Alternating Current

Capacitive & Inductive Reactance and Complex Impedance

RC & RL Circuit Analyses (DC Transients, Time Constants, Steady State)

RC & RL Passive Filters

Electrical Theory (Alternating Current)

Ohm's Law for AC $I_{RMS} = V_{RMS} / Z$ where Z is the Complex Impedance

$|Z| = [(R^2 + (XL - XC)^2]^{1/2}$

$\theta = \tan^{-1}[(XL - XC) / R]$

Power Factor $\cos \theta = R / Z$

Joule's Law Average Power $= \frac{1}{2} V_{peak} I_{peak} \cos \theta = V_{RMS} I_{RMS} \cos \theta$ Watts

Purely Resistive Element ($\theta = 0$, $\cos \theta = 1$) Average Power $= \frac{1}{2} V_{peak} I_{peak} = V_{RMS} I_{RMS}$ (Watts)

ELI the ICE man

Component	Voltage / Current
Resistor	In Phase
Capacitor	Lags
Inductor	Leads

Capacitive & Inductive Reactance and Complex Impedance

$\omega = 2\pi f$ $f = 0.159\omega$

Capacitive Reactance $X_C = 1 / \omega C = 1 / (2\pi f C) = 0.159 / f C$

Inductive Reactance $X_L = \omega L = 2\pi f L$

Complex Impedance

R in series with series CL $Z = R + j(2\pi f L - 1/(2\pi f C))$ Impedance is a minimum at resonance

R in series with parallel CL $Z = R + j(2\pi f L / (1 - (2\pi f)^2 LC))$ Impedance is a maximum at resonance

Time Constants

RC Circuit Time Constant $= R C$

RL Circuit Time Constant $= L / R$

Equations and Relationships

Inductive Reactance $X_L = 2\pi f L$

Capacitive Reactance $X_C = \frac{1}{2\pi f C}$

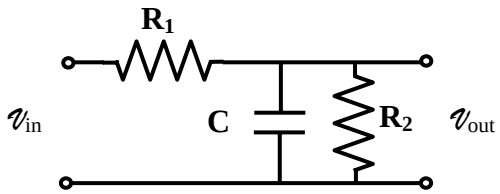
	RC Circuit	RL Circuit	RCL Circuit
Cut-off Frequency Resonant Frequency	$f_0 = \frac{1}{2\pi RC}$	$f_0 = \frac{1}{2\pi L/R}$	$f_0 = \frac{1}{2\pi\sqrt{LC}}$
Time Constant	$t = RC$	$t = L/R$	$t = \frac{R\sqrt{C/L}}{2}$

RCL Series Impedance $Z = \sqrt{R^2 + (X_L - X_C)^2}$

R&CL Parallel Impedance $Z = \sqrt{R^2 + \left(\frac{X_L X_C}{X_L - X_C}\right)^2}$

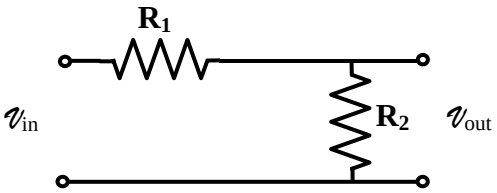
RCL Parallel Impedance $Z = \frac{R X_L X_C}{X_L X_C - R(X_L - X_C)}$

Common Configuration

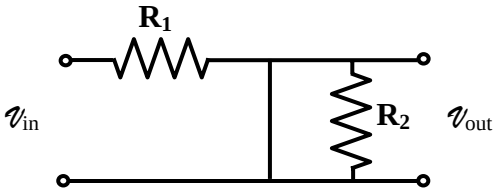


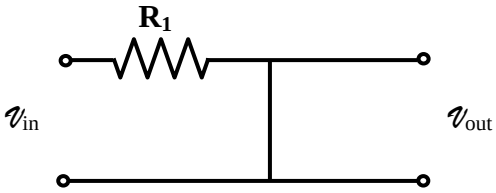
Notes:

When ω = 0, $X_C \rightarrow \infty$, i.e., **C** appears as an open circuit, so that $V_{out} = \frac{R_2}{R_1 + R_2}$



When ω >> 0, $X_C = 0$, i.e., **C** appears as a short circuit, so that $V_{out} = 0$





