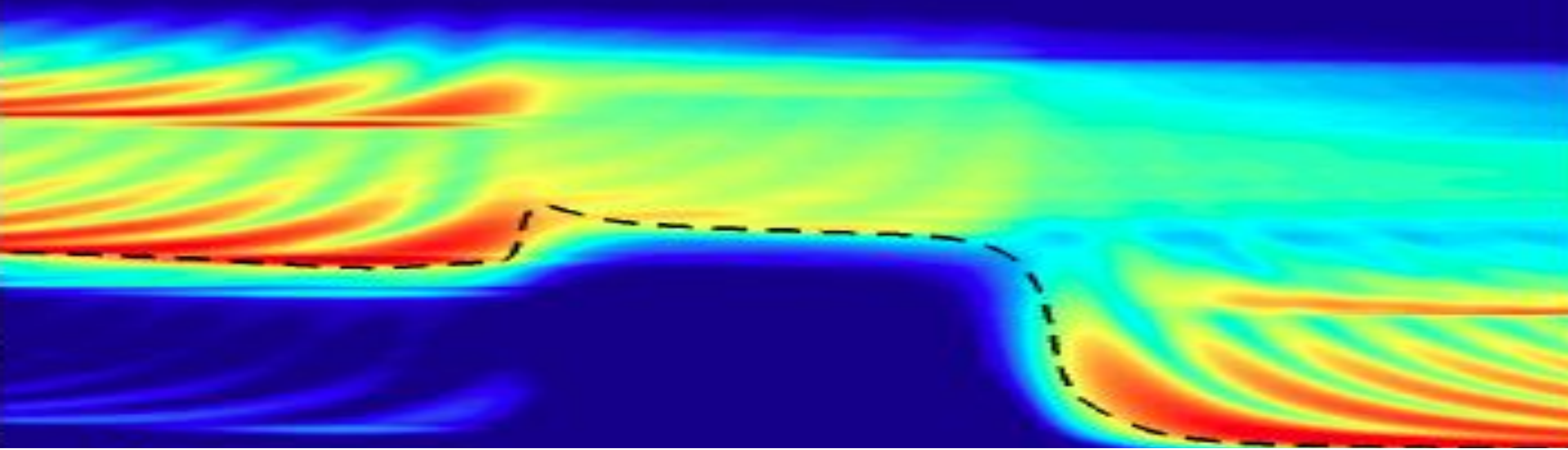

EECS 16B
Designing Information Devices and Systems II
Lecture 3

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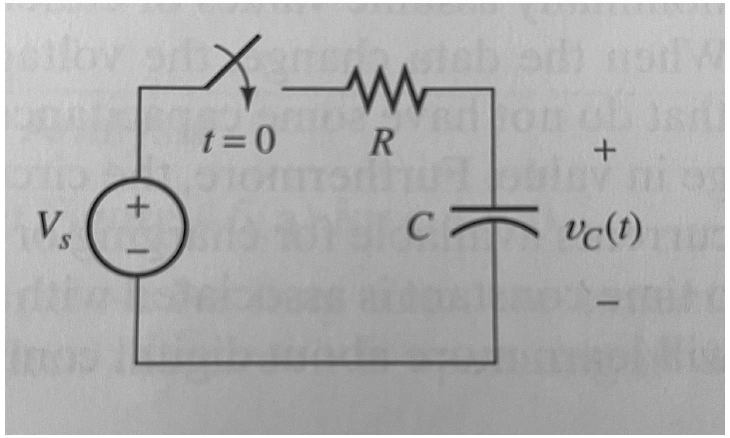
Recap: R-C circuits: Response in time

We now ask a slightly different question. What happens if a capacitor that had initially no charge is connected to a constant voltage at t=0



Transient Response

- Outline
  - R-C circuits
  - R-L circuits
  - R-L-C Circuits

R-C circuits: Response in time

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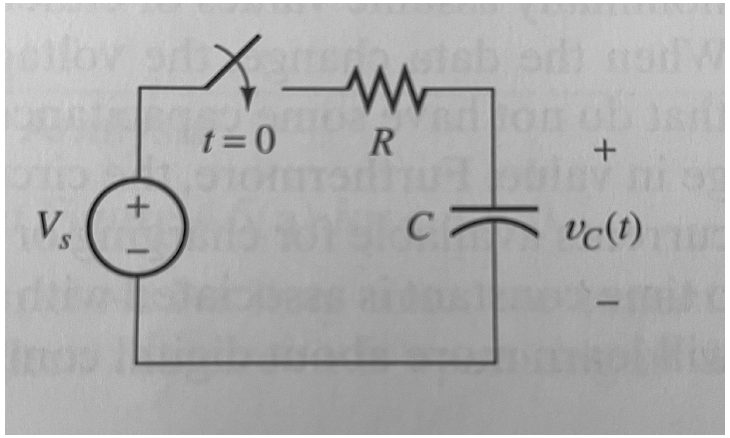

