

Queensland University of Technology

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**EGB120**  
Foundations of Electrical Engineering

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# Chapter 1

## Circuits and Sources

1.1 Fundamental Electrical Quantities

1.2 Power and Energy

1.3 Circuits and Sources

1.4 Resistors and Ohm's Law

## Chapter 2

# Filters and Rectifiers

## Chapter 3

# Source Transformation

**3.1 Thevenin Equivalent Circuits**

**3.2 Norton Equivalent Circuits**

**3.3 Superposition**

**3.4 Maximum Power Transfer**

## Chapter 4

# Ohm's Law, Kirchoff's Laws, and Resistive Circuits

### 4.1 Kirchoff's Laws

### 4.2 Series and Parallel Elements

### 4.3 Voltage and Current Dividers

### 4.4 Measuring Voltages and Currents

## Chapter 5

# Diodes

### 5.1 Introduction to Diodes

### 5.2 Voltage and Current Characteristics

### 5.3 Operating Points and Load Lines

### 5.4 Practical Diodes



## Chapter 6

# Mesh Analysis

6.1 Nodes, Loops, and Meshes

6.2 Mesh Analysis

6.3 Current Source Mesh Analysis

6.4 Dependant Source Mesh Analysis

## Chapter 7

# Inductors and Capacitors

### 7.1 Capacitors

### 7.2 Inductors

### 7.3 Inductors and Capacitors in Steady State

# Chapter 8

## RL and RC circuits and Time Response

### 8.1 Switches

### 8.2 Natural Response

#### 8.2.1 Capacitors and Inductors

Capacitors store energy as voltage

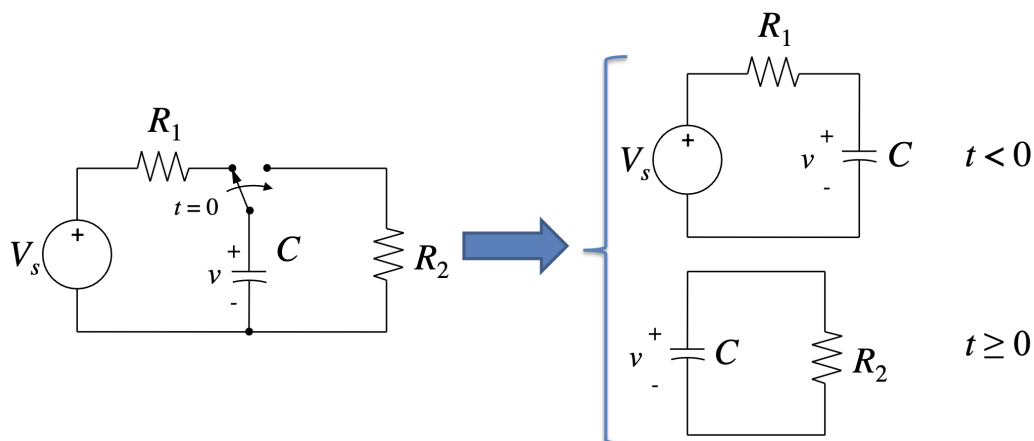
$$i = C \frac{dv}{dt}$$

Inductors store energy as current

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

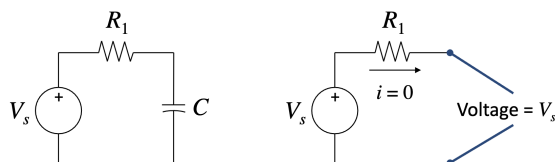
#### 8.2.2 Switched RC Circuit

Assuming that the switch has been in the first position for a long time (till reached steady state). Find the voltage right before  $t = 0$ .



