

ELECTRICAL, CONTROLS, INSTRUMENTATION

RICKY NGUYEN'S KNOWLEDGE BANK

EC&I Knowledge Encyclopedia

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1 UQ Subjects

This chapter goes through the UQ courses that was undertaken from 2016-2019. The format will be as follows, for each section, where possible:

1. Lecture notes (Use “LEC##: TITLE HERE” for each heading)
2. Tutorial questions (Use “TUT##: TITLE HERE” for each heading)
3. Summary of all equations used (Use “EQU##: TITLE HERE” for each heading)
4. References & other helping material (Use “REF##: TITLE HERE” for each heading)
5. Australian Standards (Use “STD##: TITLE HERE” for each heading)

In terms of text colour and highlights, the format will be as follows where possible:

1. Black = normal text
2. Red = Important
3. Blue = References
4. Green = Key Takeaways

1.1 CSSE2002 - Java Language

1.2 CSSE2010 - Embedded Programming

1.3 CSSE2310 - C Language

1.4 CSSE3010 - Advanced Embedded

1.5 MATH1051 - Linear Calculus

1.6 MATH2001 - Advanced Calculus

1.7 MATH2010 - Partial Differential Equations

1.8 STAT2202 - Advanced Statistics

1.9 ELEC2003 - Electronics & Circuits Pt.1

1.10 ELEC2004 - Electronics & Circuits Pt.2

1.10.1 LEC01: Capacitors and Inductors, RL and RC Circuits

CAPACITORS

Capacitors and inductors are linear circuit elements that can store electrical energy. The ideal capacitor stores energy in the form of **charge**.

$$C = \frac{\epsilon A}{d} \quad (1)$$

Where:

- C = capacitance in Farads (F)
- A = conductor plates area (both top and bottom) (mm^2)
- ϵ = dielectric of permittivity (constant)
- d = plate separation distance (m)

$$Q = CV \quad (2)$$

Where:

- Q = stored charge
- C = capacitance (F)
- V = applied voltage (V)

In DC, a capacitor is effectively an open circuit; when a steady voltage is applied. **When the voltage changes, the stored charge changes also as per equation (2) by taking the derivative.** Thus,

$$i(t) = \frac{dq(t)}{dt} = C \frac{dv(t)}{dt} \quad (3)$$

KEY TAKEAWAY: Change in voltage induces a current because there are charges moving. This electrical energy is stored in “capacitance” in the form of an electric field.

Energy storage in capacitors is calculated by integrating the instantaneous power $P(t)$. Thus,

$$P(t) = v(t)i(t) = Cv(t) \frac{dv(t)}{dt} \quad (4)$$

Integrating the instantaneous power:

$$W(t) = \frac{1}{2} C v^2(t) \quad (5)$$

Capacitors can be combined in series and in parallel to yield a single equivalent capacitance. Note: the behaviour of equivalent capacitance is the opposite of resistors. Series:

$$C_{EQ} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \dots} \quad (6)$$

Parallel:

$$C_{EQ} = C_1 + C_2 + C_3 \dots \quad (7)$$

INDUCTORS

The ideal inductor stores energy in an **induced magnetic field**.

$$\phi = LI \quad (8)$$

Where:

- ϕ = induced magnetic flux
- L = inductance in Henrys (H)
- I = applied current (A)

In DC, an inductor is effectively a short circuit (i.e. a wire with no resistance). **When the current changes, the induced field also changes.** Thus,

$$v(t) = \frac{d\phi(t)}{dt} = L \frac{di(t)}{dt} \quad (9)$$

KEY TAKEAWAY: The rate of change in magnetic flux induces a voltage. Thus, alternating current (AC) induces a change in magnetic field and thus produces a voltage. Inductance is the tendency of an electrical conductor to oppose a change in the electric current flowing through it.

Energy storage in inductors is calculated by integrating the instantaneous power $P(t)$. Thus,

$$P(t) = v(t)i(t) = Li(t) \frac{di(t)}{dt} \quad (10)$$

Integrating the instantaneous power:

$$W(t) = \frac{1}{2} Li^2(t) \quad (11)$$

Inductors can be combined in series and in parallel to yield a single equivalent inductance. Note: the behaviour of equivalent inductance is the same as resistors. Series:

$$L_{EQ} = L_1 + L_2 + L_3 \dots \quad (12)$$

Parallel:

$$L_{EQ} = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} \dots} \quad (13)$$

1.11 ELEC3100 - Advanced Electrical Theory

1.12 ELEC3300 - Motors & Electrical Energy

1.13 ELEC3400 - Amplifiers & Electronics

1.14 ELEC4300 - Power System Analysis

1.15 ELEC4302 - Power System Protection

1.16 ELEC4620 - Signal Processing

1.17 ELEC4630 - Image Processing

1.18 ENGG4800 - Project Management

1.19 METR4201 - Control System Analysis