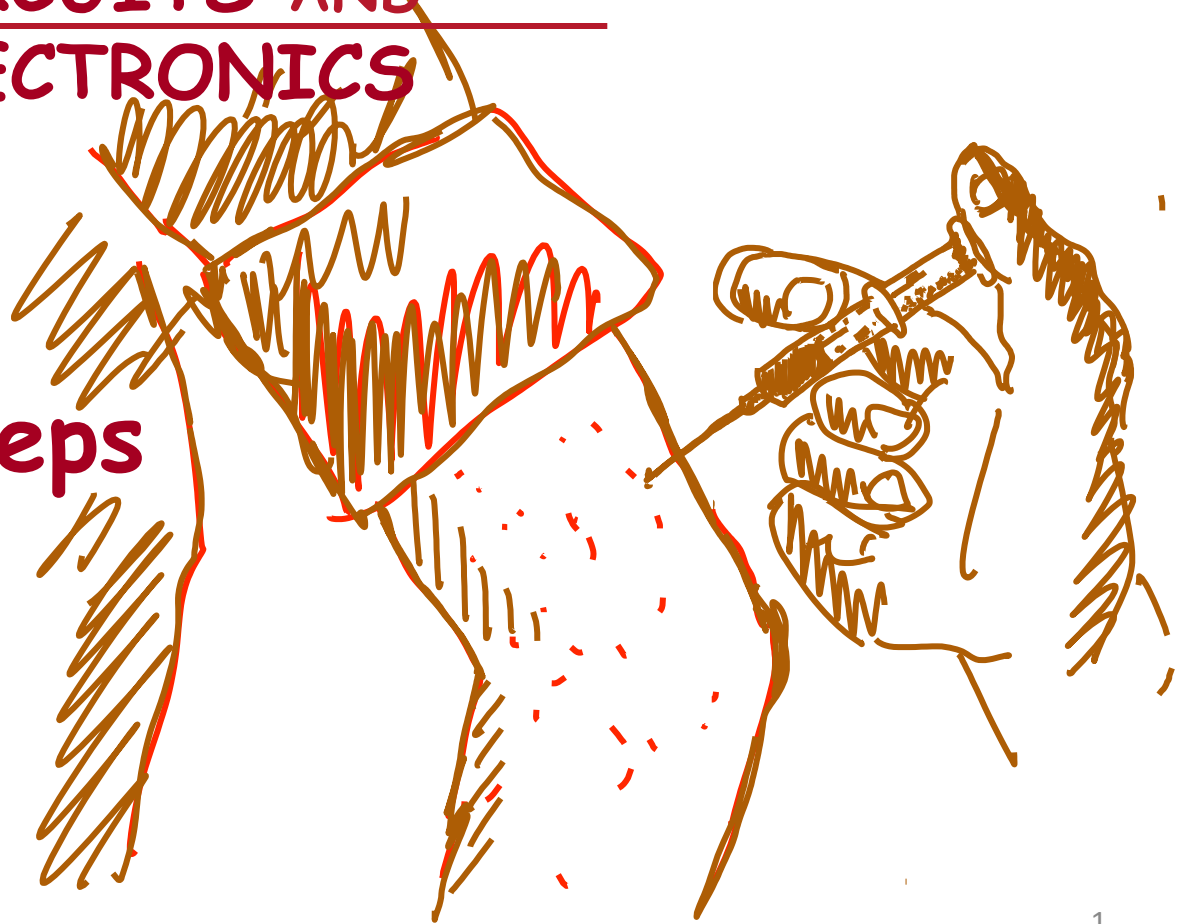**6.002x**
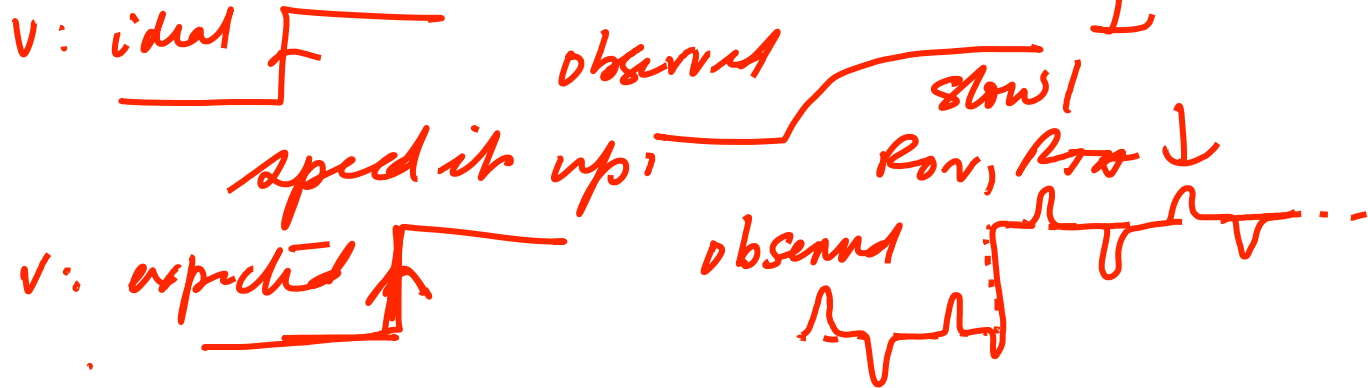
CIRCUITS AND ELECTRONICS

