A POLYTECHNIC INSTITUTION

School of Manufacturing, Electronics and Industrial Processes
Program: Robotics
Option:

Course Outline

ELEX 2205
AC Circuits for Robotics

Start Date:	January					**End Date:**	May		
Total Hours:	120	**Total Weeks:**	20			**Term/Level:**	2	**Course Credits:**	8
Hours/Week:	5	**Lecture:**	3	**Lab:**	2	**Shop:**		**Seminar:**	**Other:**

Prerequisites

Course No.	Course Name
ELEX 1205	DC Circuit Analysis for Robotics
MATH 1342	Technical Math for Robotics

ELEX 2205 is a Prerequisite for:

Course No.	Course Name
ELEX 3321	Electronic Circuits 2 (Robotics)
ROBT 3351	Automation Equipment

Course Description

Introduces the behavior of electrical circuits and networks when driven by a single-phase alternating current (AC) source and prepares the student for courses in electronics and power systems. Topics included are: DC applied to capacitors and inductors; the sine wave (average and effective values); power and power factor; resistance, capacitance and inductance in AC circuits; phasor, impedance, admittance and power diagrams; analysis of AC circuits using complex algebra; resonance and resonant circuits; highpass and lowpass filters; the application of circuit laws and theorems to AC circuits; and transients in RC circuits. Circuit theory is verified using equipment such as multimeters, sine wave generators and dual trace oscilloscopes.

Course Goals

1. Analyze circuits containing R, L, and C with single-phase AC applied.
2. Analyze AC circuits at and around the resonant frequency.
3. Analyze RC circuits with DC and AC square wave voltage applied.
4. Set up circuits in the lab and verify theory utilizing proper measuring techniques.

Evaluation

Lab work	30%
Term work	30%
Final Exam	40%
TOTAL	100%
Minimum Passing grade	**50%**

Comments: Satisfactory completion of both the lab component and the theory component of this course is a requirement for a passing grade. BCIT policy states that where:

- either the lab or the theory component is failed,

and

- the average mark is above the pass mark; a grade of U (unsatisfactory) will be assigned.

■ Course Learning Outcomes/Competencies

Upon successful completion, the student will be able to:

1. DC APPLIED TO CAPACITORS AND INDUCTORS

Analyze the electrical parameters of capacitors and inductors in a pure DC environment.

1.1 State effect of capacitor parameters on capacitance and working voltage.
1.2 Calculate energy stored in capacitor.
1.3 Calculate values of capacitors in series and parallel.
1.4 Calculate values and sketch graphs of V against time, and I against time, for steady DC current through capacitor.
1.5 State effect of inductor parameters on inductance.
1.6 Calculate energy stored in inductor.
1.7 Calculate values of inductors in series and parallel.
1.8 Calculate values and sketch graphs of V against time, and I against time, for steady DC voltage across inductor.

2. SINUSOIDAL WAVEFORMS

Apply knowledge of trigonometry and complex algebra to the analysis of AC voltages and currents.

2.1 Calculate instantaneous, average, and RMS values for AC waveforms.
2.2 Draw and interpret phasor diagrams for 2 or more sinewaves.
2.3 Measure phase angles with an oscilloscope.

3. R-ONLY, C-ONLY, L-ONLY, CIRCUITS

Analyze and measure the response of AC voltage applied to single pure electrical circuit parameters.

3.1 Calculate V, I, and P using Ohm's Law, and draw phasor diagrams for series and parallel R-only circuits at various frequencies.
3.2 Calculate V, I, P_Q, X_C, B_C and draw phasor diagrams for series and parallel C-only circuits at various frequencies.
3.3 For a capacitor, measure V and I at constant frequency and calculate X_C and B_C from the graph.
3.4 For a capacitor, measure V and I phase angle θ at various frequencies. Plot X_C and B_C against f.
3.5 Calculate V, I, P_Q, X_L, B_L, and draw phasor diagrams, for series and parallel L-only circuits at various frequencies.
3.6 For an inductor, measure V and I at constant frequency and calculate X_L and B_L from graph.
3.7 For an inductor, measure V, I, and phase angle θ at various frequencies. Plot X_L and B_L against f.
3.8 Measure power in an AC circuit using a wattmeter.

4. SERIES RC CIRCUITS

Analyze and measure the response of practical series RC circuits when AC voltage or current is applied.

