12

9.29

The element values of a parallel RLC circuit are $R = 100\ \Omega$, $L = 10\ mH$, and $C = 0.4\ mF$. Determine $\omega_0, Q, B, \omega_{c_1}, \omega_{c_2}$.

✓ **Answer**

$\omega_0 = \frac{1}{\sqrt{LC}} = 500$
$Q = \frac{R}{\omega_0 L} = 20$
$B = \frac{\omega_0}{Q} = 25$
$\omega_c = \omega_0 \left(\sqrt{1 + \frac{1}{4Q^2}} \pm \frac{1}{2Q}\right) = 512, 488$

9.41

a

Obtain an expression for $\mathbf{H}(\omega) = \mathbf{V}_0 / \mathbf{V}_s$ in standard form.

✓ **Answer**

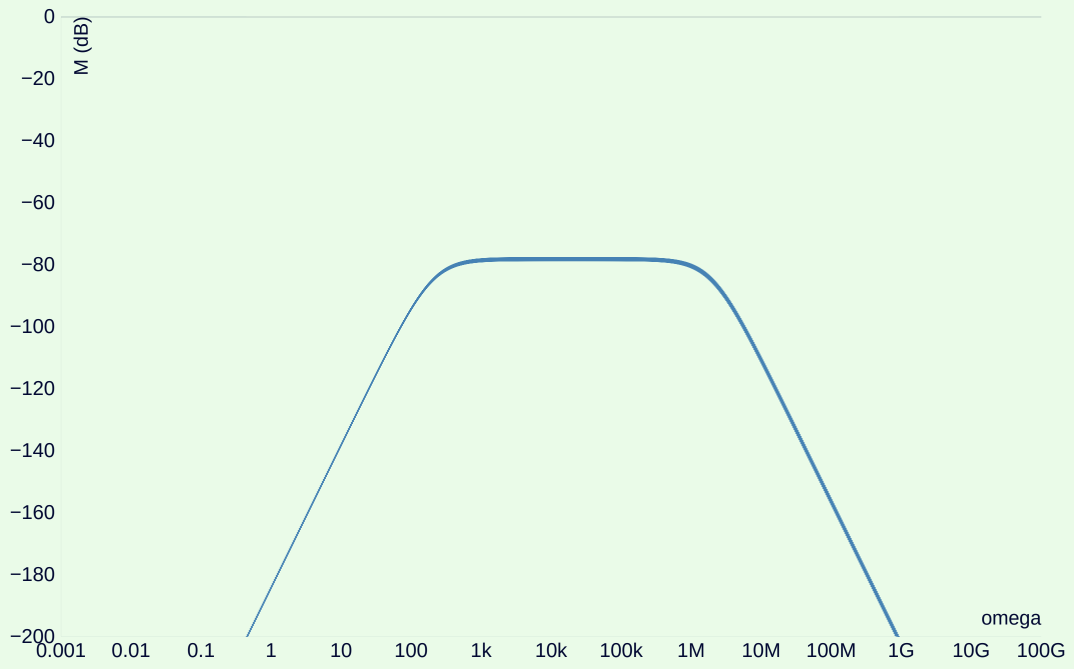
$Z_1 = R_1 + C_1 = R_1 - \frac{i}{\omega C_1}$
$Z_2 = R_2 \parallel C_2 = \frac{1}{\frac{1}{R_2} + i\omega C_2}$
$\mathbf{V}_0 = -\frac{Z_2}{Z_1} V_s$
$\mathbf{H}(\omega) = -\frac{Z_2}{Z_1} = -\frac{1}{(\frac{1}{R_2} + i\omega C_2)(R_1 - \frac{i}{\omega C_1})}$
$= \frac{i\omega C_1 R_2}{(1 + i\omega C_2 R_2)(1 + i\omega C_1 R_1)}$
$= (C_1 R_2)(i\omega)(1 + i\omega C_2 R_2)^{-1}(1 + i\omega C_1 R_1)^{-1}$

