

6.002

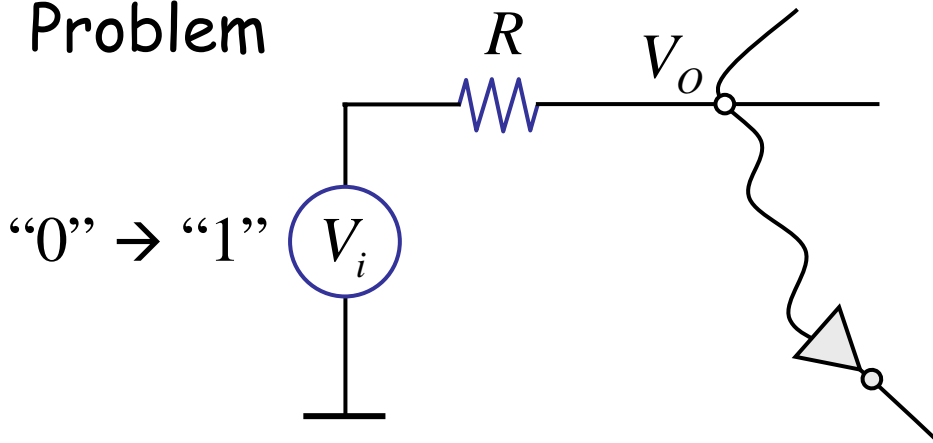
**CIRCUITS AND
ELECTRONICS**

Violating the Abstraction Barrier

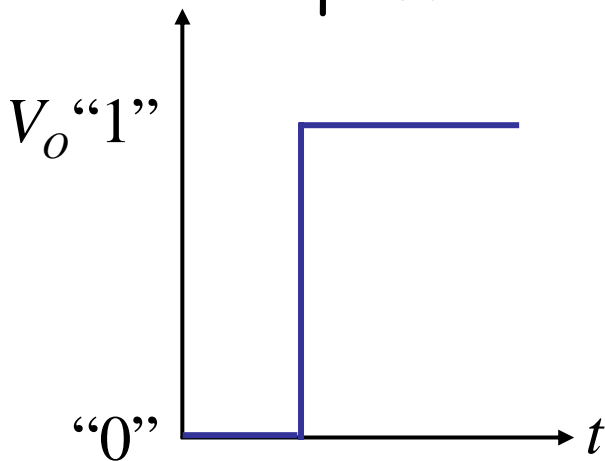
Cite as: Anant Agarwal and Jeffrey Lang, course materials for 6.002 Circuits and Electronics, Spring 2007. MIT OpenCourseWare (<http://ocw.mit.edu/>), Massachusetts Institute of Technology. Downloaded on [DD Month YYYY].

Case 1: The Double Take

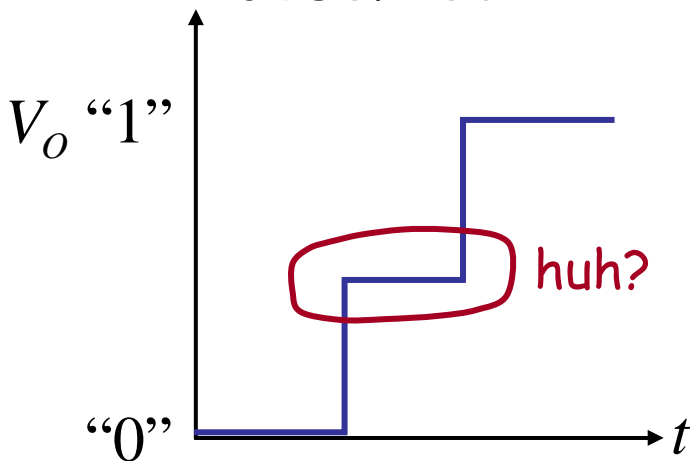
Problem



expected

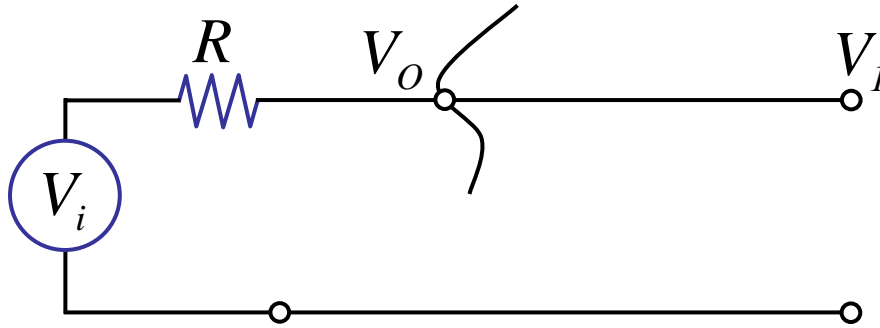


observed



in forbidden region!

