Parallel Resonance

Session 4c 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

- 0BJECTIVES: 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:

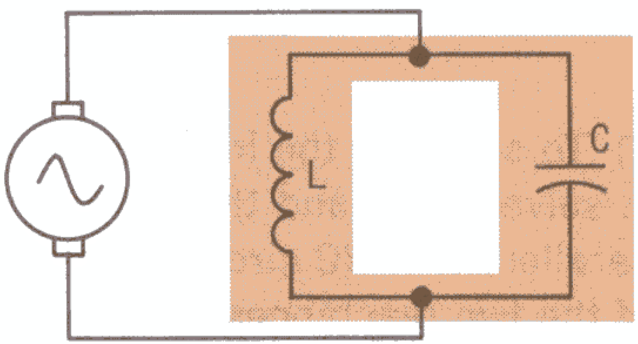
Session 4a – 07/08	Parallel L-C Circuits	Text 4.114 – 4.122
Session 4b – 07/10 (break for a week)	Parallel R-L-C Circuits (no class on 07/15 or 07/17)	Text 4.123 – 4.132
Session 4c – 07/22	**Parallel Resonance**	**Text 4.133 – 4.146**
Session 4d – 07/24 (lab - Postponed)	Tuning and Filters	Text 4.147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

(Parallel R-L-C) Review

- Capacitive reactance $X_C = 1/2\pi fC$ at -90º
- Inductive reactance $X_L = 2\pi fL$ at 90º
- Impedances in parallel add as inverses
- Break the problem down into two simple problems
  - First combine the Inductive and Capacitive branches
    - Here the vectors are in opposite directions; they just subtract.
    - Inductive reactance points up (90º); the inverse points down
    - Capacitive reactance points down (-90º); the inverse points up
    - The larger of the two inverses dominates
  - Now add in the inverse of the resistive branch
    - Find the magnitude (lengths) by using the square root of the sum of squares
    - Find the phases as the angle who's tangent is the vertical / horizontal
- Now just invert again to get the total parallel impedance