R-C circuits: Response in time

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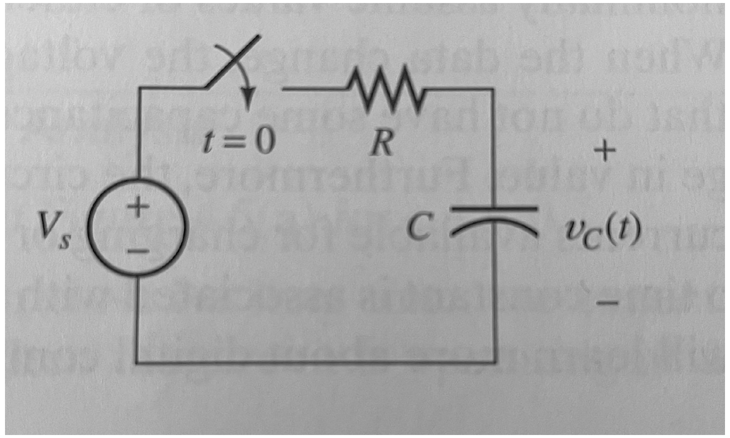


General Solution of the Differential Equation

For a first order, linear differential equation of the form

$$\frac{dy}{dt} + ay(t) = b(t)$$ where we assume a to be a constant

Homogeneous/Complementary solution

$$\frac{dy}{dt} + ay(t) = 0$$
$$\Rightarrow \frac{dy}{y} = -a$$
$$\Rightarrow \ln(y) = -at + C$$
$$\Rightarrow y(t) = Ke^{-at}$$

Particular Solution (Integrating Factor Method):

$$\frac{dy}{dt} + ay(t) = b(t)$$

We want to find a multiplier function *f(t)* such that

$$f(t)\frac{dy}{dt} + af(t)y(t) = b(t)f(t)$$

can be written as

$$\frac{d}{dt}[y(t)f(t)] = b(t)f(t) \quad \text{--(A)}$$

For equation (A) to hold

$$\frac{df(t)}{dt} = af(t)$$
$$\Rightarrow f(t) = e^{at}$$

Then from (A)

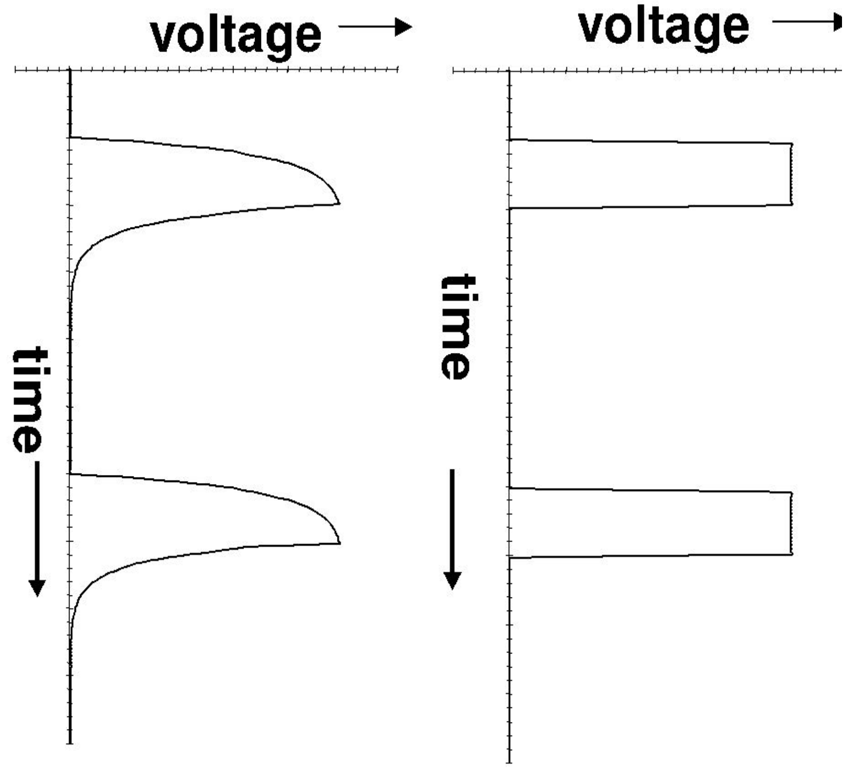
$$y(t) = \frac{1}{f(t)}\int b(t)f(t)dt$$
$$\Rightarrow y_p(t) = e^{-at}\int e^{at}b(t)dt$$