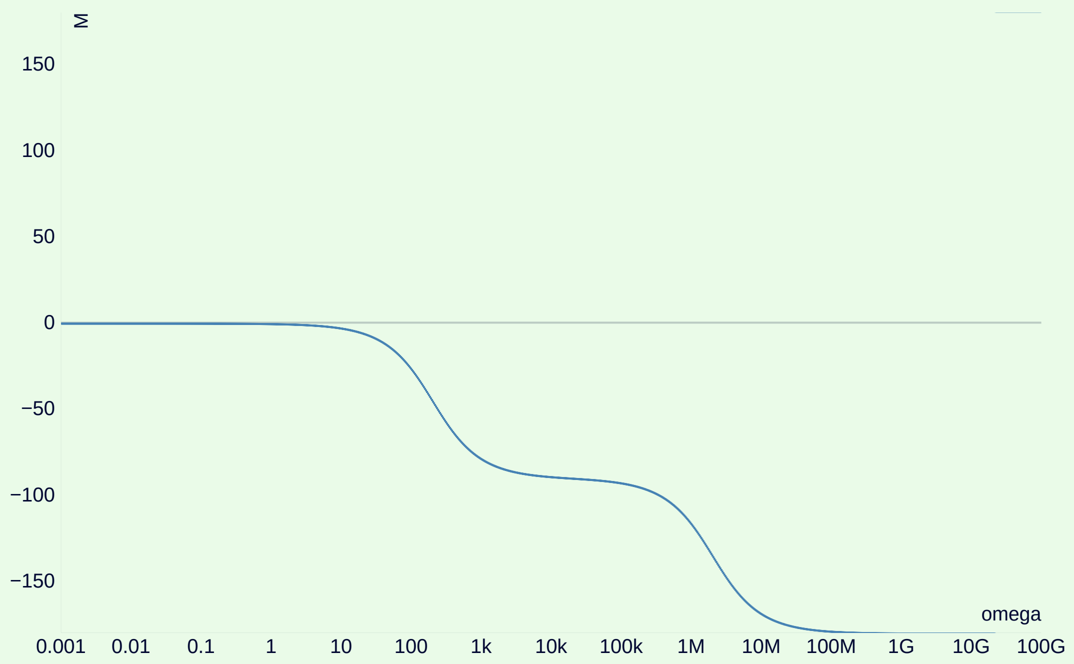
$M(\omega) = (C_1 R_2)(\omega)(\sqrt{1 + \omega^2 C_2^2 R_2^2})^{-1}(\sqrt{1 + \omega^2 C_1^2 R_1^2})^{-1}$
$\phi(\omega) = -\arctan(\omega C_2 R_2) - \arctan(\omega C_1 R_1)$

b

Generate spectral plots for the magnitude and phase of $\mathbf{H}(\omega)$, given that $R_1 = 1\ k\Omega$, $R_2 = 20\ \Omega$, $C_1 = 5\ \mu F$, and $C_2 = 25\ nF$.

✓ **Answer**





c

What type of filter is it? What is its maximum gain?

Answer

Bandpass, max gain of $-78\ dB$

11.1

Determine i_L and the average power dissipated in R_L.

✓ **Answer**

$\omega = 377$

$-12 + i_1\left(14 - 26.52519893899204j + 3.77j\right) + i_L\left(2.262j\right) = 0$

$i_L(30 + 10 + 11.31j) + i_1(2.262j) = 0$

$i_L = 0.0244\angle - 47.57^\circ\ A$

$P = \frac{1}{2}|i_L|^2 R = 2.98\ mW$

11.3

Determine $\mathbf{V}_{out}$.

✓ **Answer**

$10 = i_1(4 + 3j + 4j - 2j) + i_2(-2j)$

$0 = i_2(2 - 2j + 6j) + i_1(-2j)$

$i_1 = 1.189189189189189 - 1.135135135135135j$

$i_2 = 0.7027027027027025 - 0.2162162162162162 17j$

$V_{out} = 0.43243243243243235 + 1.405405405405405j$

$= 1.47\angle 72.9^\circ\ V$

11.12

Determine $\mathbf{I}_x$ given $\mathbf{V}_s = 20\angle 30^\circ\ V$.

✓ **Answer**

```
from sympy import symbols, solve
from sympy.matrices import Matrix
from cmath import rect
from math import pi

i1, i2, i3 = symbols("i1, i2, i3")
vi = symbols("v_i")
r, L = symbols("R, L")
omega = symbols("\\omega")

R = Matrix([[2+4j, -4j, 0], [-4j, 4-10j, -8j], [0, -8j, 6+16j]])
I = Matrix([[i1, i2, i3]]).T
V = Matrix([[rect(20, 30/180*pi), 0, 0]]).T
```

```
S = solve([R*I - V], i1, i2, i3)

display((i3).subs(S).simplify())
```

$I_x = -0.377712812181087 + 0.268068215450426i$
$= 0.4631711742115666\angle 144.63612964989045^\circ\ A$