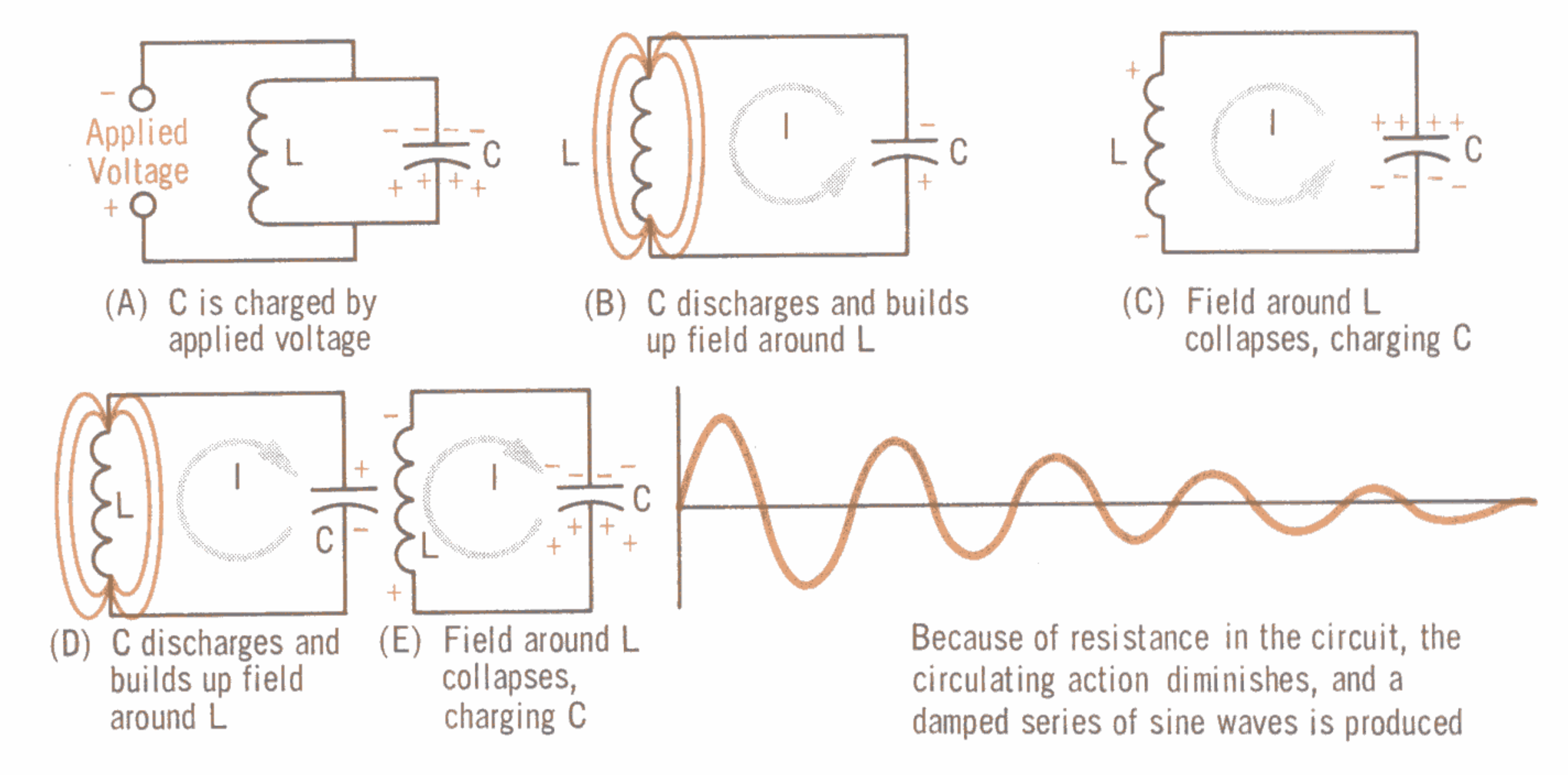
Resonance

- 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
  $2\pi fL = 1/2\pi fC$
  $f = 1/2\pi(LC)^{1/2}$



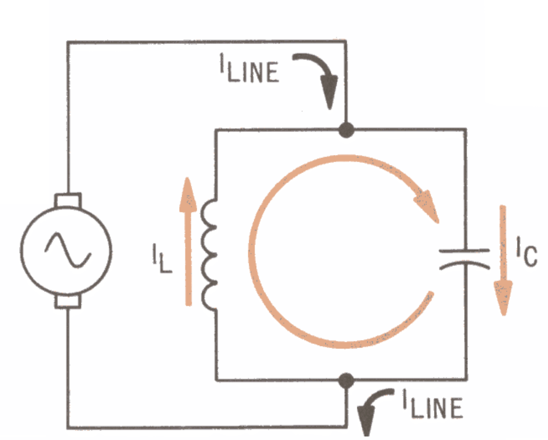
The Tank Circuit

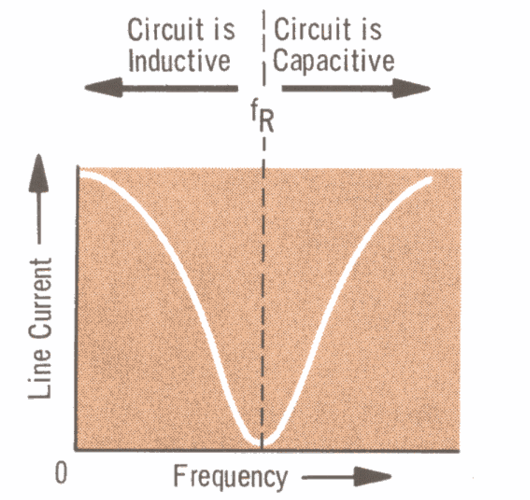
- A “tank” circuit “rings” like a bell



Current at Resonance

- At Resonance (for an Ideal parallel RC)
  - $|I_L| = |I_C|$ but they are in opposition
  - $I_{Line} = I_L + I_C = 0$

