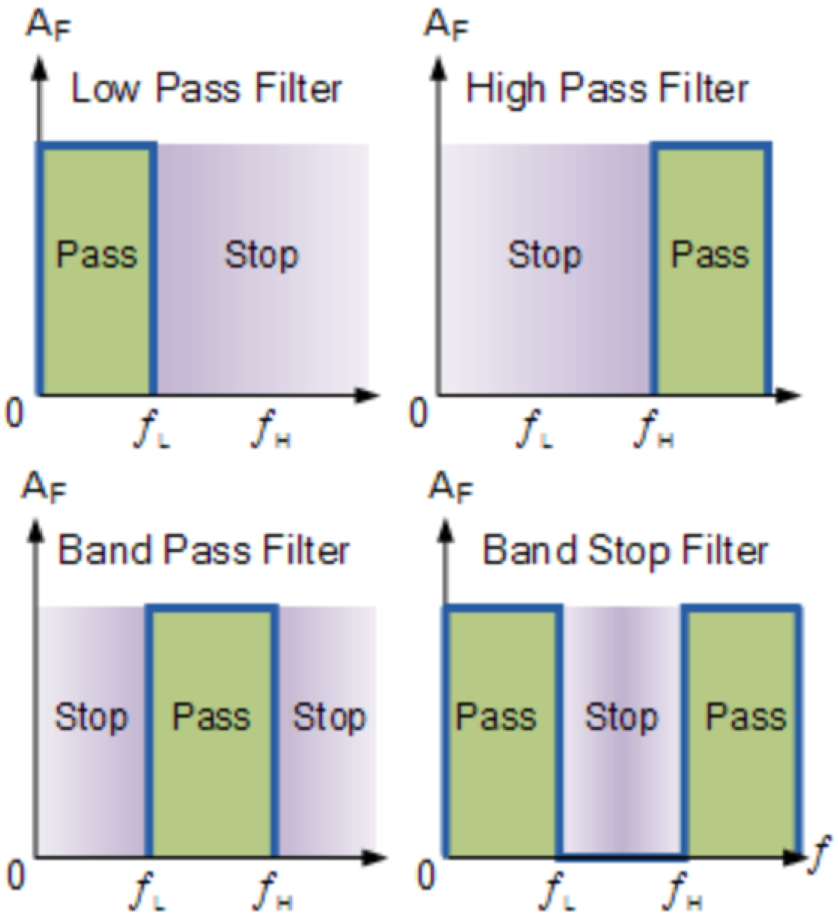
# Electronic Circuits

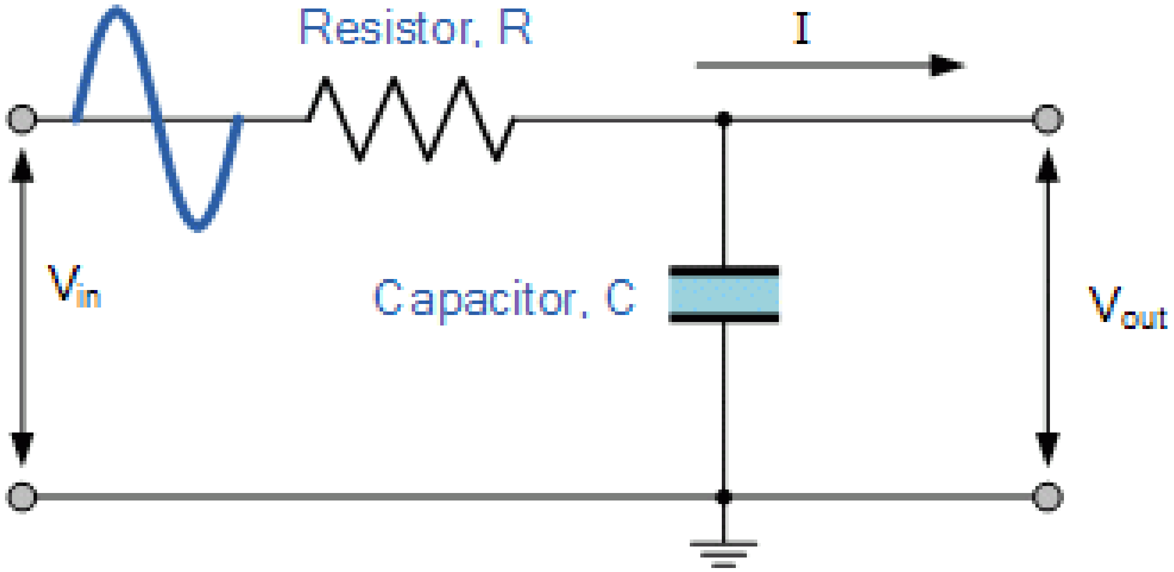
Lecture 3.1: Filters & Passive Filter Examples