4.1 List the 3 basic characteristics of any series circuit.
4.2 Calculate values of V, I, P, P_Q, P_S, phase angle, power factor, and draw phasor, impedance and power diagrams.
4.3 Measure V, I, P, and phase angle in a series RC circuit.

5. SERIES RL CIRCUITS

Analyze and measure the response of practical RL Circuits when AC voltage or current is applied.

5.1 Calculate values of V, I, P, P_Q, P_S, phase angle, power factor, and draw phasor, impedance, and power diagrams for circuits with ideal inductors.
5.2 Calculate values and draw diagrams for circuits with practical inductors. Calculate Q of an inductor.
5.3 Measure V,I,P, phase angle for circuits with practical inductors. Calculate X_{LS}, L_S, R_S.

6. PARALLEL RC CIRCUITS

Analyze and measure the response of practical RC circuits when AC voltage or current is applied.

6.1 List 3 basic characteristics of any parallel circuit.
6.2 Calculate values of V, I, P, P_Q, P_S, phase angle, power factor, and draw phasor, admittance, and power diagrams.
6.3 Measure V, I, P, and phase angle for parallel RC circuits.
6.4 Convert between series and parallel RC circuits.

7. PARALLEL RL CIRCUITS

Analyze and measure the response of practical RL circuits when AC voltage or current is applied.

7.1 Calculate values of V, I, P, P_Q, P_S, phase angle, pf and draw phasor, admittance, and power diagrams for circuits with ideal inductors.
7.2 Calculate values and draw diagrams for parallel circuits with practical inductors.
7.3 Measure equivalence between series and parallel RC circuits and RL circuits. Simulate an electric motor and measure values.
7.4 Measure V, I, P, θ for parallel RL circuit with practical inductor.
7.5 Convert between series and parallel RL circuits.

8. FREQUENCY RESPONSE OF SERIES RC CIRCUITS (BODE PLOTS)

Predict and measure the gain and phase angle of series RC circuits over a range of frequencies.

8.1 Define voltage gain (in dB) and Bode phase angle.
8.2 Draw straight-line approximations of gain and phase angle versus frequency (Bode Plots), for high pass and low pass RC filters.
8.3 Measure and plot gain and phase angle versus frequency for high pass and low pass RC filters.

9. RLC CIRCUITS AT CONSTANT FREQUENCY

Analyze and measure the response of series, parallel, and series-parallel RLC circuits when AC voltage or current at one frequency is applied.

9.1 Calculate V, I, P, phase angle and draw phasor, impedance and power diagrams for series RLC circuits. Determine equivalent series RL or RC circuits.
9.2 Calculate values and draw diagrams for parallel RLC circuits. Determine equivalent parallel RL or RC circuits.
9.3 Calculate values in series-parallel RLC circuits.
9.4 Calculate power factor and power factor correction for AC loads.
9.5 Measure and improve power factor.

10. SERIES RESONANT CIRCUITS

Analyze and measure the response of series RLC circuits at and around the resonant frequency.

10.1 Calculate effect on Z and phase angle of series RLC circuits when varying frequency is applied.
10.2 Calculate fr, V, I, P, phase angle, Z in series RLC circuits at and around resonance.
10.3 Calculate V, I, phase angle, band widths and half power frequencies for series RLC circuits.
10.4 Measure and calculate all values in series RLC circuits at, above, and below resonance.

11. PARALLEL RESONANT CIRCUIT (WITH IDEAL INDUCTORS)

Analyze the ideal RLC parallel circuit in preparation for dealing with practical inductors.

11.1 Calculate effect on Y and phase angle of parallel RLC circuits when varying frequency is applied.
11.2 Calculate fr, V, I, P, P_Q, P_S, phase angle, in parallel RLC circuit at and around resonance.
11.3 Calculate V, I, P, θ, Y, f1, f2, BW, Q in parallel RLC circuit at bandwidth frequencies for high Q and low Q circuits.
11.4 Calculate all values in parallel RLC circuits at, above, and below the resonant frequency.

12. PRACTICAL RESONANT CIRCUITS

Analyze and measure the response of practical parallel RLC circuits at and around the resonant frequency.

12.1 Calculate V, I, phase angle, fr, the upper and lower cutoff frequencies, Q, Z, in a tank circuit.
12.2 Measure values in a tank circuit.
12.3 Sketch, identify and design Hi-pass, Lo-pass, Band-pass and Band-stop filters.
12.4 Design double tuned circuits and calculate values for them.

13. CIRCUIT ANALYSIS METHODS FOR NETWORKS

Determine circuit values and circuit parameters in a wide range of applications using systematic techniques.