Impulses, Steps and Ramps

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In our previous sequence...
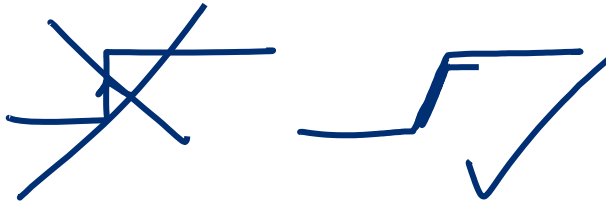
Slower may be better
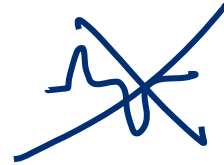

chip

V

C_L

V: ideal

observed

speed it up?

slow!

$R_{ON}, R_{??} \downarrow$

V: expected

observed
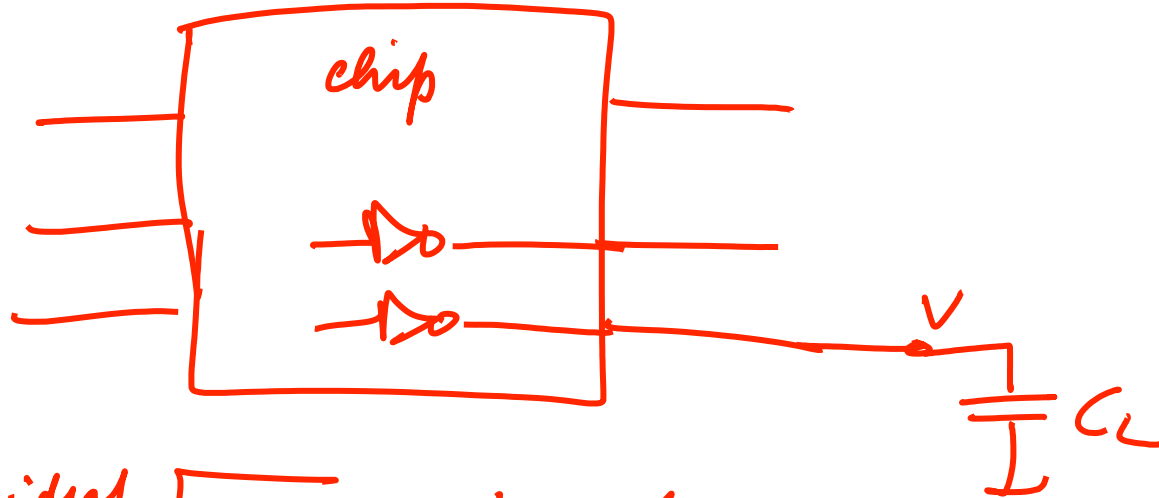
In our previous sequence…

**6.002x
expert saw
the solution!**

said — make the transition slower

at v:

Solved — no glitche

We will see why here…

We will also understand how to model drug delivery

If the input duration is much shorter than system time constant, then shape or duration of input does not matter, only total amount of drug delivered.
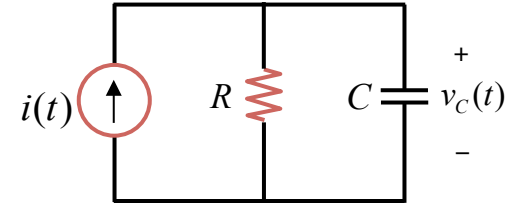
Model input as a short pulse → Impulse
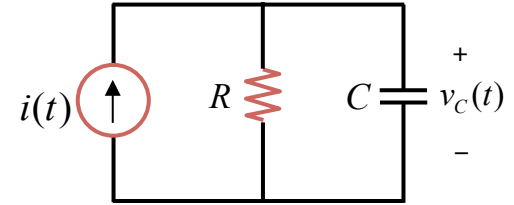
More on this soon…