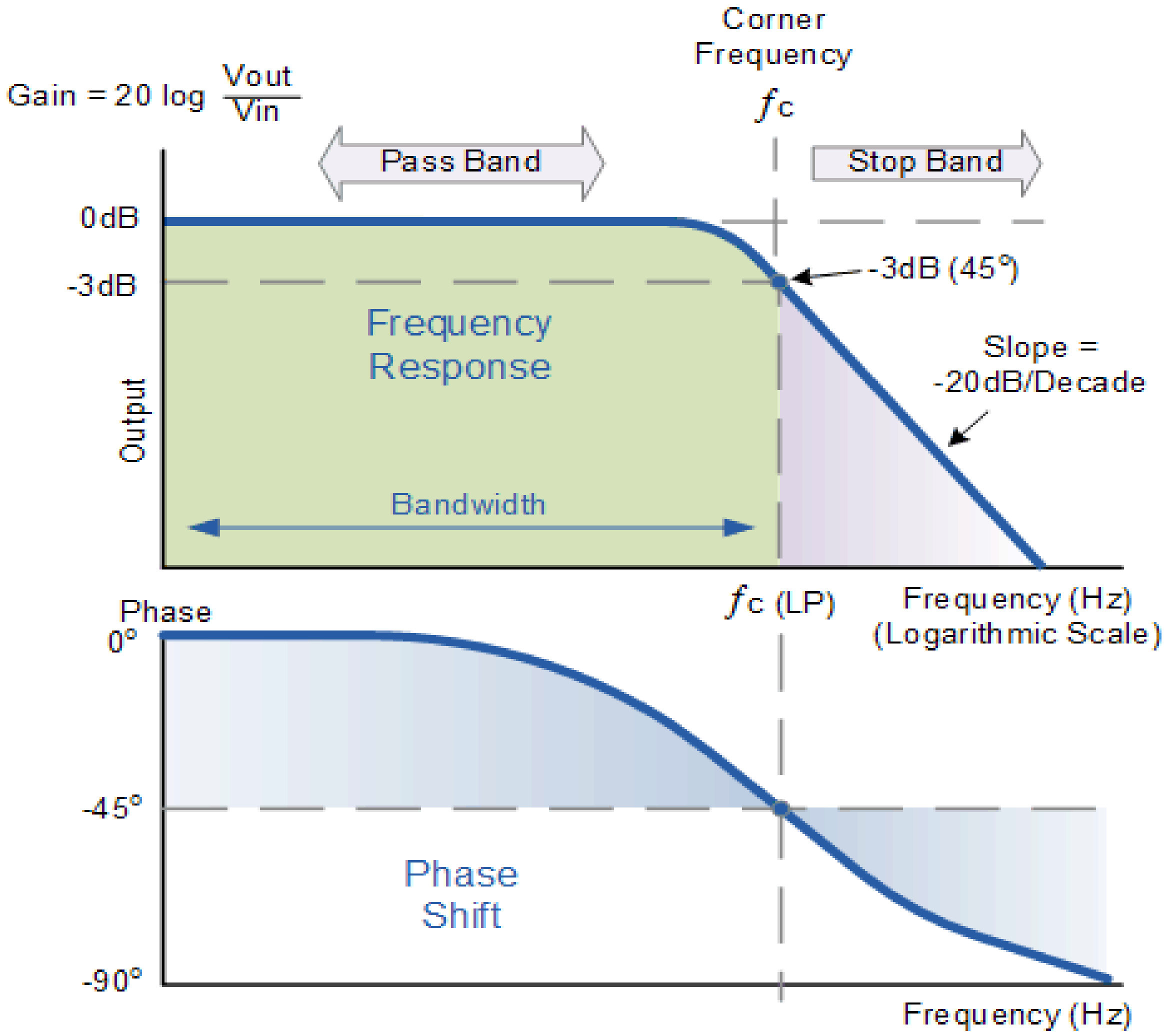
# Ideal Filter Types

- The Low-Pass Filter only allows low frequency signals from 0Hz to its cut-off frequency, ƒc point to pass while blocking those any higher.
- The High-Pass Filter only allows high frequency signals from its cut-off frequency, ƒc point and higher to infinity to pass through while blocking those any lower.
- The Band-Pass Filter allows signals falling within a certain frequency band setup between two points to pass through while blocking both the lower and higher frequencies either side of this frequency band.
- The Band-Stop Filter blocks signals falling within a certain frequency band setup between two points to pass through while allowing both the lower and higher frequencies either side of this frequency band.
- The All-Pass Filter allows all frequencies but just shifting the phase only.



