

Tuning and Filters

Session 4d for Basic Electricity
A Fairfield University E-Course
Powered by LearnLinc

Module: Basic Electronics

(AC Circuits and Impedance: two parts)

- Text: “Electricity One-Seven,” Harry Mileaf, Prentice-Hall, 1996, ISBN 0-13-889585-6 (Covers much more material than this section)
- References:
 - “Digital Mini Test: Principles of Electricity Lessons One and Two,” SNET Home Study Coordinator, (203) 771-5400
 - [Electronics Tutorial](#) (Thanks to Alex Pounds)
 - [Electronics Tutorial](#) (Thanks to Mark Sokos)
 - [Basic Math Tutorial](#) (Thanks to George Mason University)
 - [Vector Math Tutorial](#) (Thanks to California Polytec at atom.physics.calpoly.edu)
- Alternating Current and Impedance
 - 5 on-line sessions plus one lab
- Resonance and Filters
 - 5 on-line sessions plus one lab

Section 4:

AC, Inductors and Capacitors

- **OBJECTIVES:** This section discusses AC voltage / current and their effects on parallel circuit components (resistors, inductors, transformers and capacitors). The concept of resonance and its use to produce filters is also described.

Section 4 Schedule:

Session 4a	– 07/08	Parallel L-C Circuits	Text 4.114 – 4.122
Session 4b	– 07/10	Parallel R-L-C Circuits	Text 4.123 – 4.132
(break for a week)		(no class on 07/15 or 07/17)	
Session 4c	– 07/22	Parallel Resonance	Text 4.133 – 4.146
Session 4d	– 07/24	Tuning and Filters	Text 4.147 – 4.153
(lab - Postponed)			
Session 4e	– 07/29	Transformers and Impedance	Text 4.154 – 4.160
(Quiz 4 due 08/12)		Matching	
Session 4f	– 08/12	Review (Discuss Quiz 4)	
	08/14	MT2 Review	
	08/17	MT2 – AC Circuits	

Parallel Resonance Review

- Capacitive reactance $X_C = 1/(2\pi fC)$ at -90°
- Inductive reactance $X_L = 2\pi fL$ at 90°
- Impedances in parallel add as inverses
- X_L and X_C cancel
- Parallel Resonance
 - High Impedance
 - Low line current
(high current in the LC loop!)
- Series Resonance
 - Low impedance
 - High line current
- Resonant frequency
 - $2\pi fL = 1/(2\pi fC)$
 - $f = 1/2\pi(LC)^{1/2}$

Series and Parallel Resonance

Same resonant frequency

Equal reactance

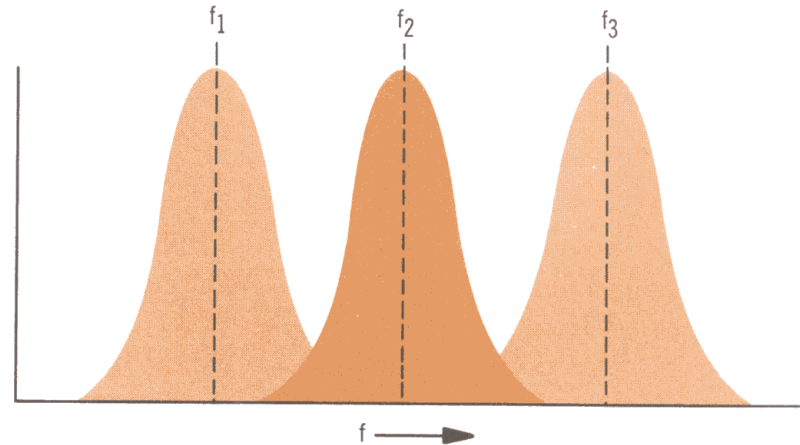
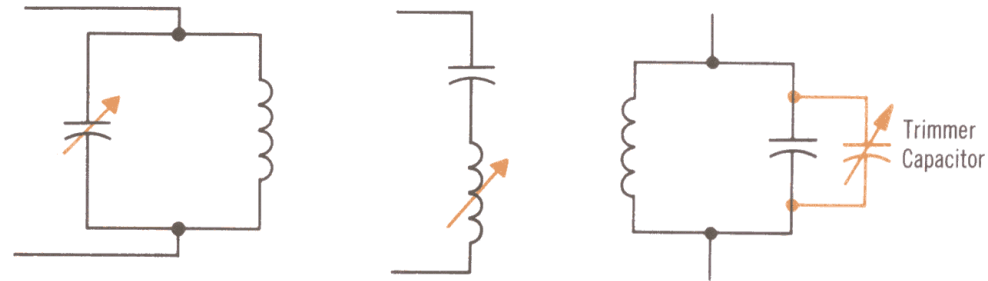
Opposite impedances