First, let's understand a step input

Rising step response of RC circuit

Sec. 10.1.1 of A&L

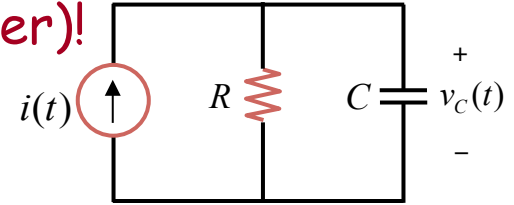# Falling step response of RC circuit

Pulse input:

Rising step followed by falling step (much later)!

Short pulse input:

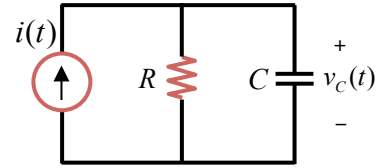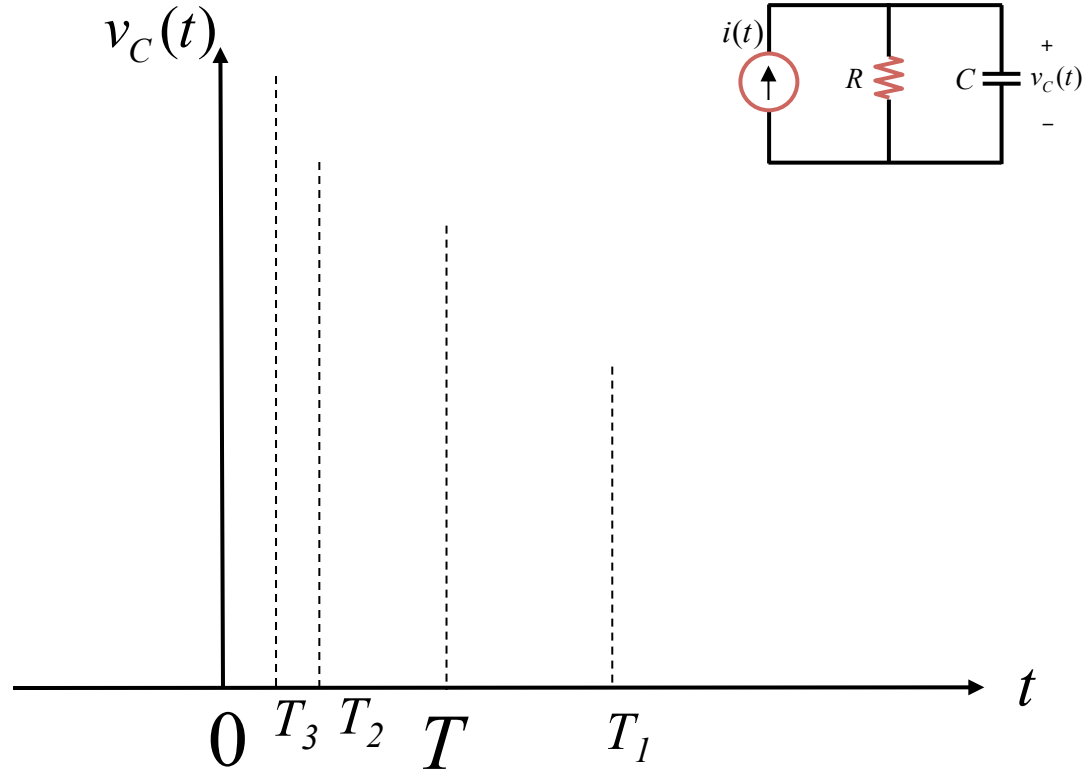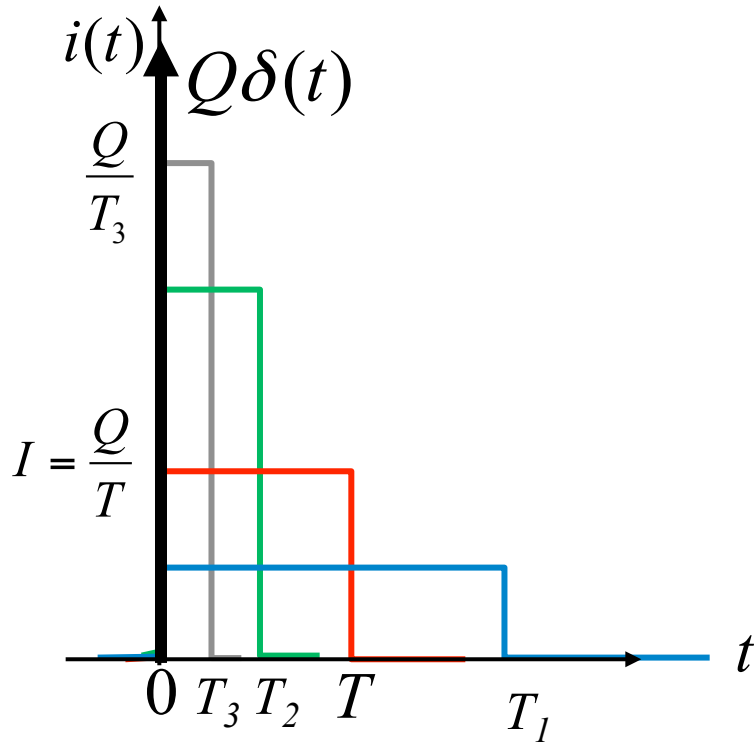Rising step followed by falling step (shortly thereafter)!