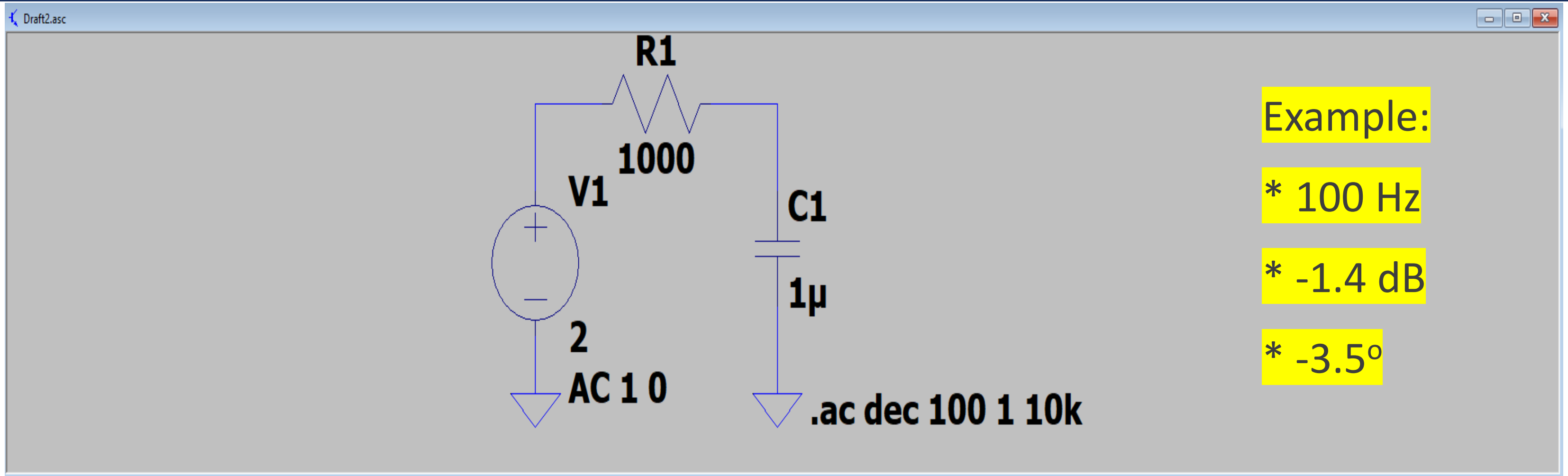
# First-Order Low-Pass Passive Filter

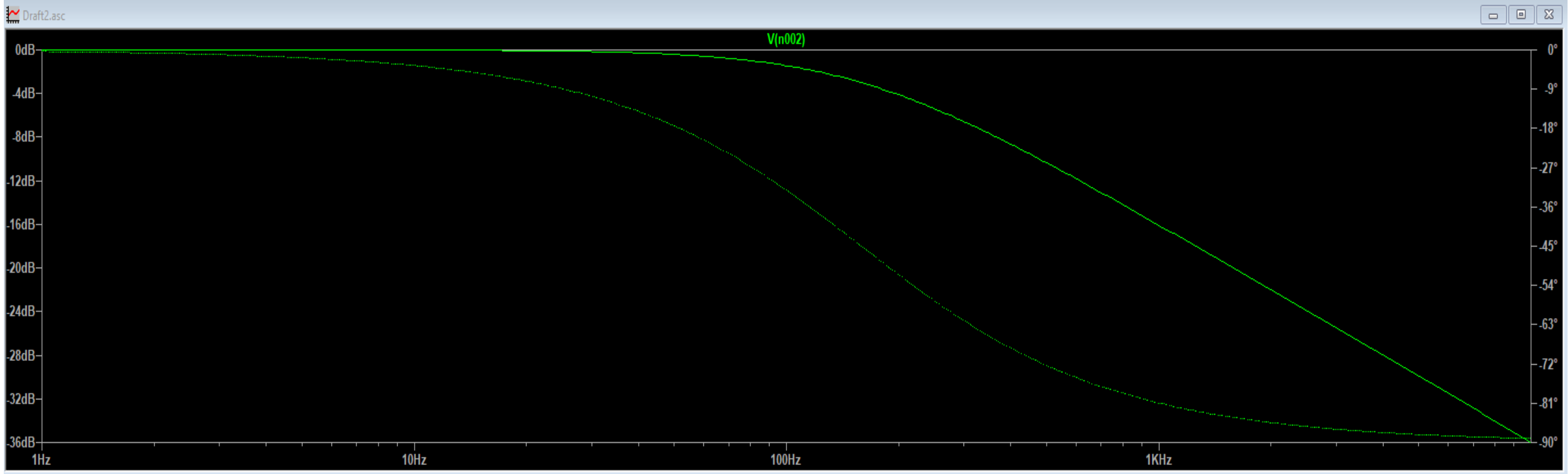



The corner freuency (fc) is defined as the half-power freuency since the power transferred to the output at this specific freuencies is the half of its maximum.This is the value to describe filter characteristics.

# First-Order Low-Pass Passive Filter Example




* Draft1.asc

C1 N002 0 1u

R1 N002 N001 1000

V1 N001 0 2 AC 1 0

.ac dec 100 1 10k

.end

# Analysis of First-Order Low-Pass Passive Filter (1)

$$-V_1(s) + R_1 * I(s) + \frac{1}{s * C_1} * I(s) = 0$$

$$V_c(s) = \frac{1}{s * C_1} * I(s) \rightarrow I(s) = s * C_1 * V_c(s)$$

$$V_1(s) = \left(R_1 + \frac{1}{sC_1}\right) * s * C_1 * V_c(s)$$

**The fraction of the output function to the input function is called transfer function, and its symbol is H:**

$$\mathrm{H(s)} = \frac{V_c(s)}{V_1(s)} = \frac{1}{\left(R_1 + \frac{1}{sC_1}\right) * s * C_1} = \frac{1}{1 + s * R_1 * C_1}$$

# Analysis of First-Order Low-Pass Passive Filter (2)

**After determining the transfer function, when you change the input signal, it is enough to multiply H(s) and the Laplace equivalent of the new input function gives the Laplace equivalent of the new output function. So, transfer function is the characateristic equation of a given system.**

**Although s = α+jω = α+j2πf is the complex frequency, we are interested in frequency (f or ω). Hence, we accept α=0 here.**

$$\mathrm{H}(\mathrm{j}\omega) = \frac{1}{1 + j * \omega * R_1 * C_1}$$

**Thanks to complex analysis, we can determing the amplitude (**$|H| = \frac{1}{\sqrt{1+(\omega * R_1 * C_1)^2}}$**) and the phase (**$\langle H = -\tan^{-1}(\omega * R_1 * C_1)$**).**

