CAN209

Exam Preparation and Revision_AY2425

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Registry-Important rules and tips for the upcoming final exams

1.Bring **two documents** for admission 携带**双证**参加考试:

a. XJTLU Student ID Card **学生证**

b. Official Identity Verification Document **官方身份证件**

i. Mainland China: Resident Identity Card（居民身份证）;

ii. Hong Kong, Macau, Taiwan: Mainland Travel Permit （通行证）

iii. International: Passport (护照)

2.Use the washroom **before** admission check. **No washroom breaks are allowed within the first two hours and last 15 minutes of each exam**. 入场**前**如厕。考试开始后两小时内及考试结束前15分钟不得离场如厕。

3. (Students) Arrive at least **30 minutes early** for admission and **metal scanner** check.
至少提前30分钟到达考场门口进行入场检查。

4.Any unauthorized materials or misbehaviors are strictly prohibited. Violation of exam rules will result in **disciplinary actions** and **the imposition of demerit points on transcripts**.
严禁携带任何考试违禁品及任何违纪行为。违反考试规则者将受到纪律处分，并在成绩单上记录违规积分。

ABOUT THE EXAM

1. This is a closed-book examination.
   - Date: Dec 31st, 2024;
   - Reading Time: 10 minutes for reading the exam paper (14:00-14:10)
   - Writing Time: 180 minutes for answering ALL questions (14:10-17:10)

No annotating is allowed in reading time or after the end of writing time

2. **FOUR** questions in total (100%)
   - 50% for **Electromagnetics** + 50% for **Electrical Circuits**
   - Each question has several sub-questions

ABOUT THE EXAM

携带学校发放的计算器类型

3. **ONLY** the university approved calculator - **Casio FS82ES/83ES** can be used. Calculators are permitted in accordance with the rules of the university. They may be used for the processing of numerical solutions ONLY. They must not have been programmed nor should they store additional information.

4. ALL materials must be returned to the exam invigilators upon completion of the exam period. **Failure to do so will be deemed academic misconduct and will be dealt with accordingly**.

INSTRUCTIONS

1. This is a closed book examination. **NO notes or books are permitted**.
2. Total marks available are 100. The number on the right indicates the mark for each question.
3. Attempt **ALL** questions. Write all the answers in the answer booklet provided.
4. Only solutions **in English** are acceptable.
5. Correct answers do not guarantee a full score: **mark penalties** may be imposed for **missing intermediate solution steps** or **illogical solution processes**.

INSTRUCTIONS

6. **ALL** communications enabled & network accessible devices **MUST** be switched OFF & placed in the storage area.

7. Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, and one scientific calculator.

   推荐(彩色)铅笔作图，便于(区分和)修改

8. You are **NOT** permitted to have on your desk or on your person any unauthorised materials. This includes but is not limited to laptops, tablets, mobile phones, smart watches and bands, smart glasses, cheat sheet , draft paper, and electronic dictionaries **Unauthorised material will be confiscated**.

PAPER CODE	EXAMINERS	DEPARTMENT	TEL
CAN209	ZHENZHEN JIANG MARK LEACH	CAN	1327 7735

2024/25 SEMESTER 1 - FINAL

BACHELOR DEGREE – Year 3

Advanced Electrical Circuits and Electromagnetics

Reading Time: 10 mins

Writing Time: 180 mins

INSTRUCTIONS TO CANDIDATES

a) This is a **closed-book** examination. NO notes or books are permitted.
b) Total marks available are 100. The number on the right indicates the mark for each question.
c) Attempt ALL questions. Write all the answers in the answer booklet provided.
d) Only solutions written in English will be accepted.
e) Correct answers do not guarantee a full score: mark penalties may be imposed for missing intermediate solution steps or illogical solution processes.
f) **No annotating is allowed in reading time or after the end of writing time.**
g) ALL materials must be returned to the exam invigilators upon completion of the exam period. Failure to do so will be deemed academic misconduct and will be dealt with accordingly.
h) A list of equations and constant values is provided at the end of this examination paper.

AUTHORISED MATERIALS

1. Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, and one scientific calculator.
2. Only the university approved calculator - Casio FS82ES/83ES can be used. Calculators are permitted in accordance with the rules of the university. They may be used for the processing of numerical solutions ONLY. They must not have been programmed nor should they store additional information.
3. You are NOT permitted to have on your desk or on your person any unauthorised materials. This includes but is not limited to laptops, tablets, mobile phones, smart watches and bands, smart glasses, cheat sheet, draft paper, and electronic dictionaries. Unauthorised material will be confiscated.
4. ALL communications-enabled & network accessible devices must be switched OFF & placed in the storage area.
5. To ensure clarity of drawn solutions use different coloured pens/pencils to indicate different question answers.

