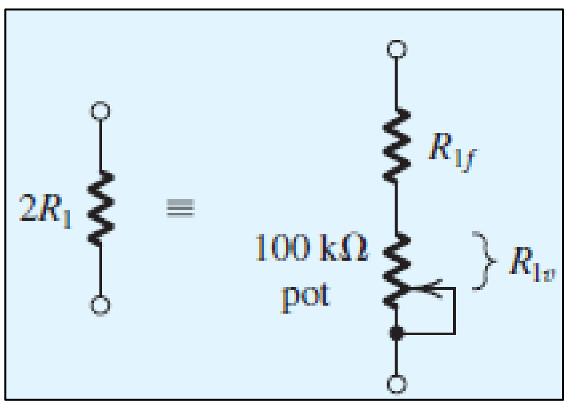
Exercício 2

Design an instrumentation amplifier (IA) to provide a gain that can be varied over the range of 2 to 1000 utilizing a 100-kΩ variable resistance. Consider $R_3 = R_4$.



$$G = \left(1 + \frac{2R_2}{R_g}\right)$$

Solução 1: IA não integrado (não é utilizada)



$$1 + \frac{2R_2}{R_{1f} + R_{1v}} = 2 \text{ to } 1000$$

$$\begin{cases} 1 + \dfrac{2R_2}{R_{1f} + 100\ \text{k}\Omega} = 2 \\ 1 + \dfrac{2R_2}{R_{1f}} = 1000 \end{cases}$$

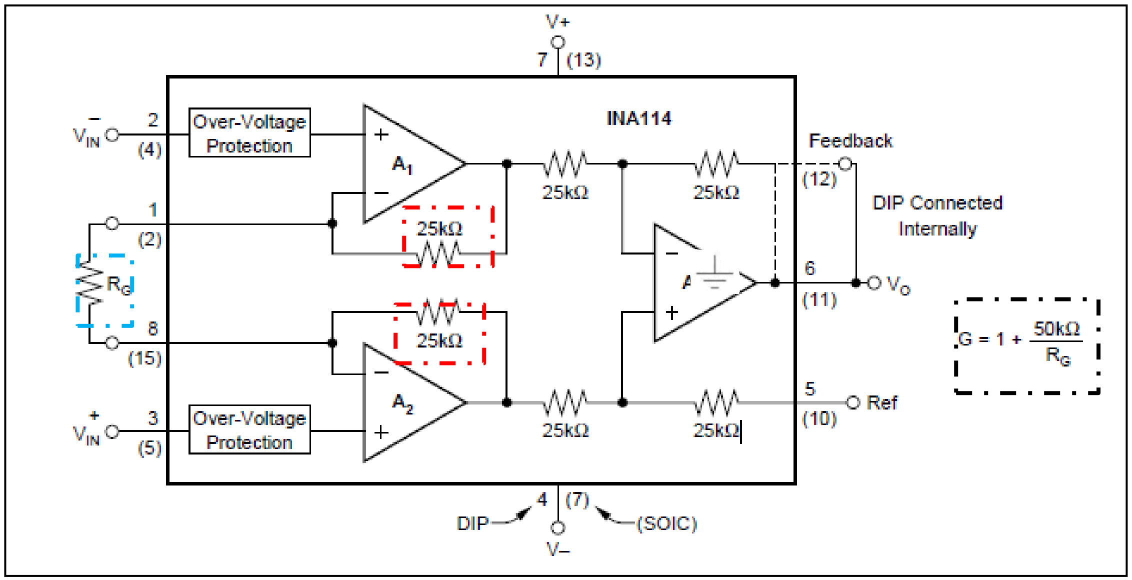
$$\begin{cases} R_{1f} = 100.2\ \Omega \\ R_2 = 50.050\ \text{k}\Omega \end{cases}$$

R_{if} = 100Ω (1% tolerance)

R_2 = 50KΩ (1% tolerance)

Solução 2: IA integrado

INA114
(tecnologia BJT)



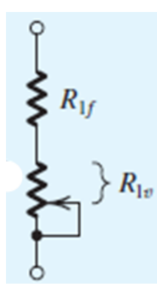
$$R_g = R_{1f} + R_{1v}$$

$$G_{max} = 1000 = 1 + \frac{50K}{R_{1f} + 0} \quad (1)$$

$$G_{min} = 2 = 1 + \frac{50K}{R_{1f} + R_{1v}} \quad (2)$$

(1) e (2) → R_{1f} e R_{1v}

R_g =



Exercício 3

An op amp has a rated output voltage of ± 10V. and a slew rate of 1 V/μs.

a) What is its full-power bandwidth?

$$f_M = \frac{SR}{2\pi V_{Omax}} \cong 15.9\text{KHz}$$

b) If an input sinusoid with frequency $f = 5f_M$ is applied to a unity-gain follower constructed using this op amp, what is the maximum possible amplitude that can be accommodated at the output without incurring SR distortion?