$i(t)$ R C $+$ $v_C(t)$ $-$

Let's Stare at Current Pulse

Becomes "impulse" as Lim T → 0
Denoted by $\delta(t)$
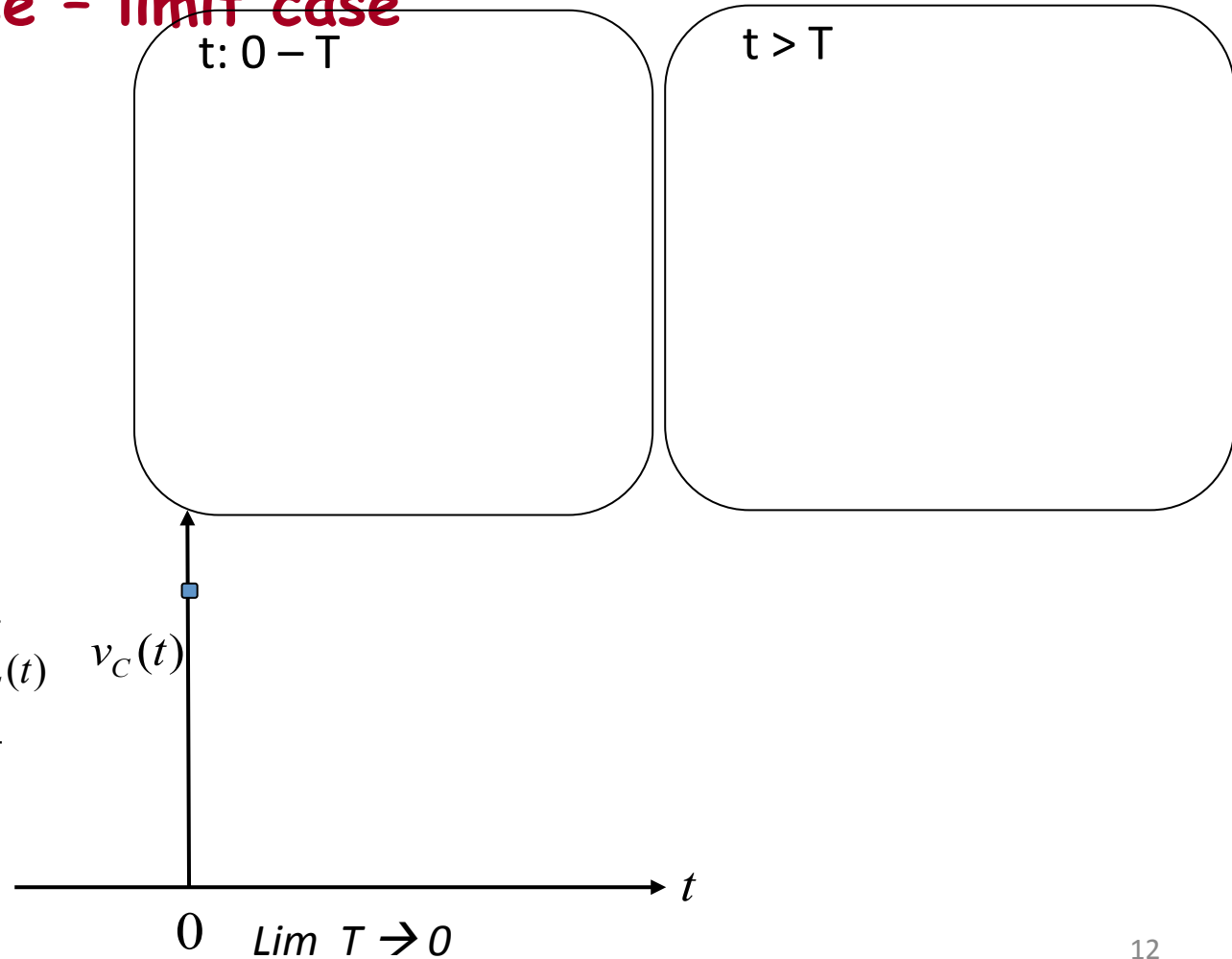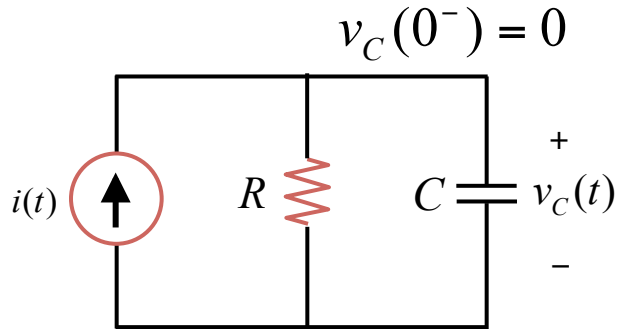Impulse is an important signal type