All kinds of academic misconduct WILL BE PUNISHED!

ELECTRICAL CIRCUITS PART (W7, W9 –W12)

- L10 Frequency Response of LTI Systems
- L11 First-order Transient Response
- L12-L13 Transient Response of 2^{nd}-Order Circuits
- L14 Two-port Network
- L15 Magnetically Coupled Circuits
- L16 Balanced Three-phase Systems

L10 FREQUENCY RESPONSE

Filter: A circuit which can pass certain frequencies and stop some other freqs.

A filter consists of some resistors and energy storage components:

"PASS": Energy can be transferred from source to loads at certain frequencies

"STOP": Energy cannot be transferred from source to loads at certain frequencies

1st order:

RL/RC (one energy storage component)

2nd order:

(series/parallel) RLC (two equivalent energy storage components)

Forward problem

With some given information of a circuit, analyse its performance & calculate related parameters.

e.g., a resistor is serially connected with a capacitor as shown by the following figure.

i) Determine the filter type

ii) Determine the cutoff frequency of this filter

Reverse problem

With given specification, design a circuit topology and determine the corresponding parameters.

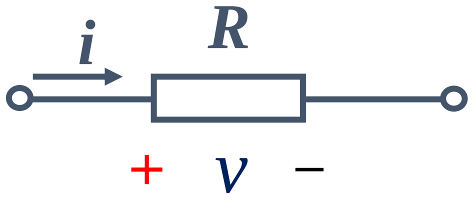
e.g., design a lowpass filter using a 100 mH inductor. The cutoff frequency should be 1 kHz.

i) Calculate the value of the resistor

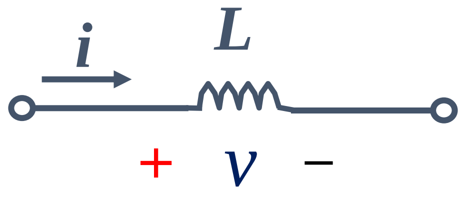
ii) Draw the circuit diagram

L11 FIRST ORDER TRANSIENT RESPONSE

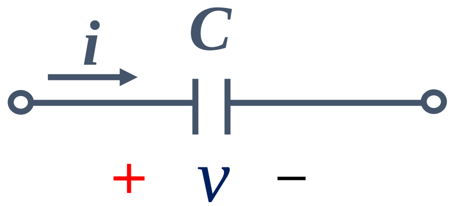
$$i = \frac{v}{R}$$



$$v = L\frac{di}{dt}$$



$$i = C\frac{dv}{dt}$$



1st order Circuits

Source-Free Circuits → Natural Response

Driven Circuits → Forced Response

$$i_L(0^+) = i_L(0^-)$$
$$v_c(0^+) = v_c(0^-)$$

1st ODE (KVL/KCL)

Complete Response

$$x(t) = x(\infty) + [x(0) - x(\infty)]e^{-t/\tau}$$

L12-13 SECOND ORDER CIRCUITS

2nd order Circuits

- Series RLC
  - Natural Response
  - Step Response
- Parallel RLC
  - Natural Response
  - Step Response

2nd ODE (KVL/KCL)

Complete response

$$x(t) = x_f(t) + x_n(t) = x_{ss}(\infty) + x_n(t)$$

L12-13 SECOND ORDER CIRCUITS

Natural Response

Solve the 2nd ODE

$$\boxed{x_n(t)}$$

Characteristic equation:

$$s^2 + 2\alpha s + \omega_0^2 = 0$$

$$\omega_0 = \frac{1}{\sqrt{LC}} \qquad \alpha = \frac{R}{2L} \qquad \alpha = \frac{1}{2RC}$$

$$s_{1,2} = -\alpha \pm \sqrt{\alpha^2 - \omega_0^2}$$

- Over Damped $\rightarrow \alpha > \omega_0$: s_1 & s_2 are two unequal real numbers

$$x(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$$

- Critical Damped $\rightarrow \alpha = \omega_0$: s_1 & s_2 are two equal real numbers

$$x(t) = e^{-\alpha t}(A_1 t + A_2)$$

- Under Damped $\rightarrow \alpha < \omega_0$: s_1 & s_2 are two complex numbers