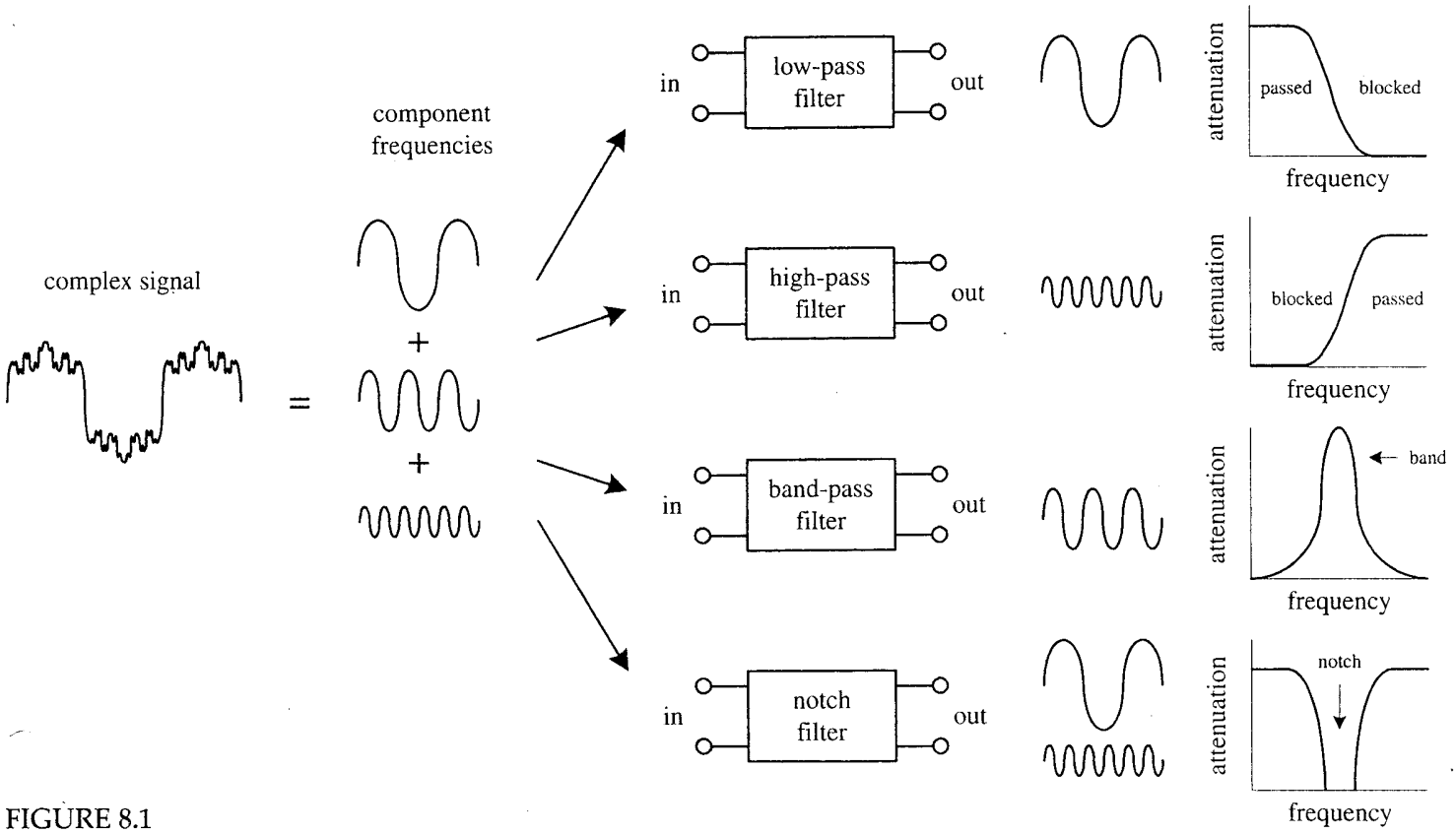

complex signal
=
component frequencies
+
+
in
low-pass filter
out
in
high-pass filter
out
in
band-pass filter
out
in
notch filter
out
attenuation
passed
blocked
frequency
attenuation
blocked
passed
frequency
attenuation
band
frequency
attenuation
notch
frequency