High Series current

PROPERTIES AT RESONANCE				
	Series Resonant Circuit		Parallel Resonant Circuit	
Resonant Frequency (f_R)	$\frac{1}{2\pi\sqrt{LC}}$		$\frac{1}{2\pi\sqrt{LC}}$	
Reactances	$X_L = X_C$		$X_L = X_C$	
Impedance	Minimum; $Z = R$		Maximum; $Z = QX_L$	
Current (I_{TOT} or I_{LINE})	Maximum; I_{TOT}		Minimum; I_{LINE}	
Q, Quality	$E_L/E_{APP} = X_L/R$		$I_{TANK}/I_{LINE} = X_L/R$	
Bandwidth	f_R/Q		f_R/Q	
PROPERTIES OFF RESONANCE				
	Series Resonant Circuit		Parallel Resonant Circuit	
	Above f_R	Below f_R	Above f_R	Below f_R
Reactances	$X_L > X_C$	$X_C > X_L$	$X_L > X_C$	$X_C > X_L$
Impedance	Increases	Increases	Decreases	Decreases
Phase Angle Between E_{APP} and I_{TOT} or I_{LINE}	I lags E	I leads E	I leads E	I lags E
Inductive or Capacitive Circuit	Inductive	Capacitive	Capacitive	Inductive

Tuning

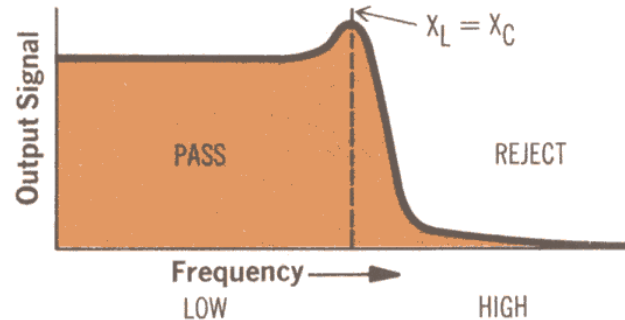
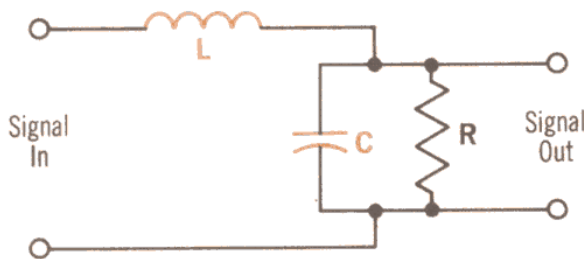
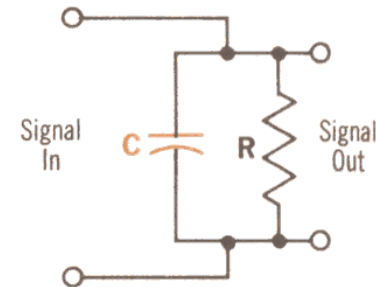
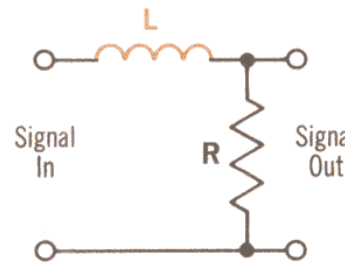
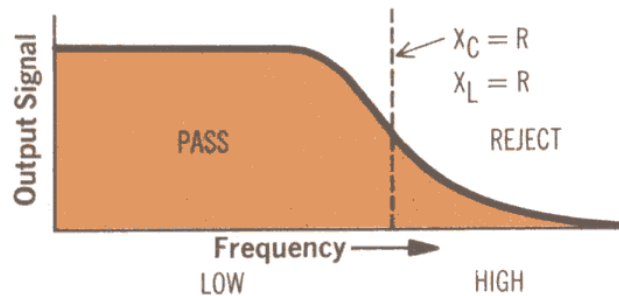
- $f_r = 1/2\pi(LC)^{1/2}$
- Increasing L or C decreases f_r
- Decreasing L or C increases f_r
- A “tuned” resonance can be used to “select” which signal you want to pass or reject



If variable capacitors or inductors are used in resonant circuits, the resonance point and bandpass frequencies can be changed to a variety of frequencies by a simple adjustment.