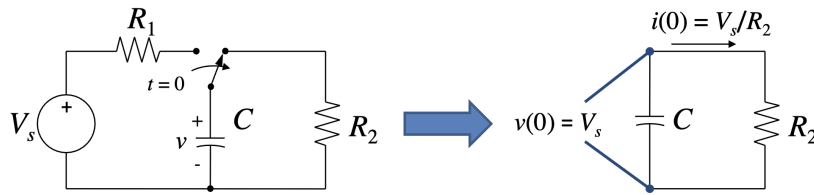
For the initial condition

- Perform steady state analysis by treating the capacitor as an open circuit



The voltage across the capacitor right before  $t = 0$  is the same as source voltage  $V_s$

Natural Response of an RC Circuit



Using KCL we get

$$-C \frac{dv}{dt} = \frac{v}{R_2}$$

Rearranging and solving the differential equation

$$\begin{aligned} \frac{dv}{dt} &= -\frac{v}{R_2 C} \\ \frac{1}{v} \frac{dv}{dt} &= -\frac{1}{R_2 C} \end{aligned}$$

Integrate both sides

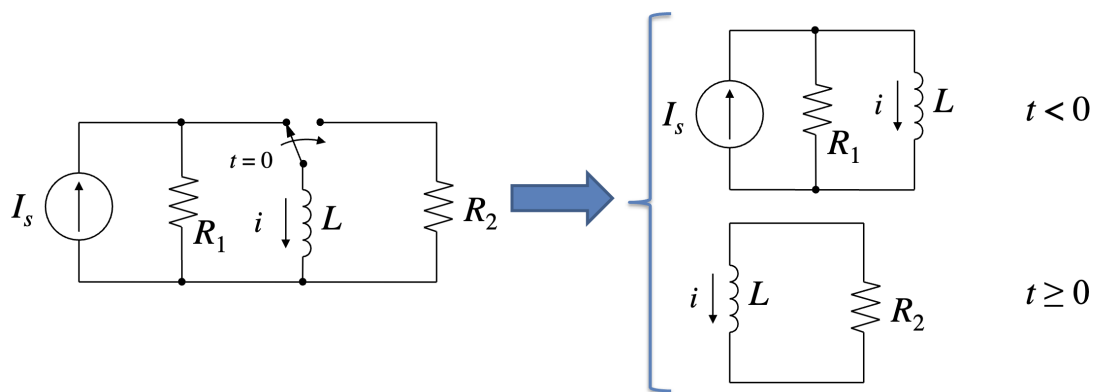
$$\begin{aligned} \int \frac{1}{v} \frac{dv}{dt} dt &= \int -\frac{1}{R_2 C} dt \\ \ln v &= -\frac{t}{R_2 C} + k \\ v &= e^{-\frac{t}{R_2 C} + k} \\ v &= A e^{-\frac{t}{R_2 C}} \end{aligned}$$

Noting that  $A = v(0) = V_s$  we get

$$v = V_s e^{-\frac{t}{R_2 C}}$$

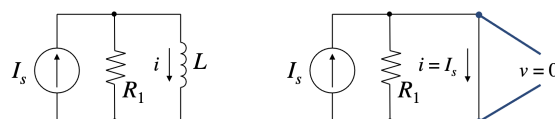
### 8.2.3 Switched RL Circuit

Assuming that the switch has been in the first position for a long time (till reached steady state). Find the current right before  $t = 0$ .



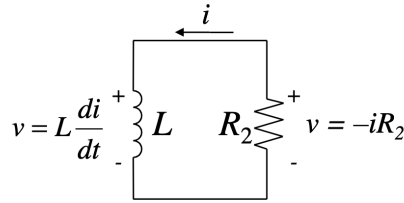
For the initial condition

- Perform steady state analysis by treating the inductor as a short circuit



The current through the inductor right before  $t = 0$  is the same as source current  $I_s$

## Natural Response of an RL Circuit



Using KVL we get

$$-L \frac{di}{dt} = R_2 i$$

Rearranging and solving the differential equation

$$\frac{di}{dt} = -\frac{R_2}{L} i$$

Using the integrating factor method

$$\frac{di}{dt} + \frac{R_2}{L} i = 0$$

Multiplying both sides by  $e^{\frac{R_2}{L}t}$

$$e^{\frac{R_2}{L}t} \frac{di}{dt} + \frac{R_2}{L} e^{\frac{R_2}{L}t} i = 0$$

Noting that  $\frac{d}{dt} \left( e^{\frac{R_2}{L}t} i \right) = e^{\frac{R_2}{L}t} \frac{di}{dt} + \frac{R_2}{L} e^{\frac{R_2}{L}t} i$

$$\frac{d}{dt} \left( e^{\frac{R_2}{L}t} i \right) = 0$$

Integrating both sides

$$\begin{aligned} \int \frac{d}{dt} \left( e^{\frac{R_2}{L}t} i \right) dt &= \int 0 dt \\ e^{\frac{R_2}{L}t} i &= k \\ i &= k e^{-\frac{R_2}{L}t} \end{aligned}$$

