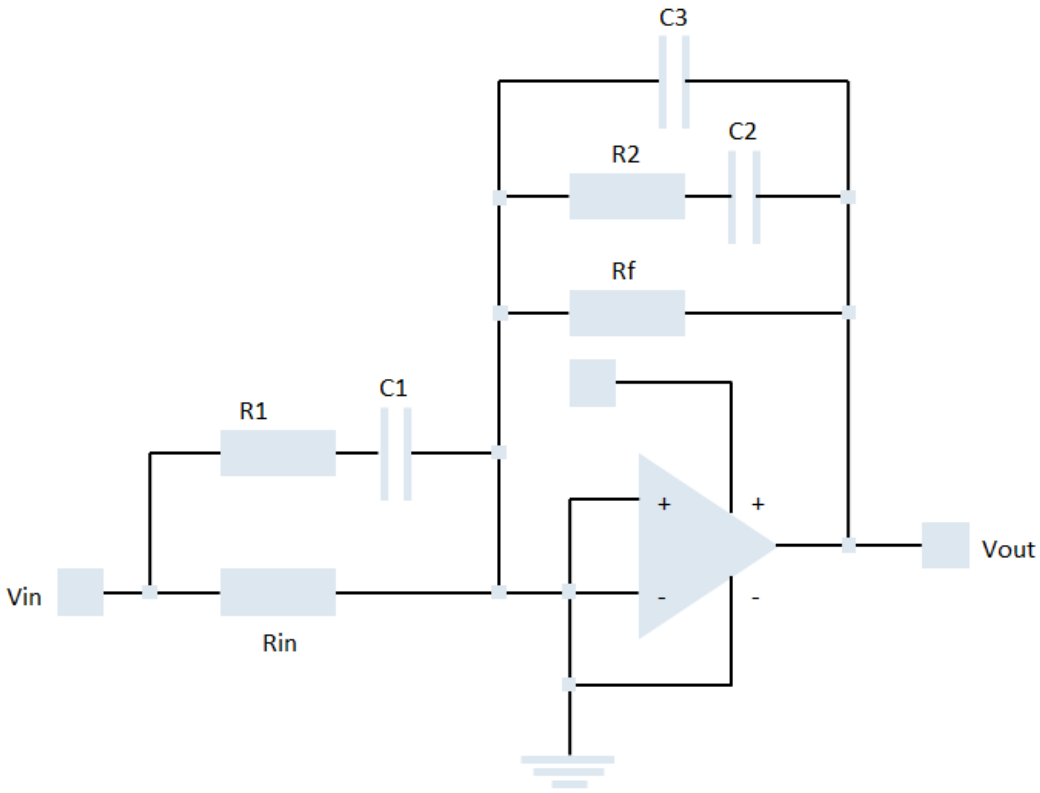
Amplifier Gain

Introduction

In this application, we will plot the gain of the following amplifier circuit, for both the ideal and non-ideal response.

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> restart :
  with( DynamicSystems ) :
  with( plots ) :
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Parameters

> $R_1 := 1000$:

> $C_1 := 10^{-7}$:

> $R_{In} := 1000$:

> $C_3 := 4.7 \cdot 10^{-8}$:

> $R_2 := 1000$:

> $C_2 := 4.70 \cdot 10^{-7}$:

> $R_f := 10^{102}$:

Amplifier bandwidth factors:

> GBP $:= 10^6$:

> LPF $:= 300$:

Support Function

> $\mathrm{II} := (Z1, Z2) \rightarrow \dfrac{Z1 \cdot Z2}{Z1 + Z2}$:

Transfer functions

> $Z_1 := R_1 + \dfrac{1}{s \cdot C_1}$:

> $Z_2 := R_2 + \dfrac{1}{s \cdot C_2}$:

> $Z_{In} := \mathrm{II}(R_{In}, Z_1)$:

> factor(Z_{In})

$$\frac{500\,(s + 10000)}{s + 5000} \tag{4.1}$$

> $Z_{fb} := \mathrm{II}\left(R_f, \mathrm{II}\left(Z_2, \dfrac{1}{s \cdot C_3}\right)\right)$:

Ideal amplifier gain:

> $G_{EAideal} := \mathrm{factor}\left(\dfrac{Z_{fb}}{Z_{In}}\right)$

$$G_{EAideal} := \frac{42553.19148\,(s + 2127.659574)\,(s + 5000.)}{(s + 1.93423597710^{-96})\,(s + 23404.25531)\,(s + 10000.)} \tag{4.2}$$

Non-ideal op-amp effects: Finite open loop gain

> $\beta := \dfrac{1}{1 + G_{EAideal}}$:

Finite open loop gain

> $A_{vo} := \frac{GBP}{LPF} \cdot \frac{1}{\left(1 + \frac{s}{2 \cdot \pi \cdot LPF}\right) \cdot \left(1 + \frac{s}{2 \cdot \pi \cdot GBP}\right)}$

$$A_{vo} := \frac{10000}{3\left(1 + \frac{s}{600\,\pi}\right)\left(1 + \frac{s}{2000000\,\pi}\right)} \tag{4.3}$$