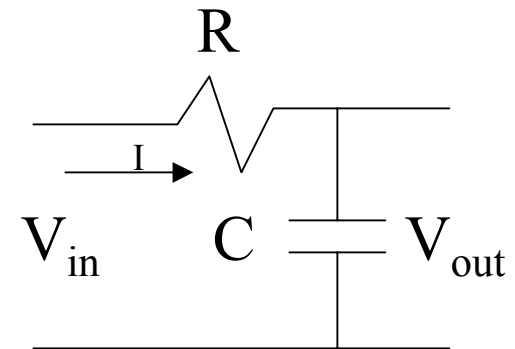
Low-Pass Filters

- A “filter” can be designed to “pass” low-frequency signals while blocking high frequency signals.



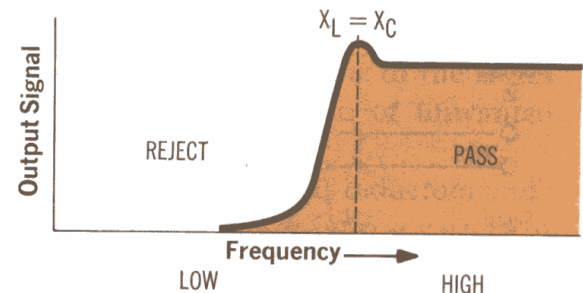
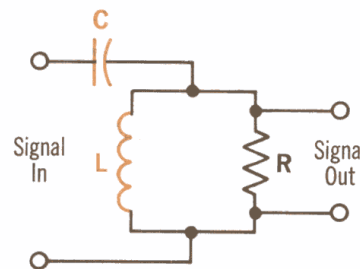
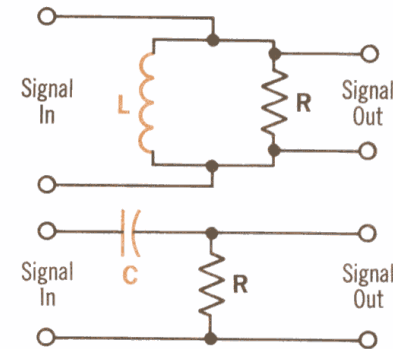
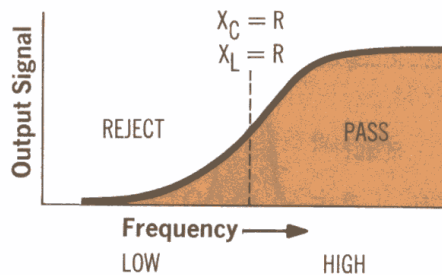
An RC Low Pass

- $|V_{\text{out}}| = |V_{\text{in}}|/[X_C/(R^2+X_C^2)^{1/2}]$
- At very low frequencies
 - $R \ll X_C$ little effect on signal
- At high frequencies
 - $R \gg X_C$ output significantly reduced



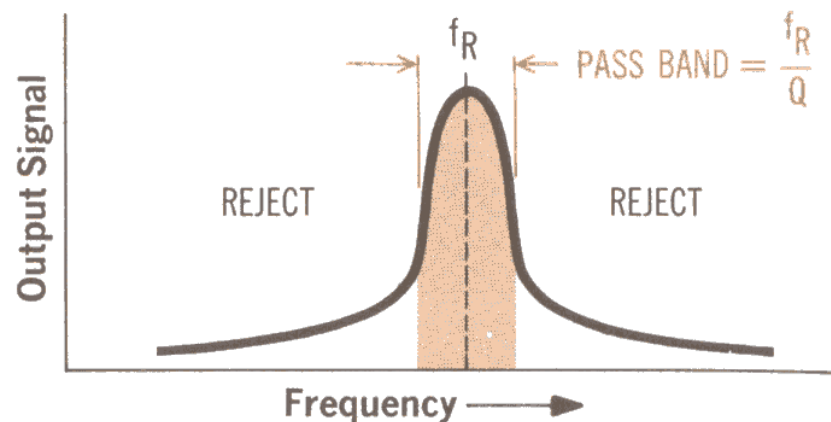
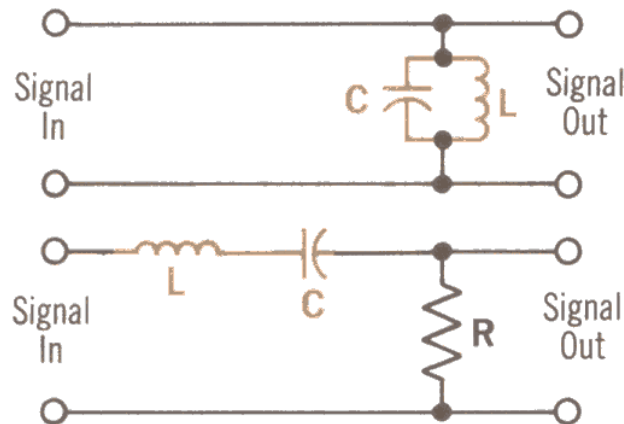
High-Pass Filters

- A “filter” can be designed to “pass” high frequency signals while blocking low frequency signals.