$$\boxed{y(t) = Ke^{-at} + e^{-at}\int e^{at}b(t)dt}$$

K is determined using initial condition

Digital Signals to a RC circuit

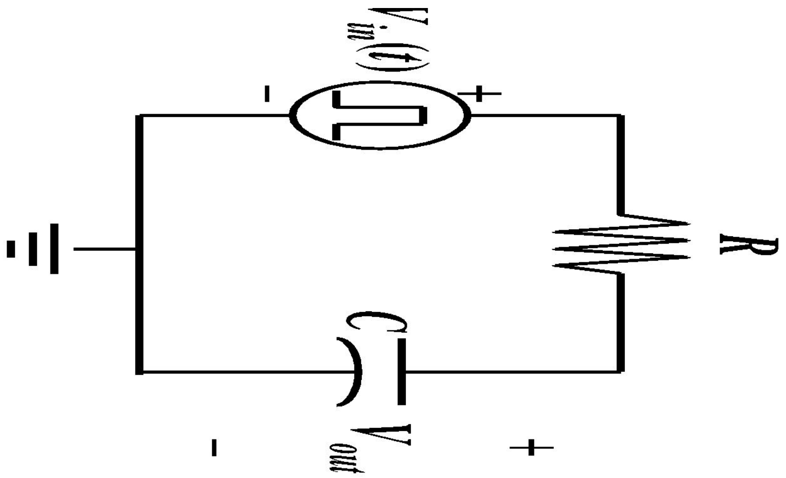
- Every node in a real circuit has capacitances

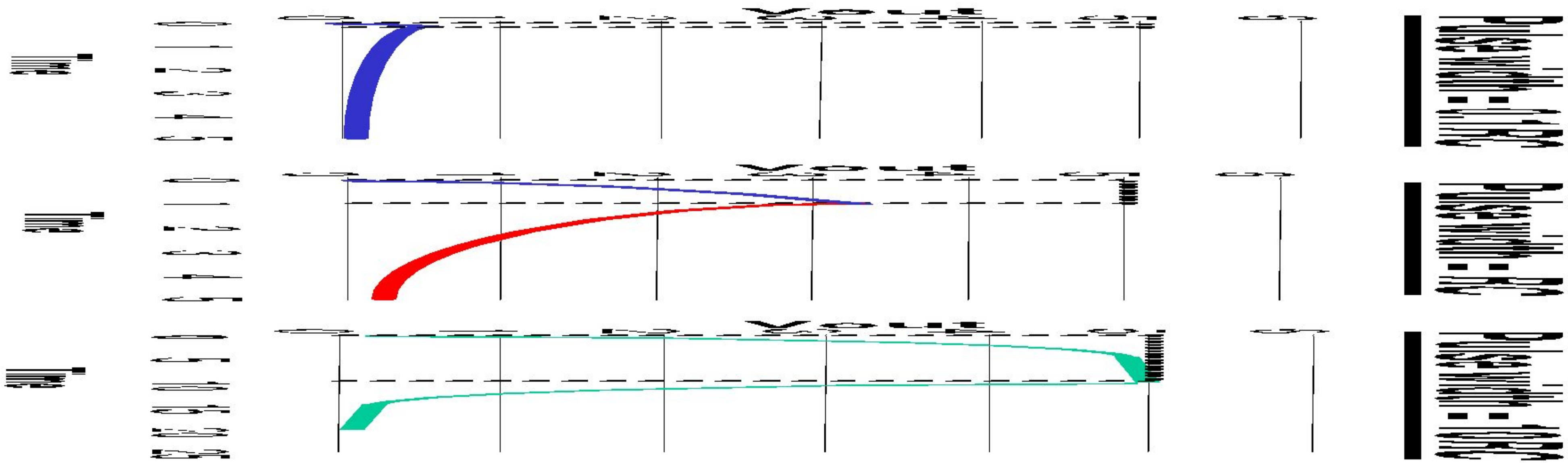


- Even if we send in very 'pure' square looking pulses what we actually get is how it looks in the right due to capacitor charging and discharging <u>unless we go very very slow</u>