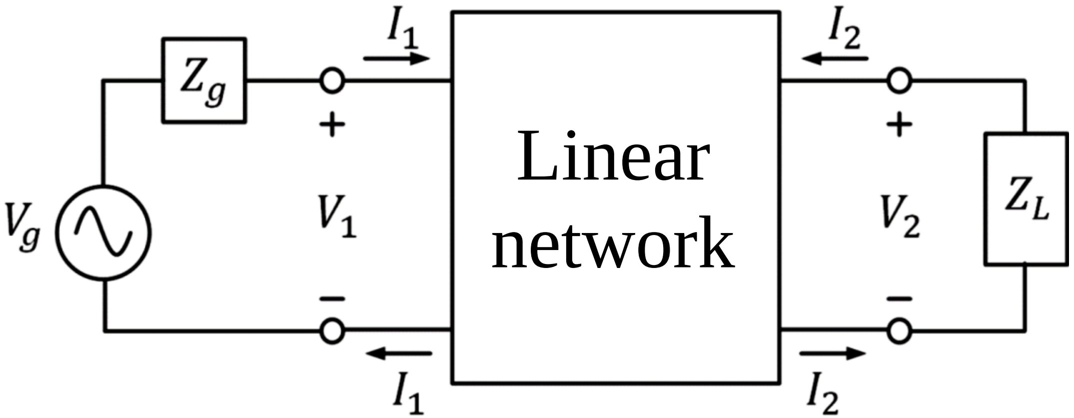
$$x(t) = e^{-\alpha t}(B_1 \cos \omega_d t + B_2 \sin \omega_d t) \qquad \omega_d = \sqrt{\omega_0^2 - \alpha^2}$$

Find the Coefficients

Initial Conditions

$$\begin{cases} v_C(0^+) = v_C(0^-) \\ i_L(0^+) = i_L(0^-) \end{cases} \qquad \begin{matrix} i_C(0) = C v_C'(0) \\ v_L(0) = L i_L'(0) \end{matrix}$$

L14 TWO-PORT NETWORKS



Impedance (Z) parameters

$$V_1 = z_{11}I_1 + z_{12}I_2$$

$$V_2 = z_{21}I_1 + z_{22}I_2$$

Admittance (Y) parameters

$$I_1 = y_{11}V_1 + y_{12}V_2$$

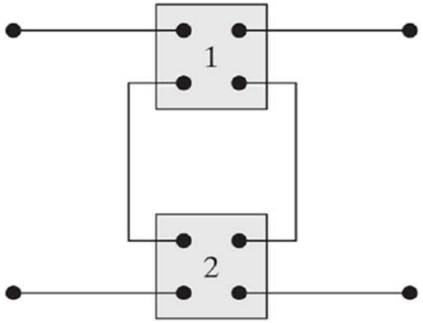
$$I_2 = y_{21}V_1 + y_{22}V_2$$

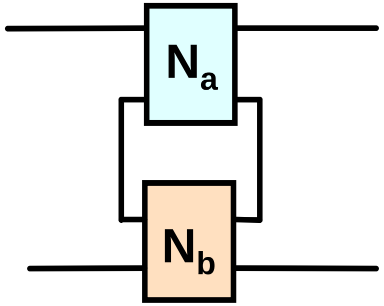
$$[z] = [y]^{-1}$$

$$[y] = [z]^{-1}$$

Series

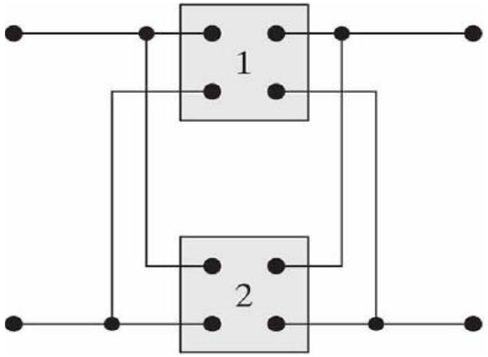
$$[z] = [z_a] + [z_b]$$

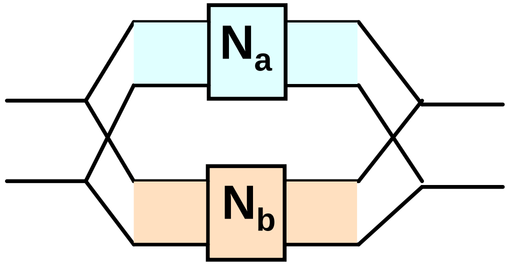




Parallel

$$[y] = [y_a] + [y_b]$$





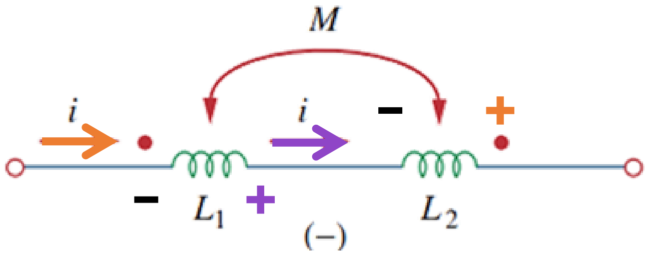
L15 MAGNETICALLY COUPLED CIRCUITS

Dot Convention for magnetically coupled coils

If a current **enters** the dotted terminal of one coil, the **reference polarity** of the mutual voltage in the **second** coil is **positive** at the dotted terminal of the second coil.