FIGURE 8.1

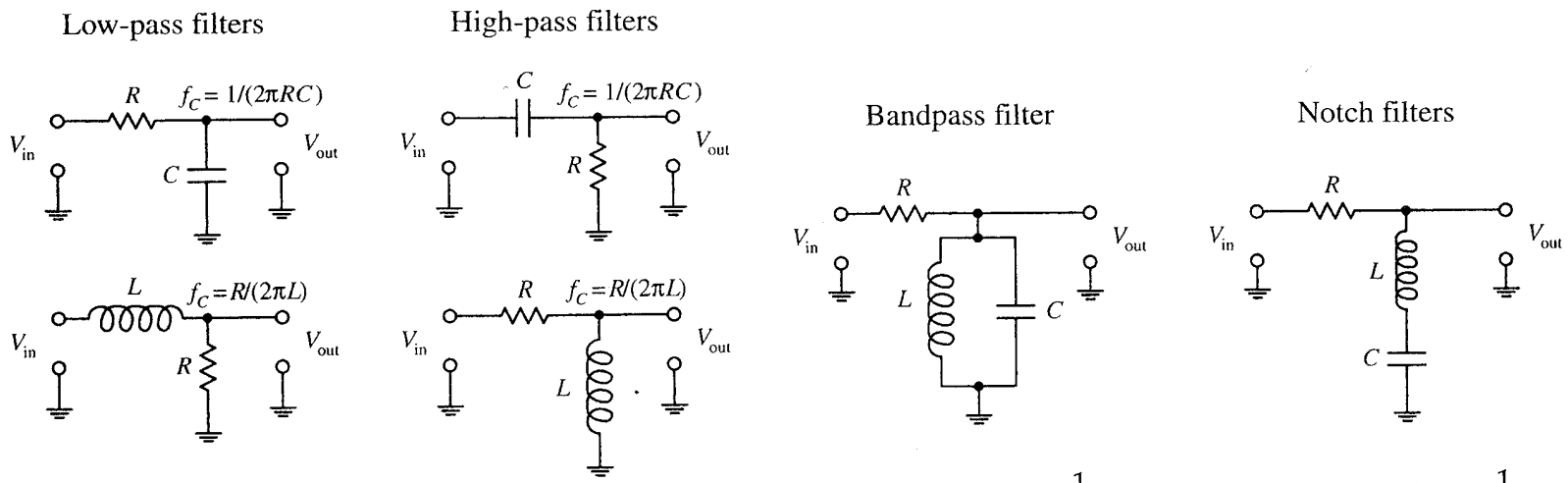


FIGURE 8.3

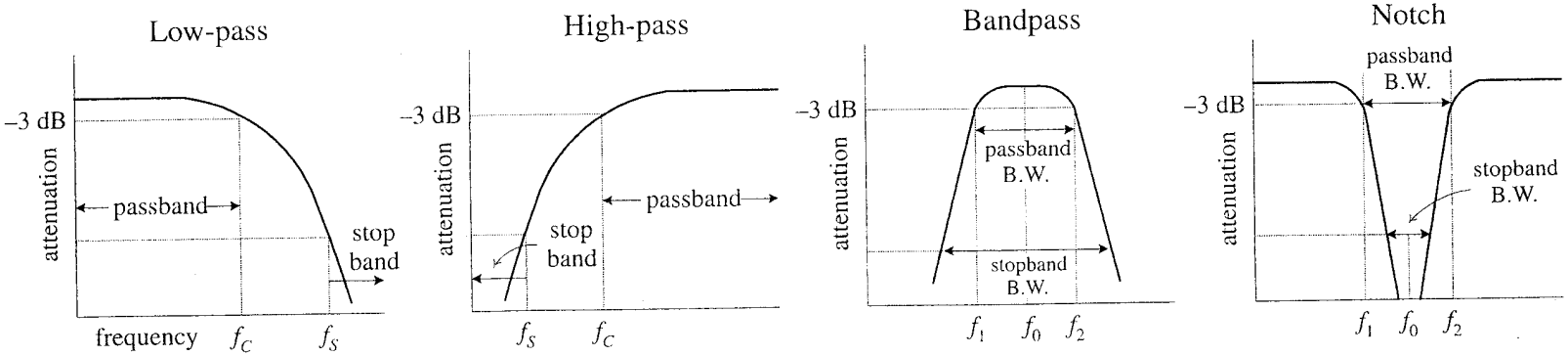


FIGURE 8.2