# Lab: Measurements and Circuit Analysis

***Module***: CAN209, Advanced Electric Circuits and Electromagnetics

***Components*:** **Part A (pre-lab exercise) 30%**

**Part B (Lab exercise: given circuit) 40%**

**Part C (Lab exercise: unknown box) 30%**

***Grouping***: **5** students per group

***Release Date***: Friday, 15th November 2024

***Deadline***: **00:01 2023/11/26** softcopy only, uploaded on Core

**Lab attendance (face-to-face) is MANDATORY: NO SHOW, NO MARK.**

**Late arrivals may not be acceptable. Attendance will be manually recorded by the module leader during the lab time.**

## INTRODUCTION

This coursework assessment aims to help develop your understanding and ability to handle problems relating to electrical circuits. The work is undertaken as a group of 5 members. There will be a single submission per group. The coursework has two parts and your group MUST complete all problems. Ensure that your submission complies with the formatting requirements set out on page 2.

Groups have been either pre-established or randomly allocated. Please check the details in the group list provided on CORE.

## LEARNING OUTCOMES

Following the completion of this assignment you should be able to:

C. Describe and analyse the transient and frequency responses of first order and second order networks.

E. Perform network analysis using appropriate parameters on two port networks.

## ACADEMIC INTEGRITY

The work submitted for the group assignment **must be produced by your group**. Plagiarism, copying, collusion, dishonest use of data, or solicitation of content from others will be penalised. Penalties will follow those of the University's Academic Integrity Policy on e-bridge and can range from capped marks to expulsion from the

university. Please contact the Module Leader in case of any confusion relating to academic integrity.

## LATE SUBMISSION POLICY

XJTLU policy is for a -5% per day penalty up to a total of -25%. Work submitted more than five working days late will receive a grade of zero.

## Formatting Requirements

You must fulfil each formatting requirement listed below. The percentage point penalty that may be applied for failing to meet each of the requirements is highlighted on each line below. Formatting penalties will not reduce your mark below 40%.

1. The entire submitted document must be created, edited (typed, not handwritten) and saved in Microsoft Office Word (5 percentage points).
2. The assignment must have a filename in this format: **Group Number**.docx (10 percentage points).

   *e.g.*, Group 3, filename: **G03**.docx.

   Group 20, filename: **G20**.docx
3. The main text of the assignment must use 1.5 line spacing (5 percentage points).
4. The main text of the assignment must use Times New Roman font with the font size of 12 point (5 percentage points).
5. The assignment must include correct page numbers (5 percentage points).
6. Handwriting (including electronically handwriting) is not acceptable (10 percentage points).
7. Equations should be edited by the embedded Microsoft Equation Editor in Word or in Mathtype (10 percentage points).
8. Number equations consecutively with equation numbers in parentheses flush with the right margin, such as:

$$\vec{E} = 8\cos(\omega t + 3z)\,\hat{x}\ V/m \qquad (1)$$

   (5 percentage points)
9. Diagrams of Bode plots (from measured data) should be generated by software: EXCEL, MATLAB, or ORIGIN (10 percentage points).
10. You MUST use the **cover page template** provided on core. Print it, fill it in, making sure all members sign in handwriting, scan it, and then attach it as the first page of your submission (5 percentage points).
11. Any citations should follow IEEE referencing style.

# Part A (30%)

A technician wants to construct two types (high-pass & low-pass) of filters using some passive components. He has a resistor $R$, an inductor $L$, a capacitor $C$, and a voltage source $V_s$ with internal resistance $R_s = 0\ \Omega$.

(a) Draw **three** possible circuit diagrams that will provide a **high-pass** response, which can be constructed with the available components and determine expressions for the **frequency response** for all three circuits. Be sure to clearly label the input voltage $V_s$ and the output voltage $V_o$ across the right components (12 marks).

(b) Given $R = 1000\ \Omega$, $L = 4.7$mH, and $C = 0.1\ \mu$F, use LTSpice to simulate the proposed circuits in (a). Provide Bode plots of $20\log_{10}(V_o/V_s)$ against log frequency scale and label the –3 dB points on each figure (3 marks).

(c) Draw **three** possible circuit diagrams that will provide a **low-pass** response which can be constructed with the available components and determine expressions for the **frequency response** for all three circuits. Be sure to clearly label the input voltage $V_s$ and the output voltage $V_o$ across the related components (12 marks).

(d) Given $R = 1000\ \Omega$, $L = 4.7$mH, and $C = 0.1\ \mu$F, use LTSpice to simulate the proposed circuits in (c). Provide Bode plots of $20\log_{10}(V_o/V_s)$ against log frequency scale and label the –3 dB points on each figure (3 marks).

# Part B (40%)

**Action 1**: Measure the output voltage and complete a Table as shown below (5 marks). You should decide how many points you need to measure to **accurately** represent the frequency response (such as clearly showing the –3 dB points).

| Frequency (Hz) | $V_1$ (V) | $V_1/V_{in}$ | $20\log_{10}(V_1/V_{in})$ |
|---|---|---|---|
| (e.g,) 20 | | | |
| | | | |
| | | | |

**Action 2**: Following Action 1, provide a bode plot of $20\log_{10}(V_1/V_{in})$ against log frequency scale (5 marks).

**Action 3**: Derive an equation for capacitance using the information related to the –3 dB point, calculate this capacitance's value, and compare it with the actual value measured by DMM (Digital Multimeter). **Show all of your working** (10 marks).

**Action 4**: Measure the output voltage and complete a Table as shown below (5 marks). You should decide how many points you need to measure to **accurately** represent the frequency response (such as clearly showing the –3 dB points and resonant point).

| Frequency (Hz) | $V_1$ (V) | $V_1/V_{in}$ | $20\log_{10}(V_1/V_{in})$ |
|---|---|---|---|
| (e.g,) 20 | | | |
| | | | |
| | | | |

**Action 5**: Following Action 4, provide a bode plot of $20\log_{10}(V_1/V_{in})$ against log frequency scale (5 marks).

**Action 6**: Derive equations for capacitance and inductance from theoretical analysis, calculate their values, and compare them with the actual component values measured by DMM (10 marks).

# Part C (30%)

**Please double check the allocated box numbers on LM Core! The BOX requiring analysis from Action 7 and 8 will be released after the laboratory. You should complete measurements for both boxes during the laboratory.**

## For assigned BOX with green-colour highlight:

**Action 7**: For this assigned box, complete a Table from DC measurements as shown below and provide ALL possible circuit topologies for it (5 marks).

| Resistance between terminals | | |
|---|---|---|
| **A&B** | **A&C** | **B&D** |
| | | |

**Action 8**: (20 marks) Show how you determine the circuit inside your box by:

- ✓ providing measured data in four Tables (BD short; BD open; AC short; AC open). *e.g.*, Table I: Experimental data when BD is short circuited.
- ✓ providing Bode plots labelling all key parameters (*e.g.*, resonant point).
- ✓ determining all components' values with analyses.
- ✓ sketching the circuit topology with all components clearly labelled with values.

## For assigned BOX without any highlight:

**Action 9** For this box, provide Bode plots labelling all key parameters (*e.g.*, resonant point) and sketch the circuit topology with all components clearly labelled with values. Data obtained from DC measurements and AC measurements (BD short; BD open; AC short; AC open) should be provided as Appendix A in your submission (5 marks).