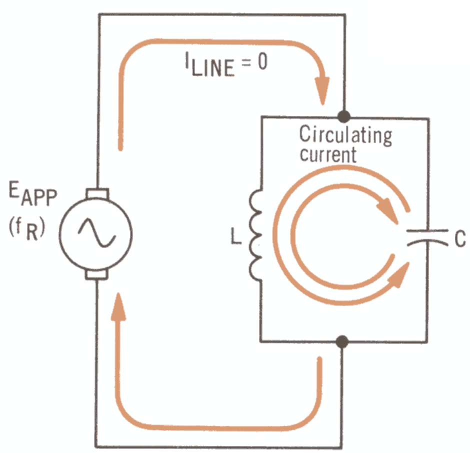


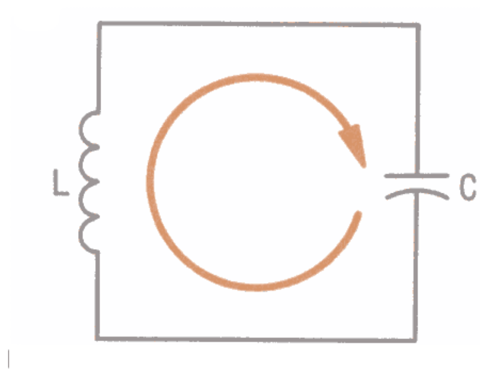


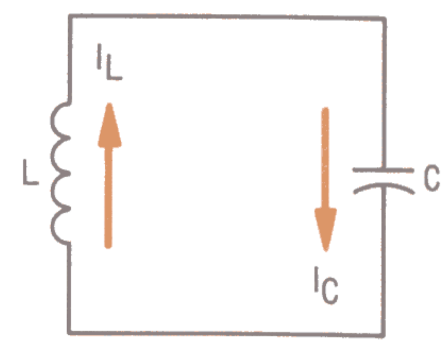
Impedance at Resonance

- At Resonance (for an Ideal parallel RC)
  - $|X_L| = |X_C|$ but they are in opposition
  - $1/Z = 1/X_L + 1/X_C = 1/\infty$

    Z is very large near resonance!

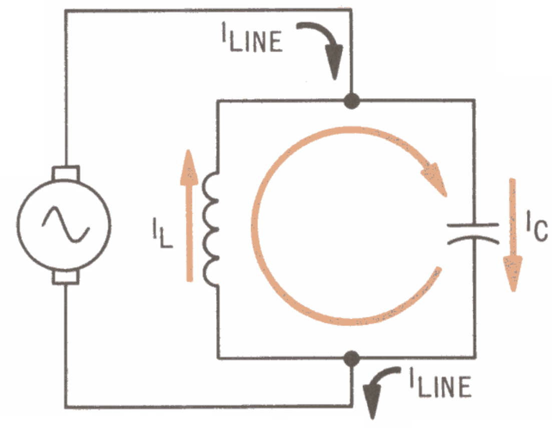


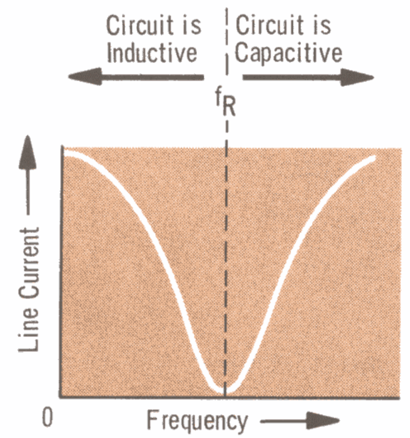




Line Current off Resonance

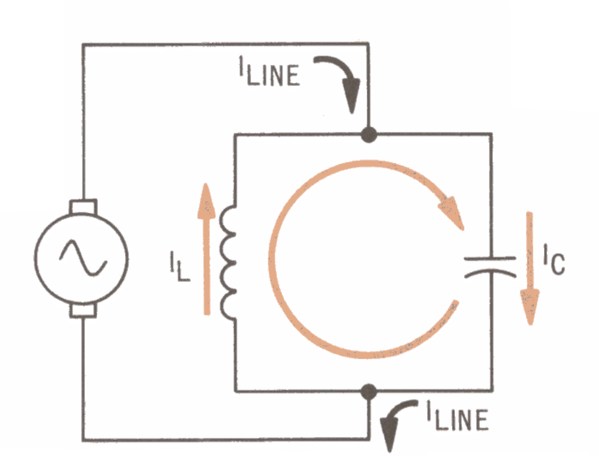
- If $|I_L| < |I_C|$ the line current is capacitive
- If $|I_L| > |I_C|$ the line current is inductive