# Analysis of First-Order Low-Pass Passive Filter (3)

**The corner freuency is defined as half-power frequency. Since H is defined the ratio of voltages, the power can be defined as the square of it. Hence,**

$$|\mathrm{H}(\mathrm{j}\omega_c)|^2 = \frac{1}{2} * |\mathrm{H}|^2_{max}$$

**and**

$$\left|\frac{1}{\sqrt{1+(\omega_c * R_1 * C_1)^2}}\right|^2 = \frac{1}{2}$$

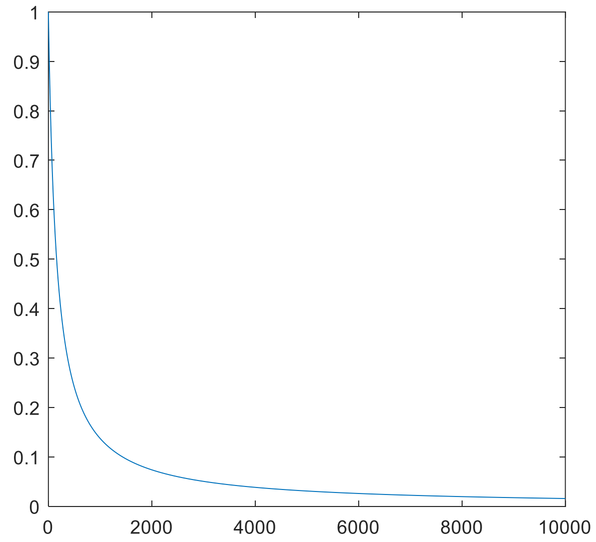
$$\omega_c * R_1 * C_1 = 1$$

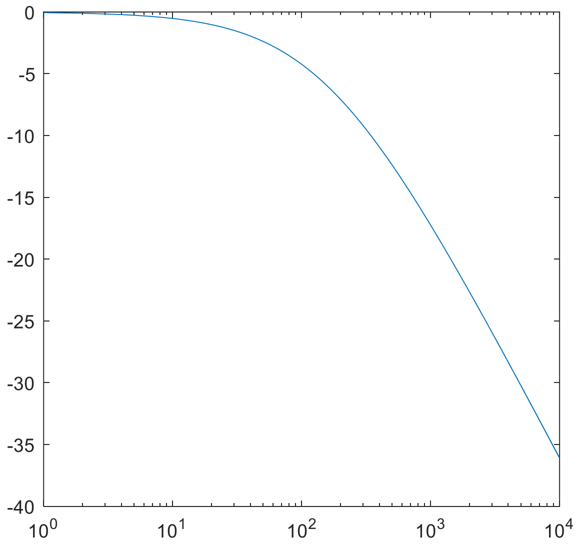