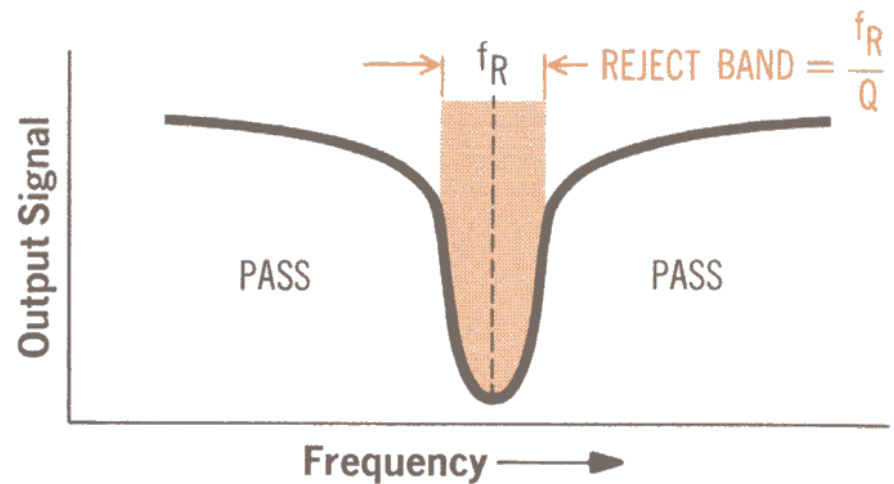
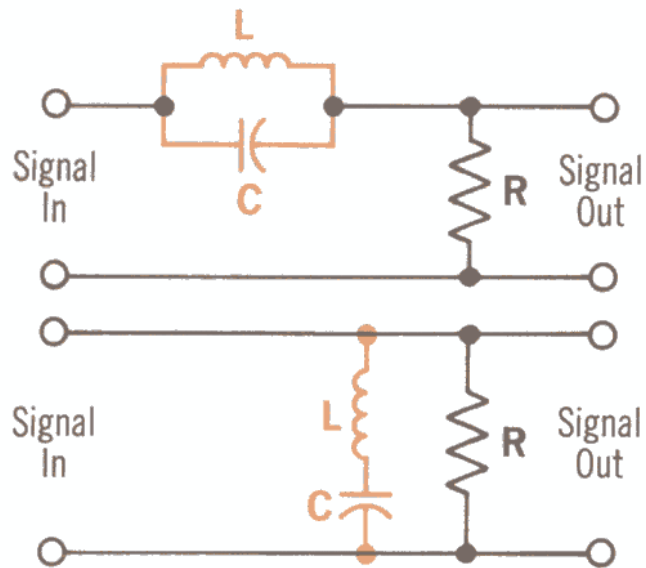
Band Pass Filters

- Here a high “shunt” impedance and/or a low series impedance is tuned to be in the middle of the “pass” band.