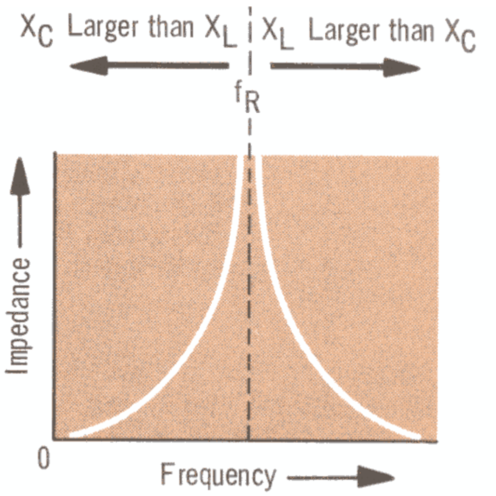




Impedance off Resonance

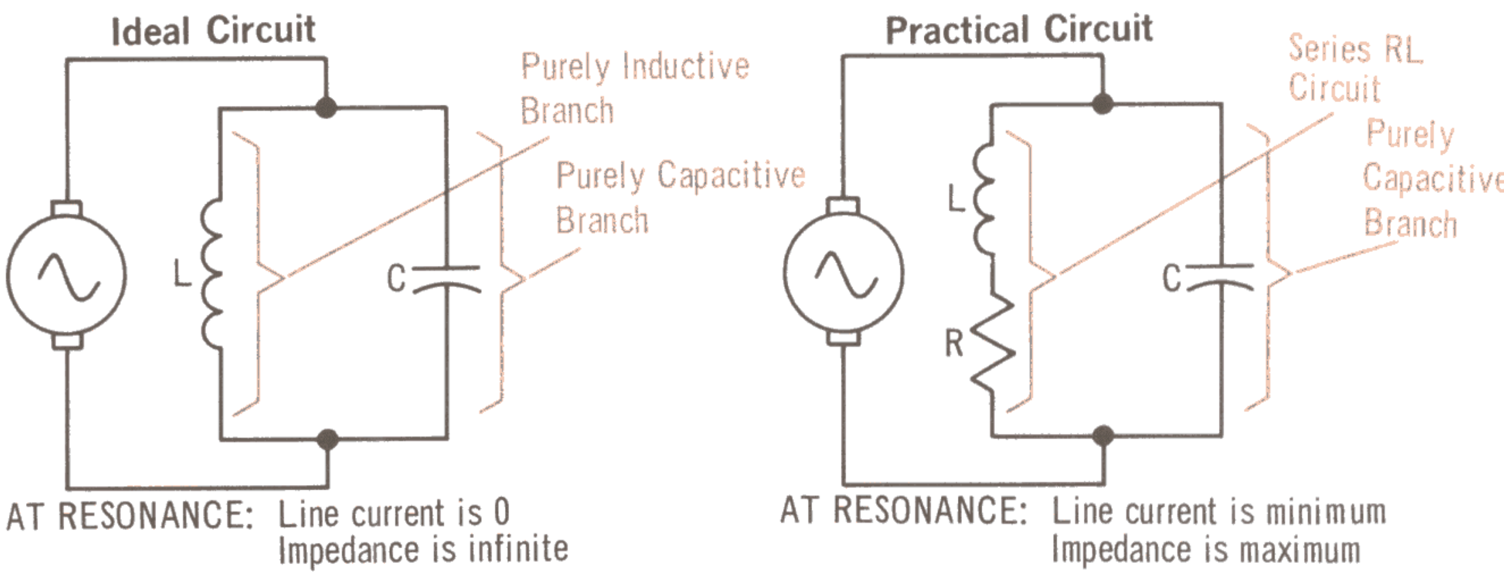
- If $|X_L| > |X_C|$ the impedance is capacitive
- If $|X_L| < |X_C|$ the impedance is inductive
- Line Impedance
  - $1/Z = 1/X_L + 1/X_C$