If a current **leaves** the dotted terminal of one coil, the **reference polarity** of the mutual voltage in the **second** coil is **negative** at the dotted terminal of the second coil.

$$V = j\omega(L_1 + L_2)I + (-2j\omega MI)$$



Procedure:

- ✓ Function of time → Phasor form
- ✓ Write KCL or KVL equations
- ✓ Solve the equations and get voltage/current

The total stored energy in a mutually coupled inductor is:

$$w = \frac{1}{2}L_1 i_1^2 + \frac{1}{2}L_2 i_2^2 \pm i_1 i_2 M$$

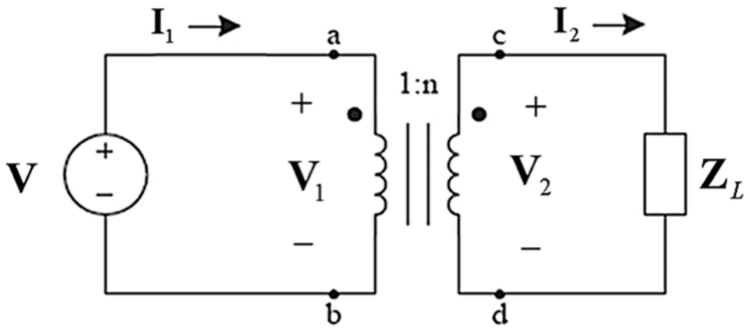
Coupling coefficient k: a measure of the magnetic coupling between two coils.

$$0 \le k = \frac{M}{\sqrt{L_1 L_2}} \le 1$$

L15 MAGNETICALLY COUPLED CIRCUITS

- Linear Transformers
- Ideal Transformers
- Auto Transformers

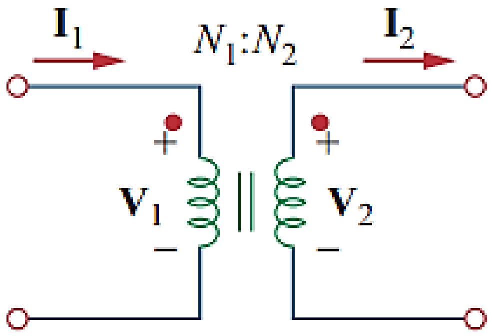
Reflected Impedance



$$Z_r = \left|\frac{V_1}{I_1}\right| = \frac{V_2}{n^2 I_2} = \frac{Z_L}{n^2}$$

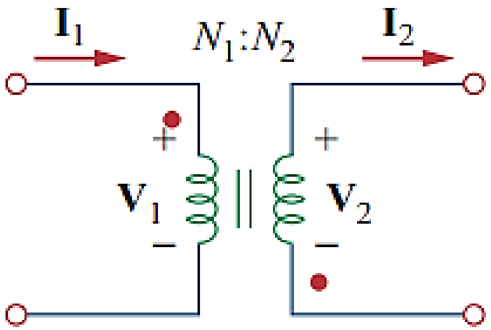
Dot Convention for transformers

- If V_1 and V_2 are both + or both – at the dotted terminals, then use $+n$
- If I_1 and I_2 both enter or both leave the dotted terminals, then use $-n$



