BME/ISE 3511 **Bioelectronics - Test Four Review Notes** **Fall 2015**

Test Four Topics: AC Reactance, Impedance, RC & RL Circuit Analyses, DC Transients, Time Constants

Review materials include:
- Reading Assignments & Homework Problems
- AC Course Notes
- Review Problems including Reactance & Impedance Quizzes

Types of possible exam questions and problems:
- Equivalent Capacitances and Inductances (series & parallel)
- Calculate impedance (resistive, capacitive reactance, inductive reactance)
- Sketch resistor-capacitor and resistor-inductor transient voltage curves
- Determine DC transient voltages & current for simple RC & RL circuits
- Calculate RC & RL time constants
- Application of Ohm's Law to AC Circuits

See Test Four Review Problems (attached)

For the test, you may use:
- a calculator,
- two page of YOUR OWN self-generated review notes

*Note: Phones may **NOT** be used during the exam; NOT as calculators, NOT as Internet connections, NOT for resource retrieval (i.e., electronic copies of notes, files, tables, etc.), NOT for communications. If the exam proctor suspects the use of a phone during the exam, your test will be confiscated and zero points will be assigned.*

Calculate Capacitive and Inductive Reactance
Calculate Complex Impedance
Calculate Series & Parallel Equivalent Impedance for Resistors, Capacitors, Inductors, Impedances
Calculate RC and RL Time Constants
Sketch the current i(t) and voltage v(t) curves for charging and discharging RC circuits.
Sketch the current i(t) and voltage v(t) curves for charging and discharging RL circuits.

1. Calculate Series & Parallel Impedance (See page 6 for Answers)

RCL Series Configuration	RCL Parallel Configuration
R = 20 Ω	R = 220 Ω
C = 50 μf	C = 10 μf
L = 25 mh	L = 720 mh

2. For an RC series circuit with an instantaneously imposed DC step voltage:
   Sketch the curves for the charging current *i* and for the capacitor voltage V_C

3. For a steady state DC, RL series circuit with an instantaneous removal of the DC voltage:
   Sketch the curves for the discharging current *i* and for the inductor voltage V_L

4. For Figure A, calculate the circuit impedance if the excitation frequency is 1800 Hz. (See page 6 for Answers)

5. For Figure B, calculate the circuit impedance if the excitation frequency is 900 KHz. (See page 6 for Answers)

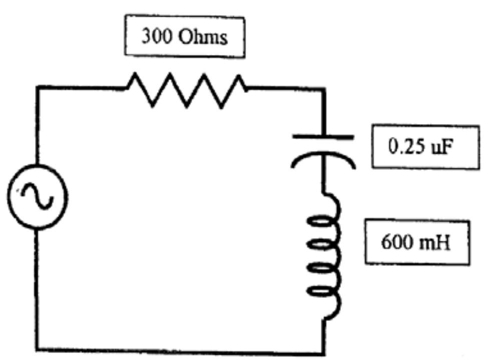


Figure A

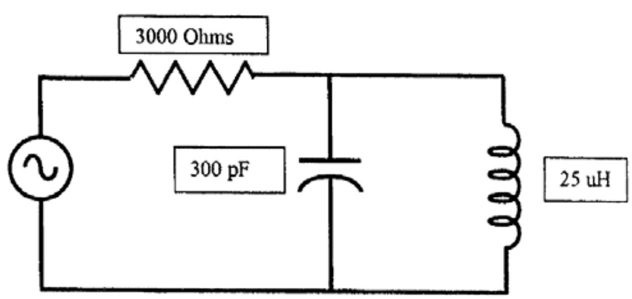


Figure B

6. Additional AC Circuit Analysis Problems

Basic Electronics for Scientists - James J. Brophy

5-3 Determine the rms current in the 1000-Ω resistor of the circuit in Fig. 5-22. Is the current inductive or capacitive?

Answer: 6.5 mA; capacitive

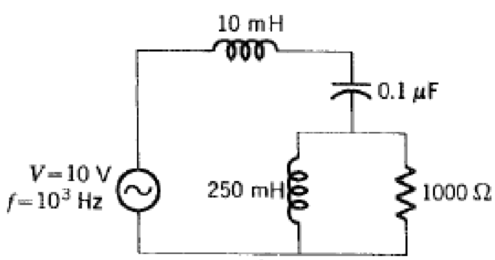


Figure 5-22

5-4 Calculate the equivalent impedance of the circuit in Fig. 5-23 at a frequency of 100 Hz. Repeat for 1000 Hz.

Answer: $0.198 + j2.63 \times 10^{6}\ \Omega$; $384 + j2.47 \times 10^{9}\ \Omega$

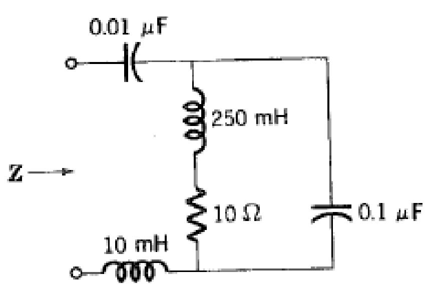
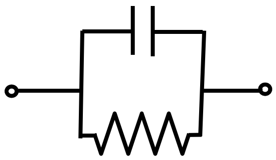