As the pulse gets narrower → impulse

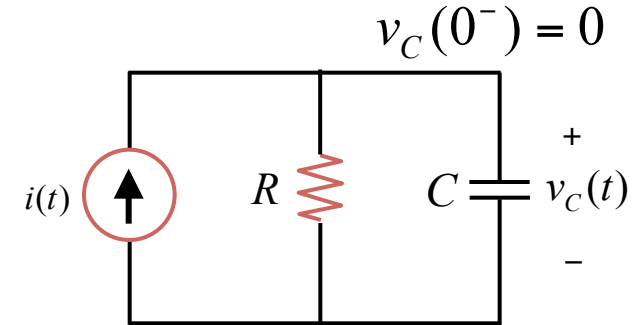$$Q\delta(t)$$

$i(t)$

$\dfrac{Q}{T_3}$

$I = \dfrac{Q}{T}$

$0 \quad T_3 \; T_2 \quad T \qquad T_1 \qquad t$

$v_C(t)$

$0 \quad T_3 \; T_2 \quad T \qquad T_1 \qquad t$

$i(t) \qquad R \qquad C \quad v_C(t)$
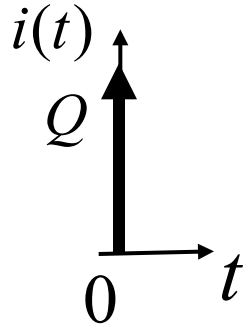
Becomes "impulse" as Lim T → 0
Denoted by $\delta(t)$
Impulse is an important signal type

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Response to impulse – limit case

$i(t)$

Q

Charge Q

0 T t

$v_C(0^-) = 0$

$i(t)$ R C $+$ $v_C(t)$ $-$

$t: 0 - T$

$t > T$

$v_C(t)$

0 $Lim\ T \rightarrow 0$ t

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Response to impulse

$i(t)$

Q

0 t

$v_C(t)$

0 t

$v_C(0^-) = 0$

$i(t)$ R C $+$
$v_C(t)$
$-$
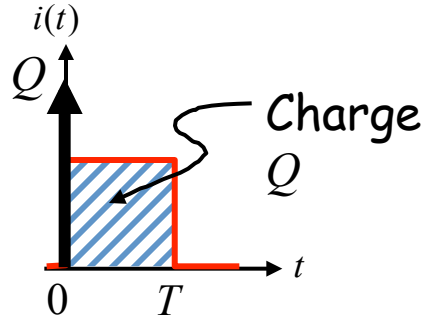
Current and voltage impulses