Noting that  $k = i(0) = I_s$  we get

$$i = I_s e^{-\frac{R_2}{L}t}$$

## 8.2.4 Natural Response

$$v(t) = v(0) e^{-\frac{t}{R_2 C}}$$

(Where  $\tau = RC$  is the time constant)

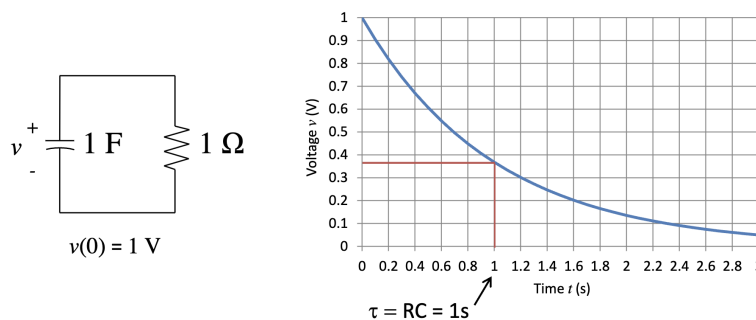


Figure 8.1: Natural Response of RC Circuit for  $v(t) = v(0) e^{-\frac{t}{R_2 C}}$  where  $v(0) = 1V$ ,  $R_2 C = 1\Omega$ , and  $C = 1F$

$$i(t) = i(0)e^{-\frac{t}{R_2C}}$$

(Where  $\tau = \frac{L}{R_2}$  is the time constant)

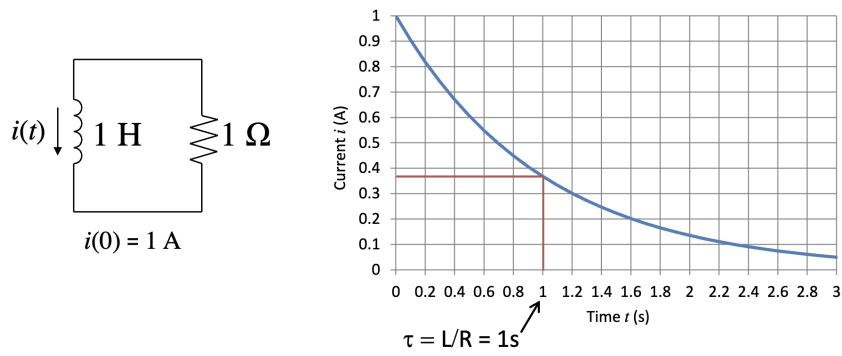


Figure 8.2: Natural Response of RL Circuit for  $i(t) = i(0)e^{-\frac{t}{R_2C}}$  where  $i(0) = 1A$ ,  $R_2C = 1\Omega$ , and  $L = 1H$

### 8.3 Step Response

## Chapter 9

# Operational Amplifiers

9.1 Introduction to Operational Amplifiers

9.2 Op Amp Analysis

9.3 Practical Op Amps

## Chapter 10

# Sinusoidal State Analysis

10.1 Sinusoidal Signals

10.2 RMS

10.3 Phasors

10.4 Circuit Analysis with Phasors



## Chapter 11

# Frequency Response of RL and RC Circuits

### 11.1 AC Circuit Analysis

### 11.2 Frequency Response and Transfer Functions

### 11.3 Bode Plots

## Chapter 12

# Filters and Rectifiers

### 12.1 Filter Introduction

### 12.2 Passive Filters

### 12.3 Active Filters

## Chapter 13

# Zener Diodes and Voltage Regulators

13.1 Rectifiers and Regulators

13.2 Zener Diode Regulators

13.3 Series Regulators

13.4 Op Amps as Regulators