Se f = f $_{M1}$ → $f_{M1} = \dfrac{SR}{2\pi V_{Omax1}}$

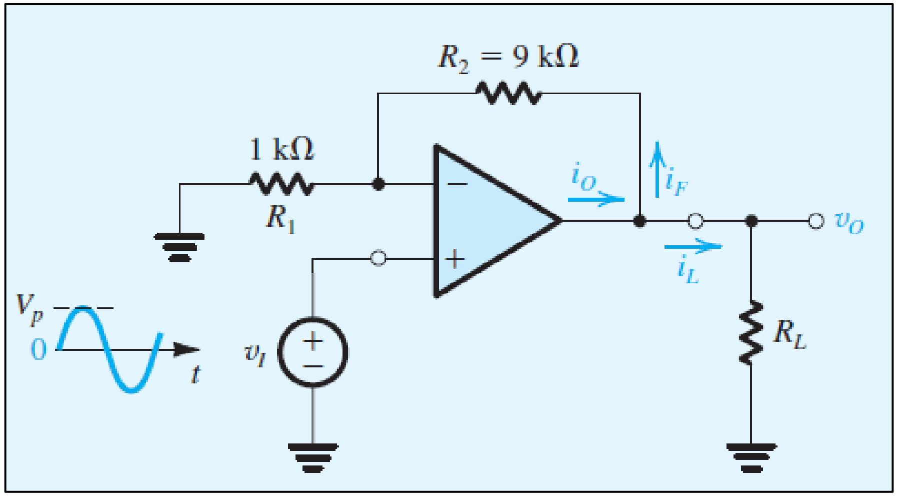
Se f = f $_{M2}$ → $f_{M2} = \dfrac{SR}{2\pi V_{Omax2}}$

→ $V_{omax2} = V_{omax1}\left(\dfrac{f_{M1}}{f_{M2}}\right)$

→ $$V_{omax2} = 10\left(\frac{f_{M1}}{5f_{M1}} = 2V_{(peak)}\right)$$

Exercício 4

Consider the noninverting amplifier circuit shown below. The circuit is designed for a nominal gain $(1+ R_2 /R_1)$=10V/V. It is fed with a low-frequency sine-wave signal of peak voltage V_P and is connected to a load resistor R_L. The op amp is specified to have output saturation voltages ± 13V and output current limits of ± 20mA.



a) For V_p = 1 V and R_L = 1 kΩ, specify the signal resulting at the output of the amplifier.

b) For V_p = 1.5 V and R_L = 1 kΩ, specify the signal resulting at the output of the amplifier.

c) For R_L= 1kΩ, what is the maximum value of V_p for which an undistorted sine-wave output is obtained ?

d) For V_p = 1V, what is the lowest value of R_L for which an undistorted sine-wave output is obtained?

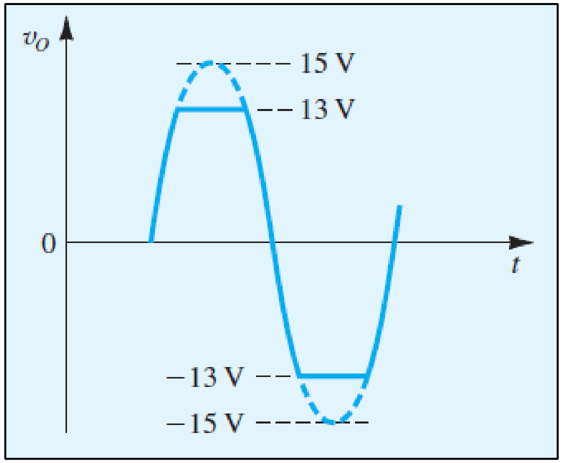
a) For $V_p = 1$ V and $R_L = 1$ kΩ, specify the signal resulting at the output of the amplifier.

Se $V_p = 1$ V e $R_L = 1$ kΩ, a saída será um sinal senoidal com pico de 10 V. Este é menor que o nível de saturação de ± 13V e não haverá corte do sinal na saída.

Quando $V_{saída}$ =10 V e a corrente será I_L=(10V)/1kΩ=10mA.
A corrente na malha de realimentação será I_F =10V/(9+1)kΩ=1mA.
A corrente total de saída será I_o =11 mA < $I_{o(max)}$=20 mA.

b) For $V_p = 1.5$ V and $R_L = 1$ kΩ, specify the signal resulting at the output of the amplifier.

Se V_p é 1.5 V, idealmente a saída será um sinal senoidal com 15V de pico. O op amp satura em ± 13V, assim o sinal de saída será cortado.
Se a saída é 13V e $R_L = 1$ kΩ, $i_L = 13$ mA and $i_F = 1.3$ mA. Logo, $i_O = 14.3$ mA < $I_{o(max)}$=20 mA.
A saída terá um corte com pico ± 13V, como mostrado abaixo.



c) For R_L= 1kΩ, what is the maximum value of V_p for which an undistorted sine-wave output is obtained ?

Se R_L= 1kΩ, o máximo valor de V_p para uma saída senoidal não distorcida é 1.3 V.
A saída será uma senóide com 13V de pico e corrente de saída de 14.3 mA.

d) For V_p = 1V, what is the lowest value of R_L for which an undistorted sine-wave output is obtained?

Se V_p = 1V , o menor valor de R_L para uma saída com 10V de pico é:

$$i_{o(max)} = 20 = \frac{10}{R_{L(min)}} + \frac{10}{9+1} \longrightarrow \boxed{R_{L(min)} = 526\Omega}$$