$$\frac{V_2}{V_1} = \frac{N_2}{N_1} = n$$

$$\frac{I_1}{I_2} = \frac{N_2}{N_1} = n$$



$$\frac{V_2}{V_1} = -\frac{N_2}{N_1} = -n$$

$$\frac{I_1}{I_2} = -\frac{N_2}{N_1} = -n$$

L16 BALANCED THREE PHASE CIRCUITS

Steady AC Circuit Analysis

$$v(t) = V_m \cos(\omega t + \theta)$$

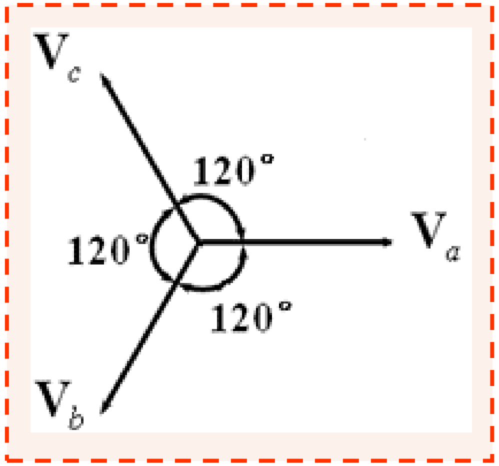
$$V = V_m \angle \theta$$

4 Possible Connections:

1. Y-Y connection
2. Δ-Δ connection
3. Y-Δ connection
4. Δ-Y connection

Phase voltage *vs* line voltage

Phase current *vs* line current

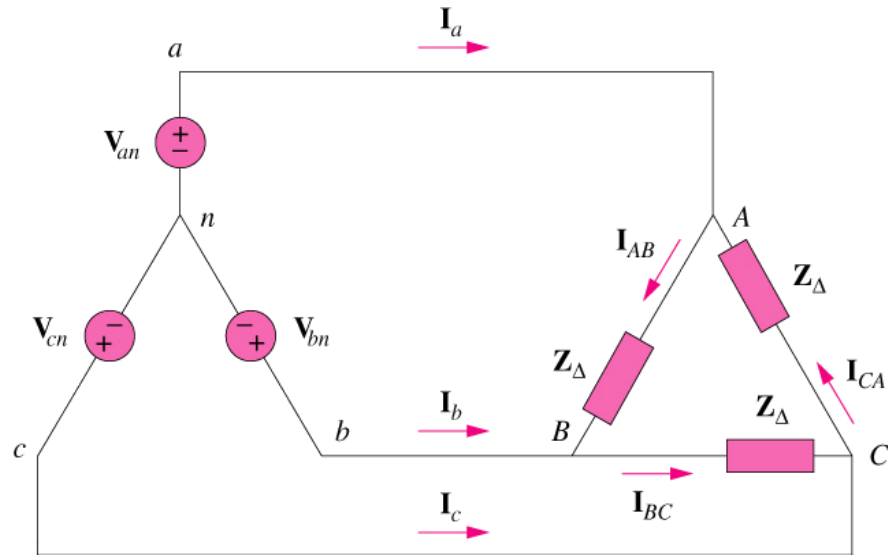


$$V_a = V_m \angle 0°$$

$$V_b = V_m \angle (-120°)$$

$$V_c = V_m \angle (-240°) = V_m \angle 120°$$

$$V_a + V_b + V_c = 0$$



L16 BALANCED 3 PHASE CIRCUITS

$$\mathrm{S} = \mathrm{V}_{rms}\mathrm{I}^{*}_{rms} = \boxed{V_{rms}I_{rms}}\angle(\theta_v - \varphi_i) = \boxed{V_{rms}I_{rms}\cos(\theta_v - \varphi_i)} + j\boxed{V_{rms}I_{rms}\sin(\theta_v - \varphi_i)}$$

Complex Power | Apparent Power | Average (Real) Power | Reactive Power

The instantaneous phase power is a function of time

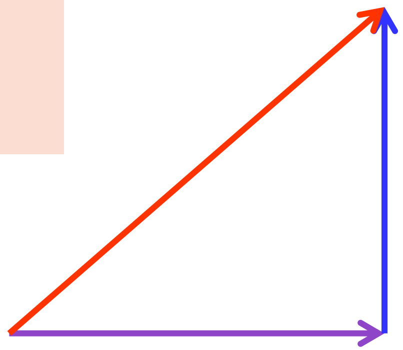
The **total** instantaneous power is ***independent*** of time

Independent on the connection methods

Complex Power:

$$\mathrm{S} = P + jQ = 3V_pI_p^{\ *}$$

V_p, I_p: effective values



$$P = \sqrt{3}V_LI_L\cos\phi = 3V_pI_p\cos\phi = 3|I|^2Re\{Z\}$$

$$Q = \sqrt{3}V_LI_L\sin\phi = 3V_pI_p\sin\phi = 3|I|^2Im\{Z\}$$

$$S = \sqrt{3}V_LI_L = 3V_pI_p$$

ELECTRICAL CIRCUITS PART

Q3 25%

- L11 First-order Transient Response
- L12-L13 Transient Response of 2nd-Order Circuits
- L10 Frequency Response of LTI Systems

ELECTRICAL CIRCUITS PART

Q4 (a-c) 25%

- L15 Magnetically Coupled Circuits
- L16 Balanced Three-phase Systems
- L14 Two-port Network

Next:
EM Revision

Good Luck