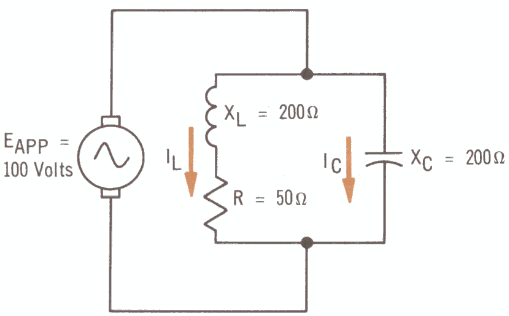


Real Tank Circuits

- Inductors have a series resistance; not a parallel one



A Parallel RLC Example



- First invert the series RL

$1/Z_1 = 1/(50\angle 0^o + 200\angle 90^o)$

$= 1/[(50^2 + 200^2)^{½}\angle \arctan(200/50)$

$= 1/[(50^2 + 200^2)^{½}\angle \arctan(200/50)$

$= 1/(206.2\angle 76^o)$

$= 0.00485\angle -76^o$

$1/Z_2 = 1/(200\angle -90^o)$

$1/Z_t = 0.00485\angle -76^o + 0.005\angle 90^o$

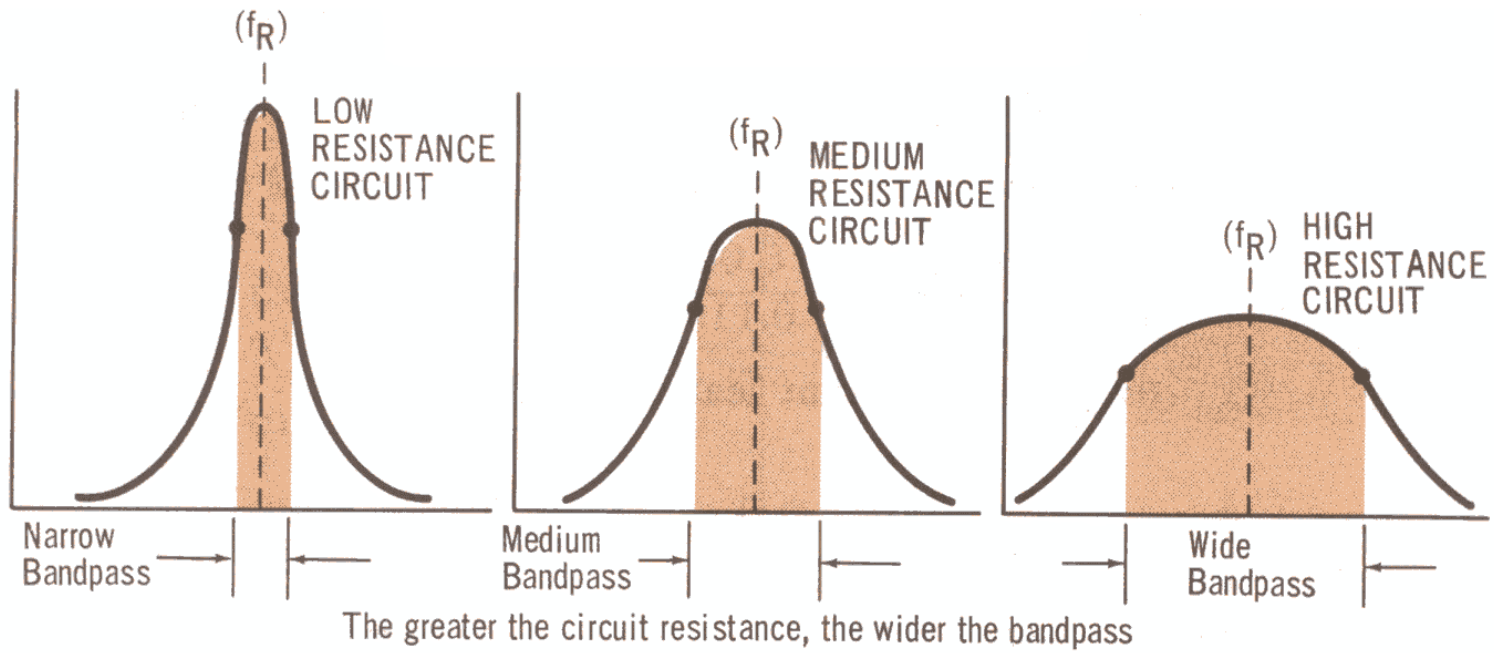
$= .00485*\cos(76)\angle 0^o + .00485*\sin(-76)\angle 90^o + .005\angle 90^o$