$$\omega_c = \frac{1}{R_1 * C_1}$$

$$\mathrm{f}_c = \frac{1}{2 * \pi * R_1 * C_1}$$

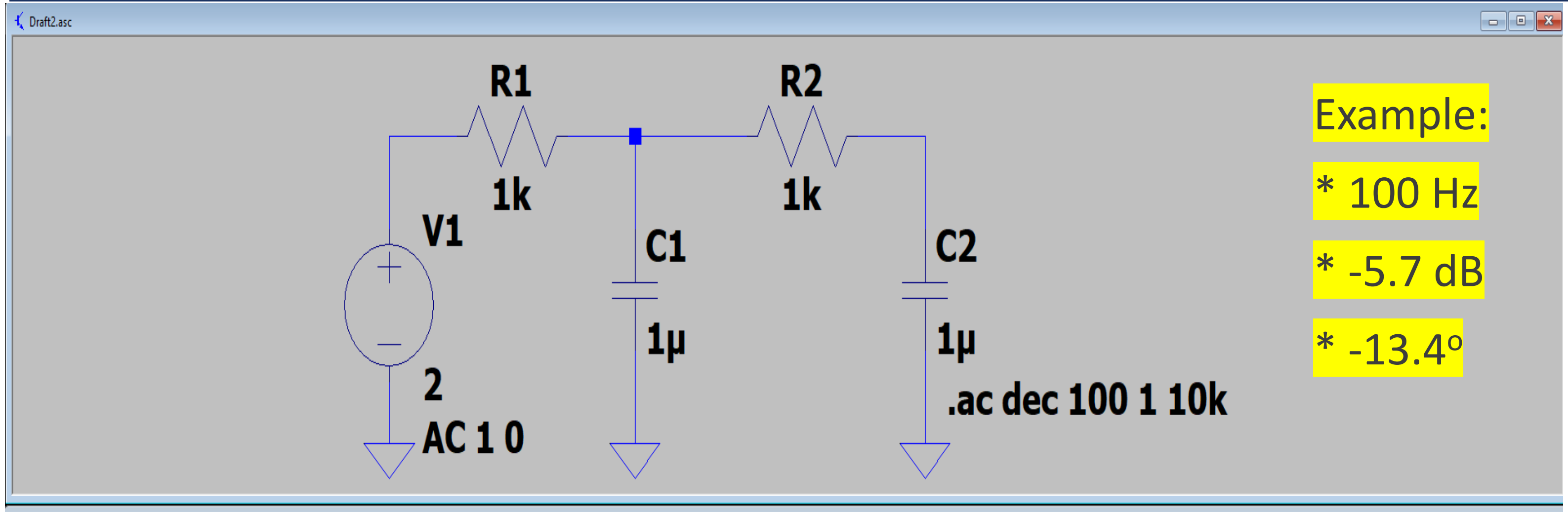
$$\mathrm{f}_c = \mathbf{159.2\ Hz}$$

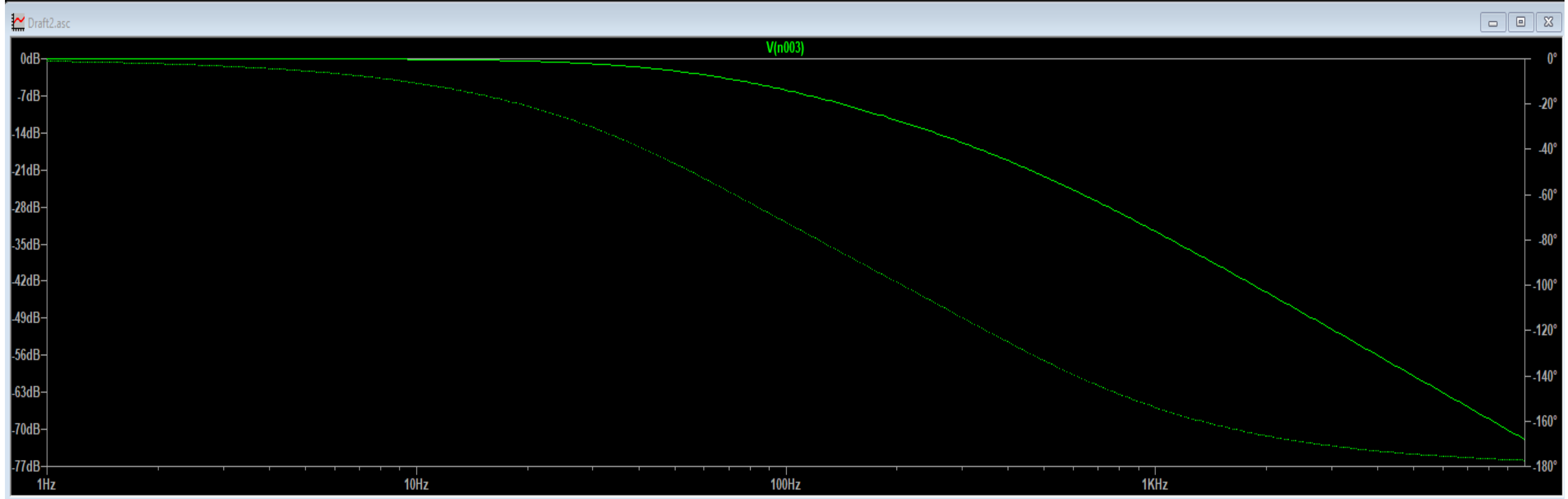
$\omega_c$ =**1000 rad/sec**



# Second-Order Low-Pass Passive Filter Example




* Draft2.asc

C1 N002 0 1u

R1 N002 N001 1k

V1 N001 0 2 AC 1 0

R2 N003 N002 1k

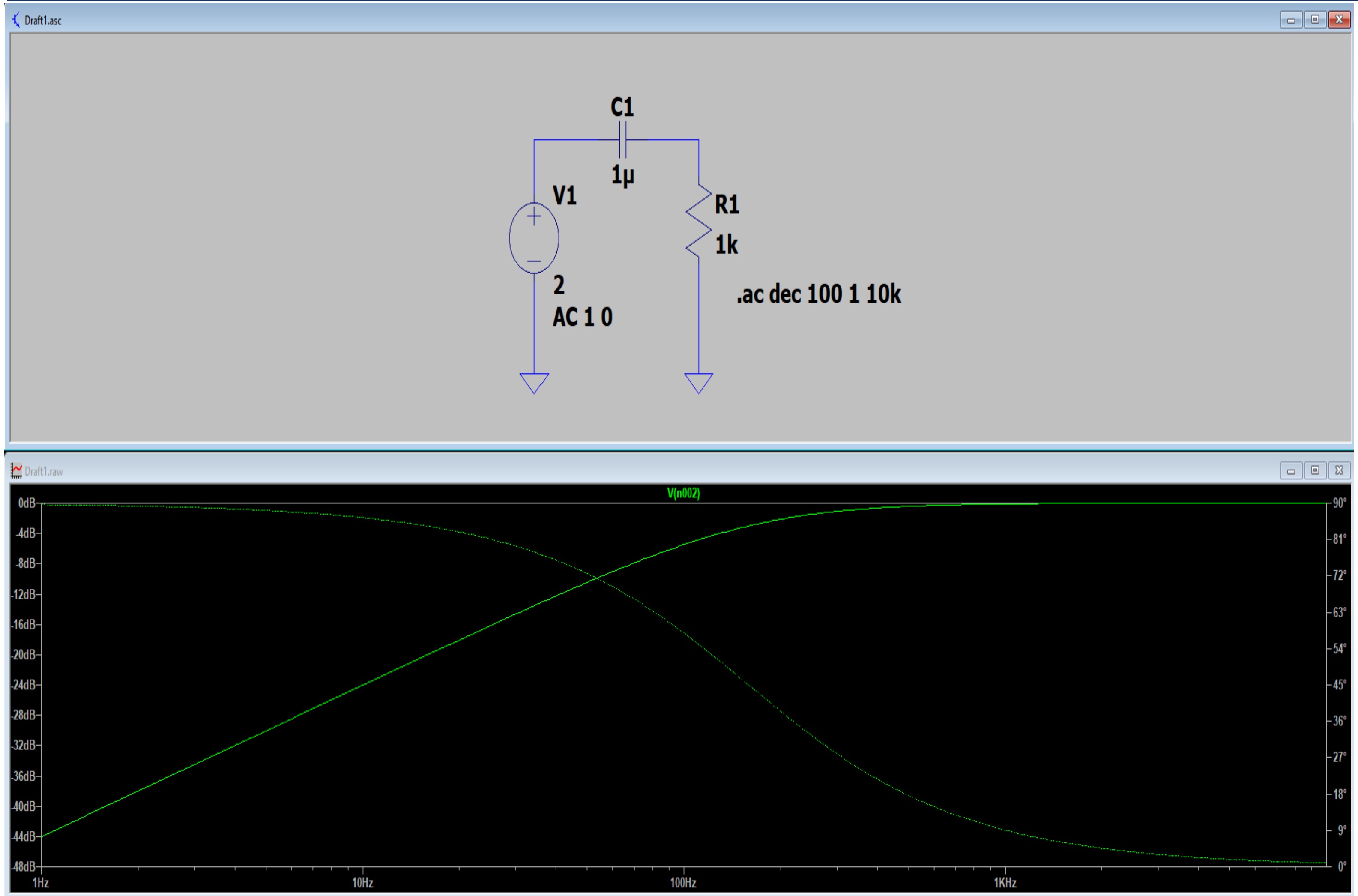
C2 N003 0 1u

.ac dec 100 1 10k

.end

Analyze this circuit using Laplace equivalance just similar to the previous example. You should use one of circuit analysis theorems!

# LTS: Left to Students (First-Order High-Pass Filter)




* Draft1.asc

R1 N002 0 1k

C1 N002 N001 1µ

V1 N001 0 2 AC 1 0

.ac dec 100 1 10k

.end

Analyze this circuit using Laplace equivalance just similar to the previous example. You should use one of circuit analysis theorems!

# Thanks for listening ☺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