Pulse Distortion

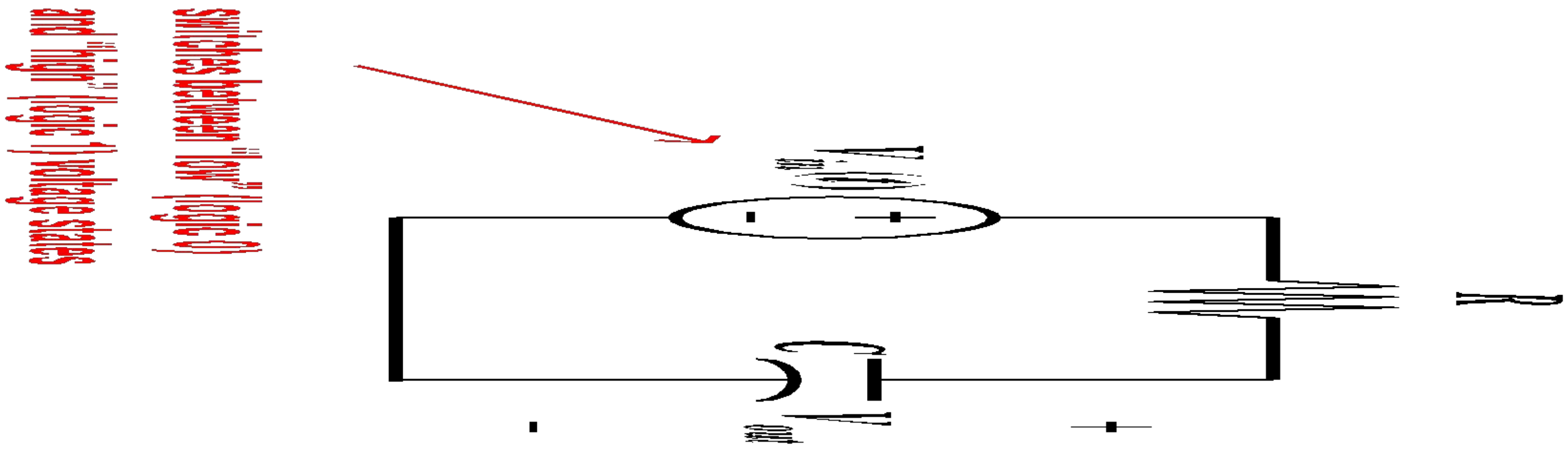
The input voltage pulse width must be large enough; otherwise the pulse is distorted



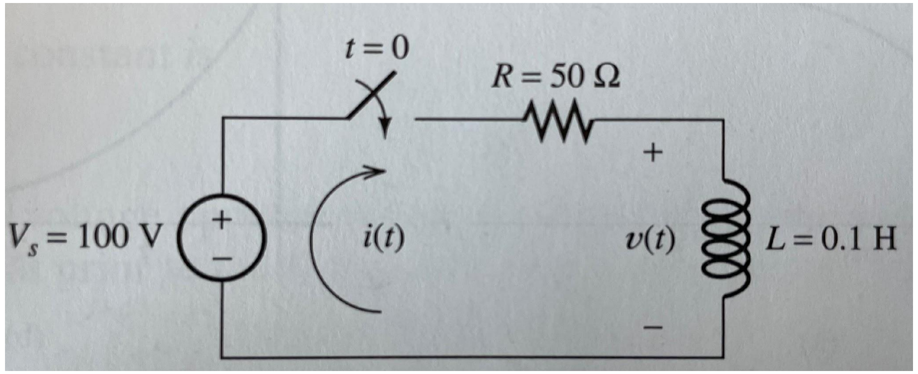


Computers are RC circuits (almost)

- Digital circuits are predominantly RC circuits (other than the communication part)
- Simplistically a logic gate can be model as a RC circuit
- The speed of the computer is limited by the RC time constant



R-L Circuits



Steady State

Capacitors:

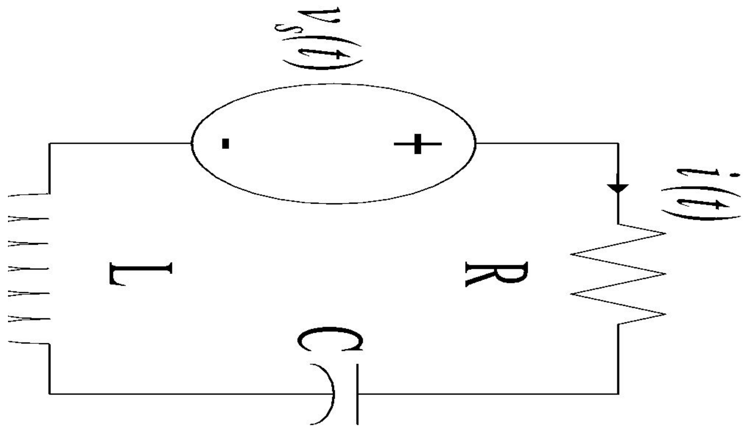
Inductors:

Complex Numbers

- $e^{i\theta} = \cos(\theta) + isin(\theta)$

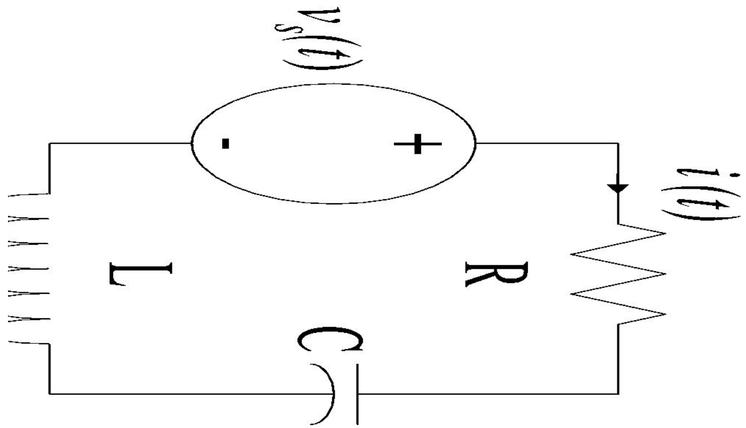
- Read the note j

R-L-C circuits: Response in time



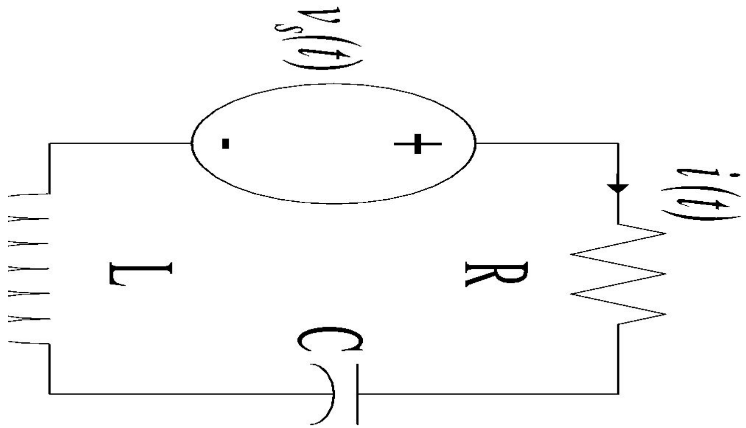
Filters, antennas, resonances

R-L-C circuits: Response in time



Filters, antennas, resonances

R-L-C circuits: Response in time



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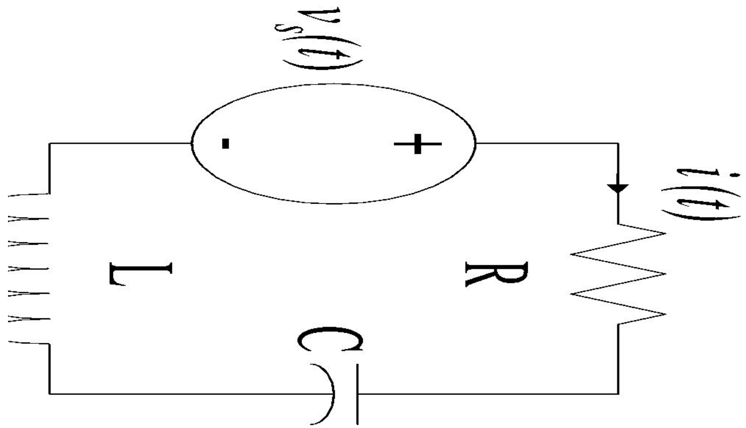
R-L-C circuits: Response in time



Filters, antennas, resonances

Summary

- Overdamped – real unequal roots
- Critically damped – Real Equal roots
- Underdamped – Complex roots