$i(t)$

Q

0 t

$i(t) = Q\delta(t)$

$v_C(0^-) = 0$

R C $+$ $v_C(t)$ $-$
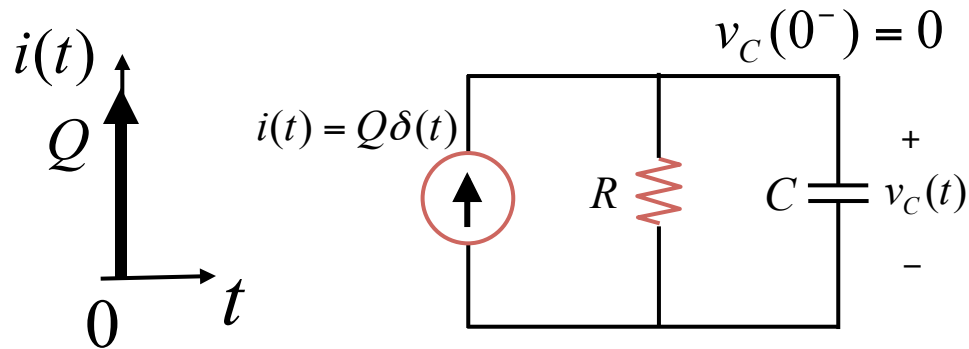
Current impulse delivers charge Q

$v_C(t)$

$\dfrac{Q}{C}$

$\dfrac{Q}{C} e^{\frac{-t}{RC}}$

0 t
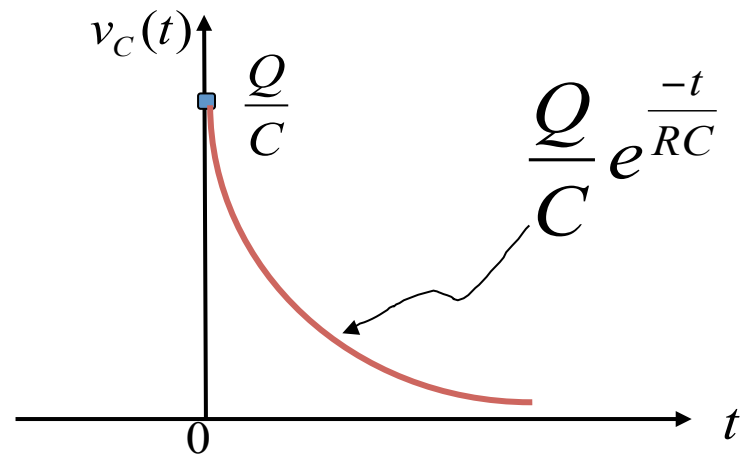
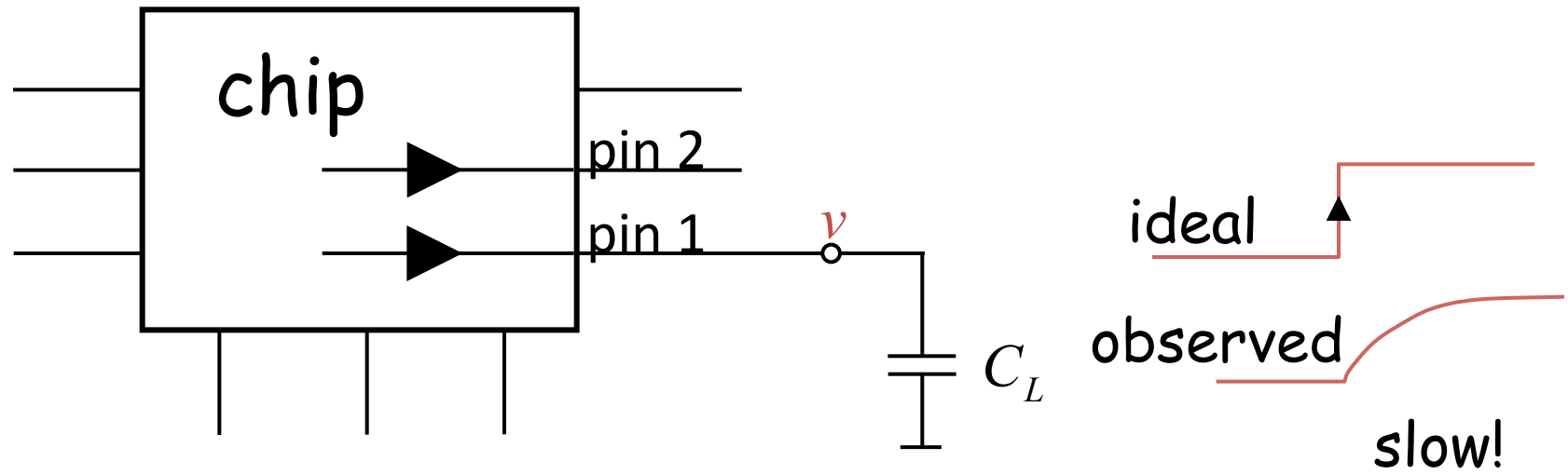Voltage impulse delivers flux linkage Λ