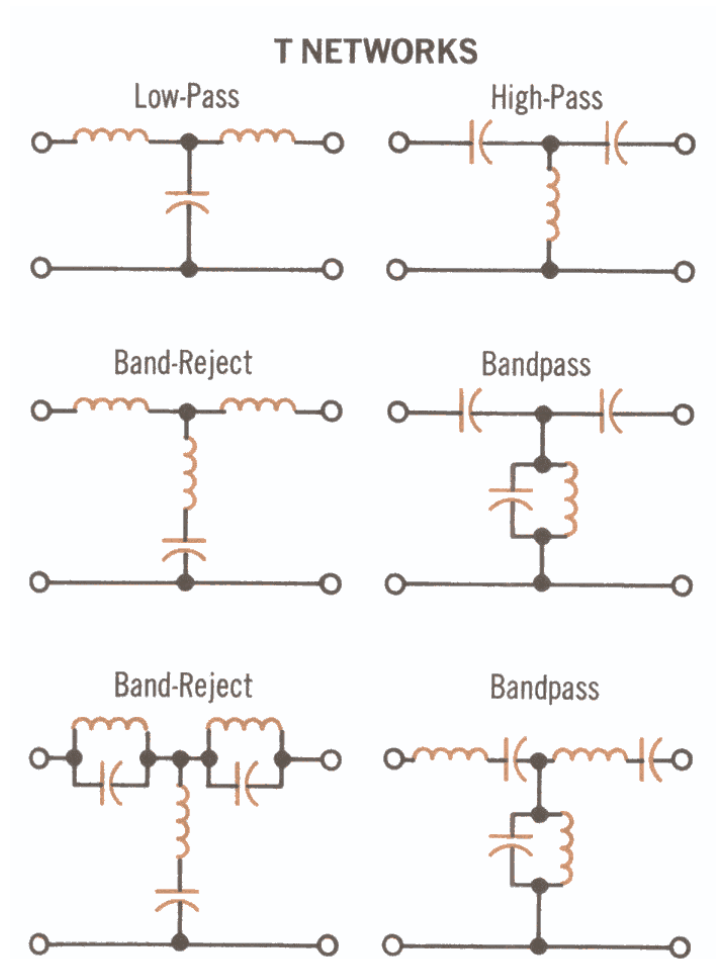
Band Reject Filters

- In a band reject (or band stop) filter a high series impedance and/or a low shunt impedance is tune to the reject band



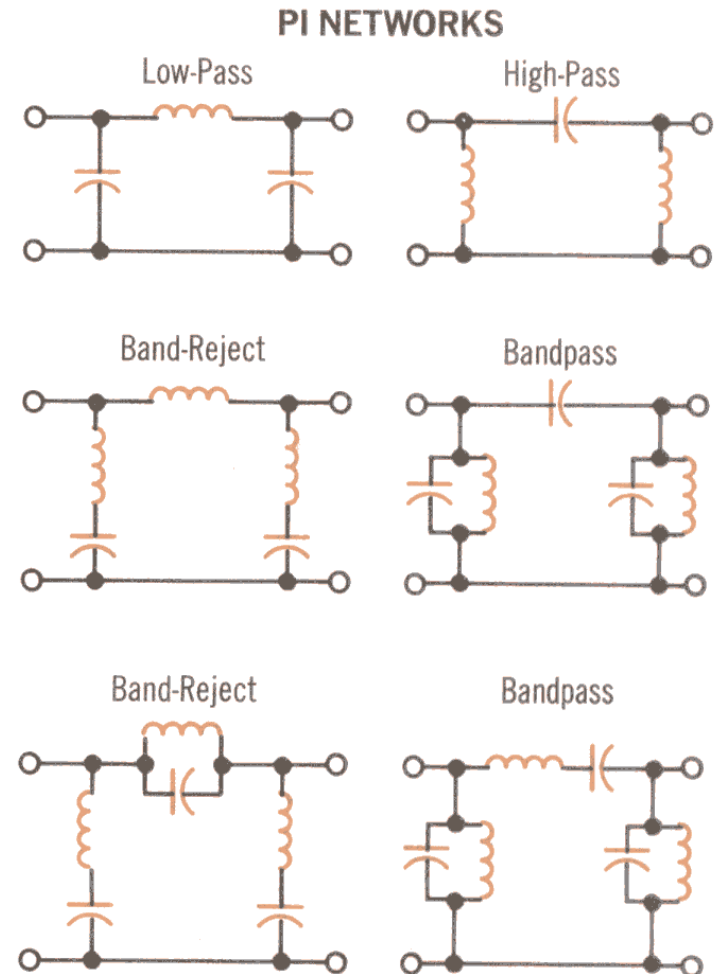
T-Networks

- T networks are symmetric
- Equal elements in both series branches



PI-Networks

- Again each is symmetrical
- Shunt branches are equal



Section 4 Schedule:

Session 4a	– 07/08	Parallel L-C Circuits	Text 4.114 – 4.122
Session 4b	– 07/10	Parallel L-R-C Circuits	Text 4.123 – 4.132
(break for a week)		(no class on 07/15 or 07/17)	
Session 4c	– 07/22	Parallel Resonance	Text 4.132 – 4.146
Session 4d	– 07/24	Tuning and Filters	Text 4.147 – 4.153
(lab - Postponed)			
Session 4e	– 07/29	Transformers and Impedance	Text 4.154 – 4.160
(Quiz 4 due 08/12)		Matching	
Session 9 starts	– 08/05	Business Writing	
Session 4f	– ??	Review (Discuss Quiz 4)	
	??	MT2 Review	
7/23/2002	??	MT2 – AC Basic Circuits	

Q and A