$= 0.00117\angle 0^o + 0.0003\angle 90^o = 0.0012\angle 14.4^o$

$Z_t = 833\angle -14.4^o$

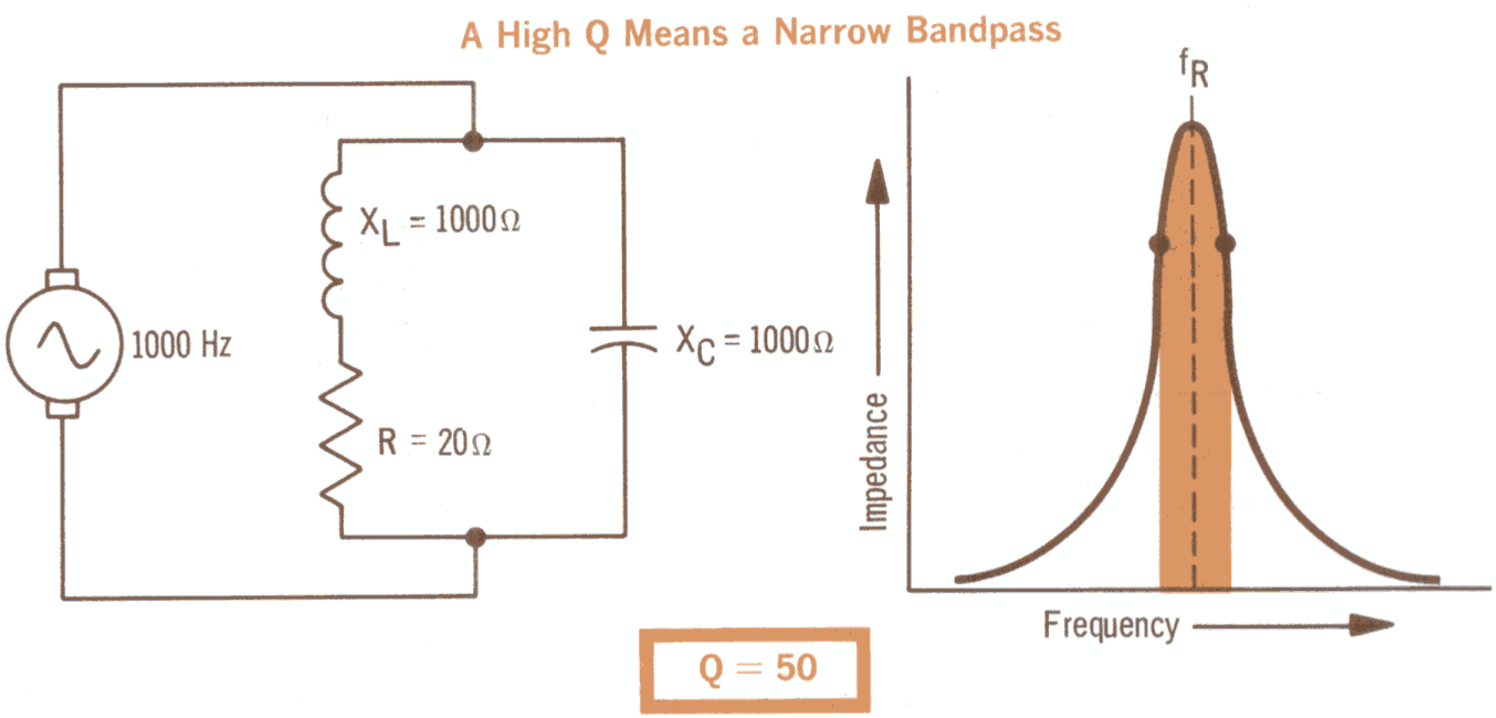
The Resonance Band

- Changing the Inductor's series resistance changes the "Bandwidth"



“Q”

- $Q = X_L / R = X_C / R$ at resonance



Changing Q

- Adding a parallel (shunt) resistor lowers Q
- More resistance in tank loop lowers Q

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 Matching	Text 4.154 – 4.160
(Quiz 4 due 08/12)			
Session 9 starts	– 08/05	Business Writing	
Session 4f	– ??	Review (Discuss Quiz 4)	
	??	MT2 Review	
	??	MT2 – AC Circuits	