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Superposition with initial conditions and sources

Impulses, steps and ramps

For linear systems (remember, no sources and initial conditions)

Back to:

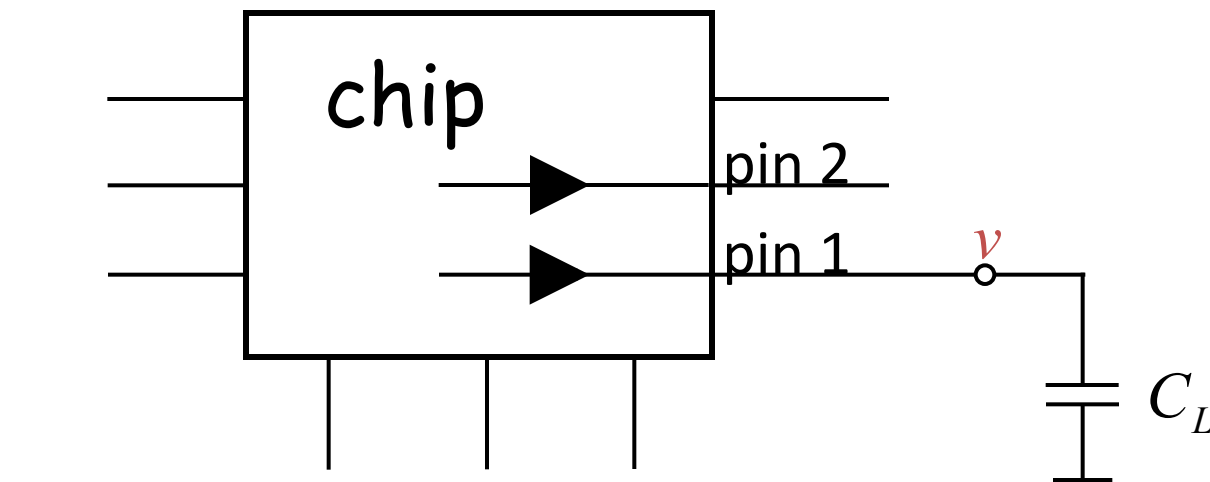## Problem:
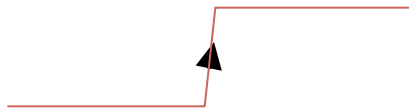

So the engineers decided to speed it up...

$\dfrac{R_L}{R_{ON}}$ made R_L small
made R_{ON} small

Slower may be better

... 6.002x expert saw the solution

chip

pin 2

pin 1

v

C_L

v:

We now have the tools to understand why

Slow the edges down!