> simplify((4.3), 'size')

$$\frac{4000000000000\,\pi^2}{(600\,\pi + s)\,(2000000\,\pi + s)} \tag{4.4}$$

Non-ideal error amplifier gain:

> $G_{EA} := \text{simplify}\left(G_{EAideal} \cdot \frac{1}{1 + \frac{1}{A_{vo} \cdot \beta}}\right)$

$$G_{EA} := \left(1.78716240910^{25} + 1.6799326410^{18} s^2 + 1.1973988110^{22} s\right) / \left(5.3614872221054410^{21} + s^5 + 6.3610277091157110^{6} s^4 + 3.9968196384156710^{13} s^3 + 1.3230244629712310^{18} s^2 + 9.2488389486204110^{21} s\right) \tag{4.5}$$

Analysis

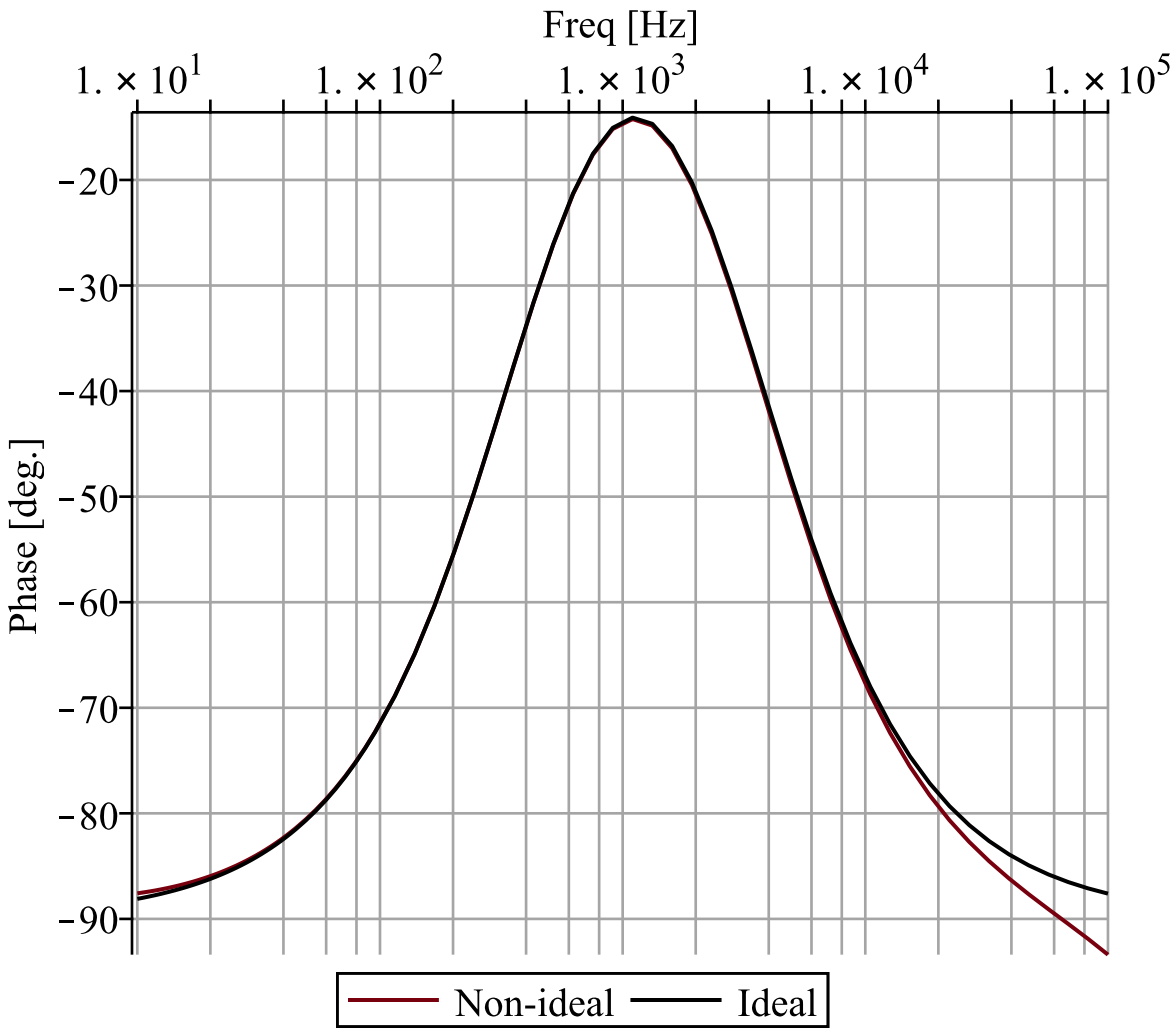
> sys1 := TransferFunction(G_{EA}) :

> sys2 := TransferFunction($G_{EAideal}$) :

> p1 := PhasePlot(sys1, range = 10 ..100000 , hertz = true, legend = "Non-ideal") :

> p2 := PhasePlot(sys2, range = 10 ..100000 , hertz = true, legend = "Ideal" , color = black) :

> display(p1, p2)


Freq [Hz]
1. × 10^1
1. × 10^2
1. × 10^3
1. × 10^4
1. × 10^5
Phase [deg.]
-20
-30
-40
-50
-60
-70
-80
-90
Non-ideal
Ideal

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