Figure 5-23

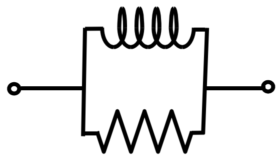
7. Reactance Quiz

8. Complex Impedance Quiz

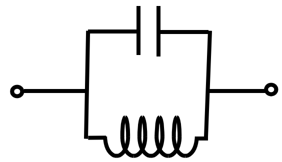
Reactance Quiz



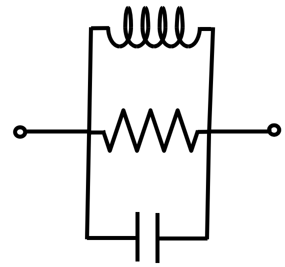
A & E



B & F



C & G



D & H

For each of the above configurations for both $\omega = 0$ and $\omega = \propto$,
determine whether or not the resulting circuit appears as either
a resistive circuit, a short circuit, or an open circuit. Check the appropriate blank(s).

For $\omega = 0$

Figure	**Resistive Circuit**	**Short Circuit**	**Open Circuit**
A.	________	________	________
B.	________	________	________
C.	________	________	________
D.	________	________	________

For $\omega = \propto$

Figure	**Resistive Circuit**	**Short Circuit**	**Open Circuit**
E.	________	________	________
F.	________	________	________
G.	________	________	________
H.	________	________	________

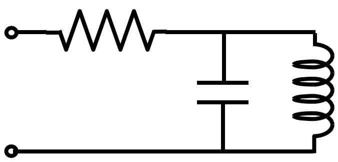
Complex Impedance Quiz

Devise formulas for each of the complex impedance configurations using R, X_C, and X_L.

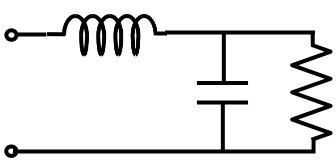
Hint: Impedances in series add, i.e., $Z = Z_1 + Z_2$

Two impedances in parallel equal the "*product over the sum*", i.e. $Z = \dfrac{Z_1\ Z_2}{Z_1 + Z_2}$

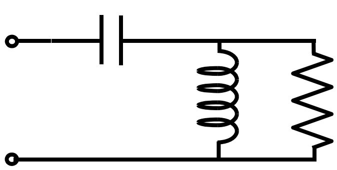
A.



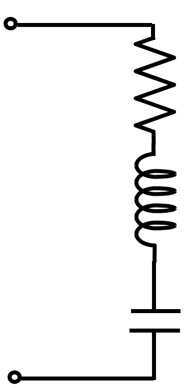
B.



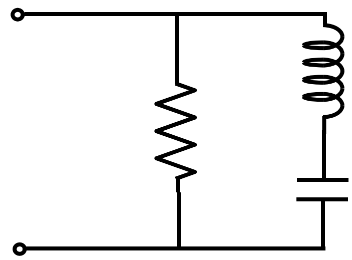
C.



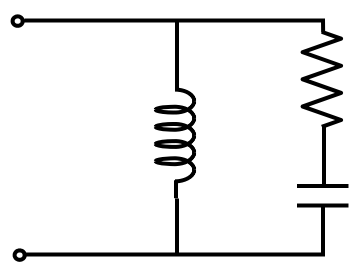
D.



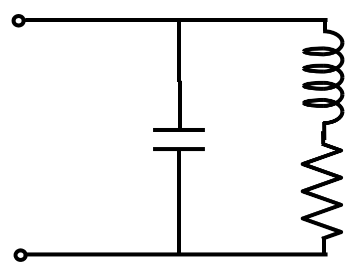
E.



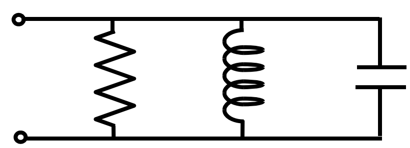
F.



G.



H.



RC & RL Charging and Discharging Curves
http://hades.mech.northwestern.edu/index.php/RC_and_RL_Exponential_Responses

RCL Series Configuration Z = 20 - j40 = 45@ -63°

RCL Parallel Configuration Z = 76 - j7 = 97 @ 3°

Figure A, Circuit Impedance (1800 Hz) Answer: Z = 300 + j6428

Figure B, Circuit Impedance (900 KHz) Answer: Z = 3000 + j141

Reactance Quiz

A. Resistive **B.** Short Circuit **C.** Short Circuit **D.** Short Circuit

E. Short Circuit **F.** Resistive **G.** Short Circuit **H.** Short Circuit

Complex Impedance Quiz

A. $R + \dfrac{X_C X_L}{X_C + X_L}$ **B.** $X_L + \dfrac{R X_C}{R + X_C}$ **C.** $X_C + \dfrac{R X_L}{R + X_L}$ **D.** $R + X_C + X_L$

E. $\dfrac{R(X_C + X_L)}{R + X_C + X_L}$ **F.** $\dfrac{X_L(R + X_C)}{R + X_C + X_L}$ **G.** $\dfrac{X_C(R + X_L)}{R + X_C + X_L}$

H. $\dfrac{1}{Z} = \dfrac{1}{R} + \dfrac{1}{X_C} + \dfrac{1}{X_L} = \dfrac{X_C X_L + R X_L + R X_C}{R X_C X_L}$ $\quad Z = \dfrac{R X_C X_L}{R X_C + R X_L + X_C X_L}$