13.1 Calculate values in networks using superposition theorem.
13.2 Calculate values in networks using mesh analysis.
13.3 Calculate values in networks using nodal analysis.
13.4 Calculate values in networks using Thevenin's theorem.
13.5 Calculate values in networks using Norton's theorem.
13.6 Calculate the load impedance for maximum power transfer.

14. TRANSIENT VALUES IN RC AND RL CIRCUITS

Analyze and determine values of voltages and currents during the transient period.

14.1 Calculate and sketch voltage and current in series RC circuits when square wave voltage is applied.
14.2 Calculate and sketch V's and I in series RL circuit when square wave voltage is applied.
14.3 Measure transient voltage and current in series RC circuits with square wave voltage applied.

■ Verification

I verify that the content of this course outline is current.

Norman WM Cousins | Dec 23 2005
Authoring Instructor | Date

I verify that this course outline has been reviewed.

David Lowrs | Dec 23, 2005
Program Head/Chief Instructor | Date

I verify that this course outline complies with BCIT policy.

Dean/Associate Dean | Date

Note: Should changes be required to the content of this course outline, students will be given reasonable notice.

■ Instructor(s)

Norman Cousins	Office Location:	SW3-2905	Office Phone:	604-412-7588
	Office Hrs.:	As posted	E-mail Address:	norman_cousins@bcit.ca

■ Learning Resources

Required:

Circuit Analysis with Devices: Theory and Practice, by Robbins and Miller
ELEX 2205 Lab Manual
Lab Notebook
Calculator with polar to rectangular conversion feature

Recommended:

Circuit Analysis (2nd Canadian Edition) by Robert L. Boylestad
Introduction to Electric Circuits by Jackson

■ Information for Students

Assignments: Late assignments, lab reports or projects will **not** be accepted for marking. Assignments must be done on an individual basis unless otherwise specified by the instructor.

Makeup Tests, Exams or Quizzes: There will be **no** makeup tests, exams or quizzes. If you miss a test, exam or quiz, you will receive zero marks. Exceptions may be made for **documented** medical reasons or extenuating circumstances. In such a case, it is the responsibility of the student to inform the instructor **immediately**.

Ethics: BCIT assumes that all students attending the Institute will follow a high standard of ethics. Incidents of cheating or plagiarism may, therefore, result in a grade of zero for the assignment, quiz, test, exam, or project for all parties involved and/or expulsion from the course.

Attendance: BCIT policy states that students who are absent for any cause, other than substantiated illness, for more than 10% of the time prescribed for the course/program may be prohibited from completing their program or courses.

Illness: A doctor's note is required for any illness causing you to miss assignments, quizzes, tests, projects, or exam. At the discretion of the instructor, you may complete the work missed or have the work prorated.

Attempts: Students must successfully complete a course within a maximum of three attempts at the course. Students with two attempts in a single course will be allowed to repeat the course only upon special written permission from the Associate Dean. Students who have not successfully completed a course within three attempts will not be eligible to graduate from the appropriate program.

Course Outline Changes: The material or schedule specified in this course outline may be changed by the instructor. If changes are required, they will be announced in class.

■ LABS

1. Introduction to the oscilloscope.
2. Measuring phase angle with the oscilloscope.
3. Capacitor Parameters
   Project 1 – Measurement of capacitive reactance and susceptance
   Project 2 – Effect of varying frequency on capacitive reactance and susceptance
4. Inductor Parameters
   Project 1 – Measurement of inductor impedance and effective resistance
   Project 2 – Effect of varying frequency on inductors
5. Measuring power using the wattmeter
6. Series RC and RL Circuits
   Project 1 – The series RC circuit
   Project 2 – The series RL circuit
7. Parallel RC and RL Circuits
   Project 1 – The parallel RC circuit
   Project 2 – The parallel RL circuit
8. Frequency response of RC circuits (Bode Plots)
9. Equivalent Circuits
   Project 1 – Designing the equivalent parallel circuit of a series circuit
   Project 2 – Designing the equivalent series circuit of a parallel circuit
   Project 3 – The equivalent circuit of a motor
10. Series resonant circuits
    Project 1 – Low Q
    Project 2 – High Q
11. Parallel resonant circuits (Tank Circuits)
    Project 1 – Low Q
    Project 2 – High Q
    Project 3 – Effect of inductor resistance on resonance and bandwidth
    Project 4 - Power Factor correction
12. Transients in RC circuits.