Why? Consider ...
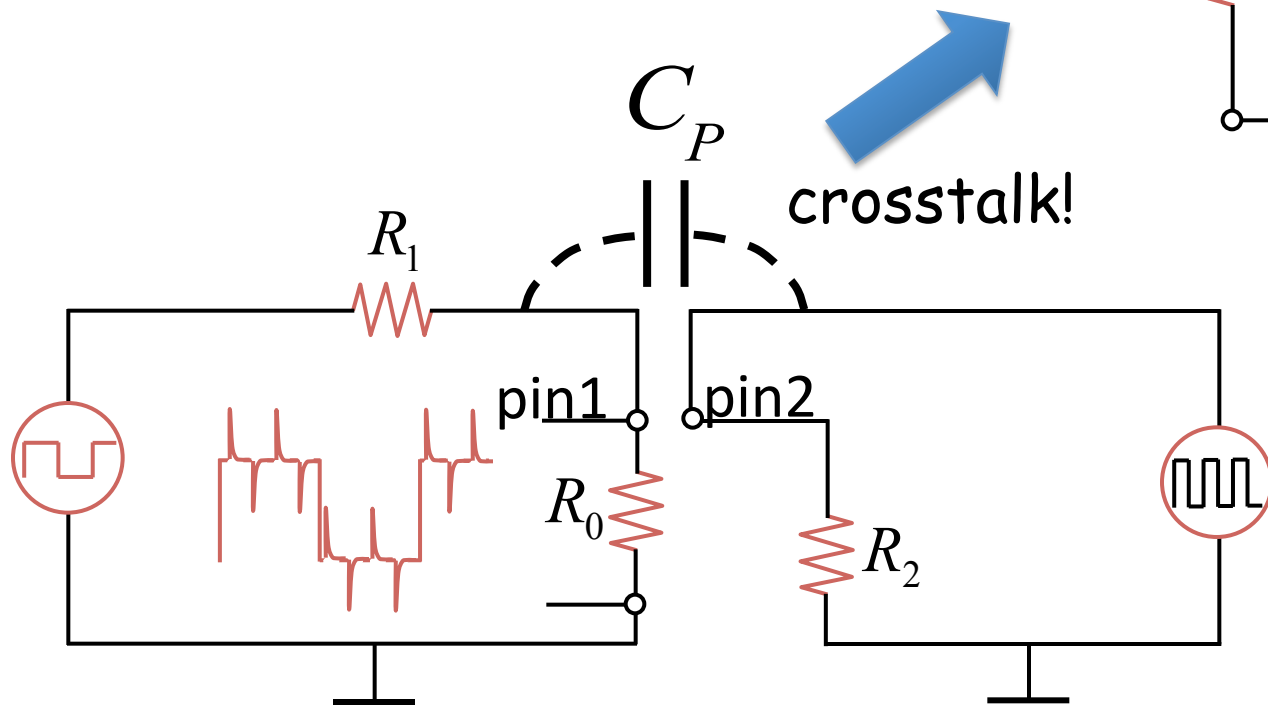
Case ①

Why? Consider ...

Case ②
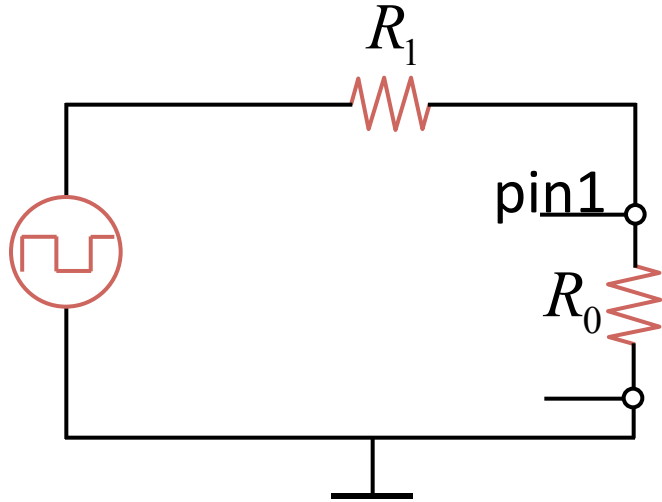
Why? Consider ...

Model:

Why? Consider ...

Case ②

Model:

crosstalk!
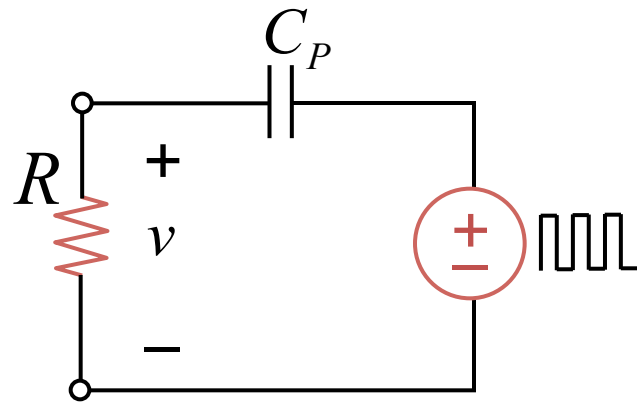
Case ③

... **6.002x expert saw the solution**

slower transitions!

Demo

Why? Consider ...

Model:

$-\ v_C\ +$

R $\quad +$ $\quad C$

v_R $\qquad \left(\begin{array}{c} + \\ - \end{array}\right) v_I$

$-$

v_I

t