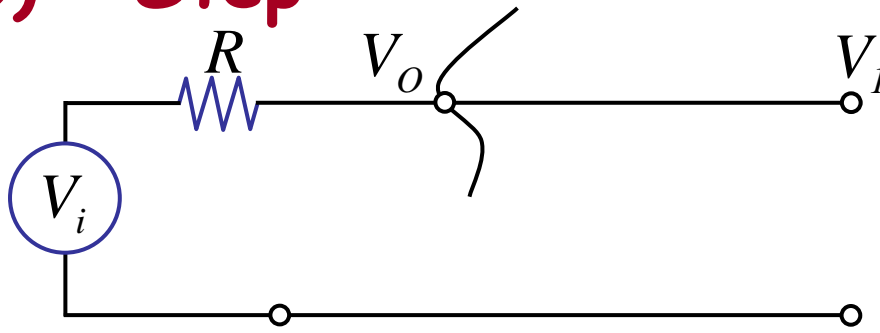
(a) DC case



very high
impedance,
like open
circuit

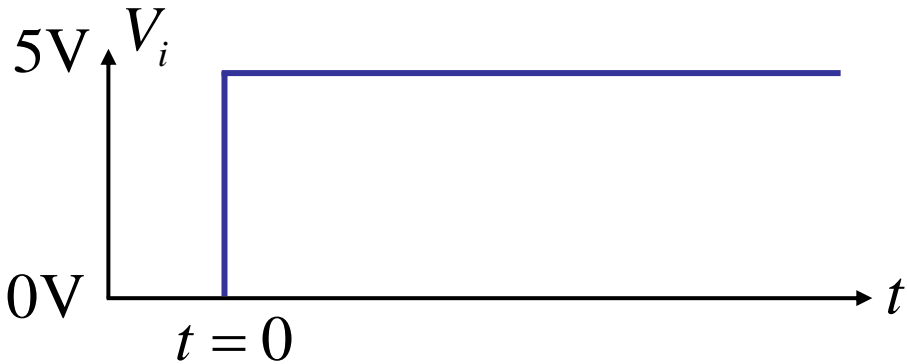
$$V_i = 5V \text{ DC} \quad V_o = 5V \text{ DC} \quad V_1 = 5V \text{ DC} \longrightarrow \text{OK}$$

(b) Step

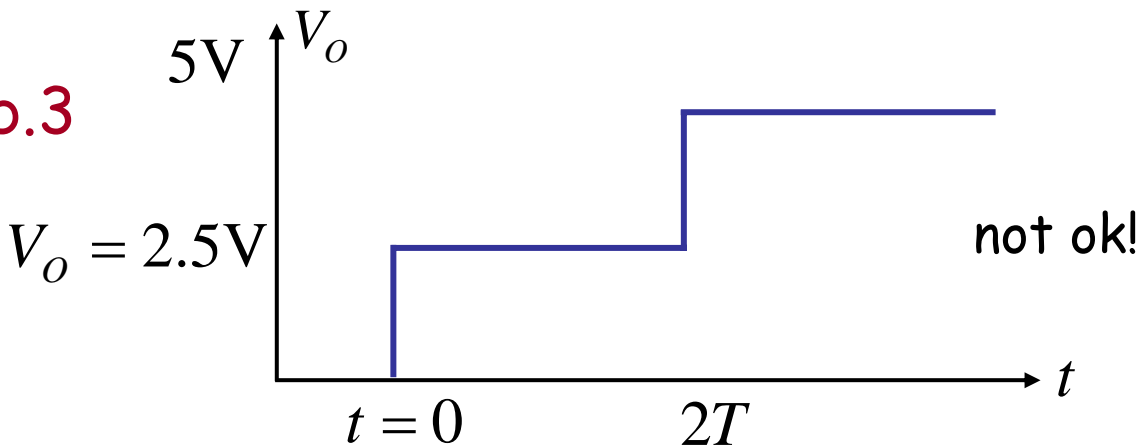


very high impedance, like open circuit

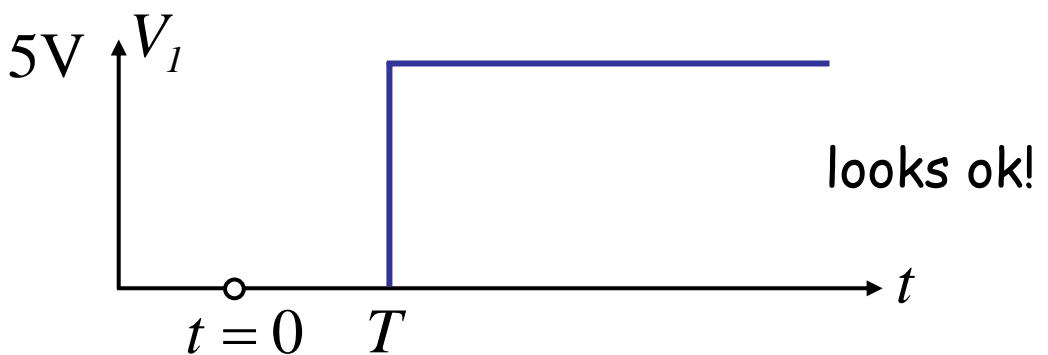
b.1

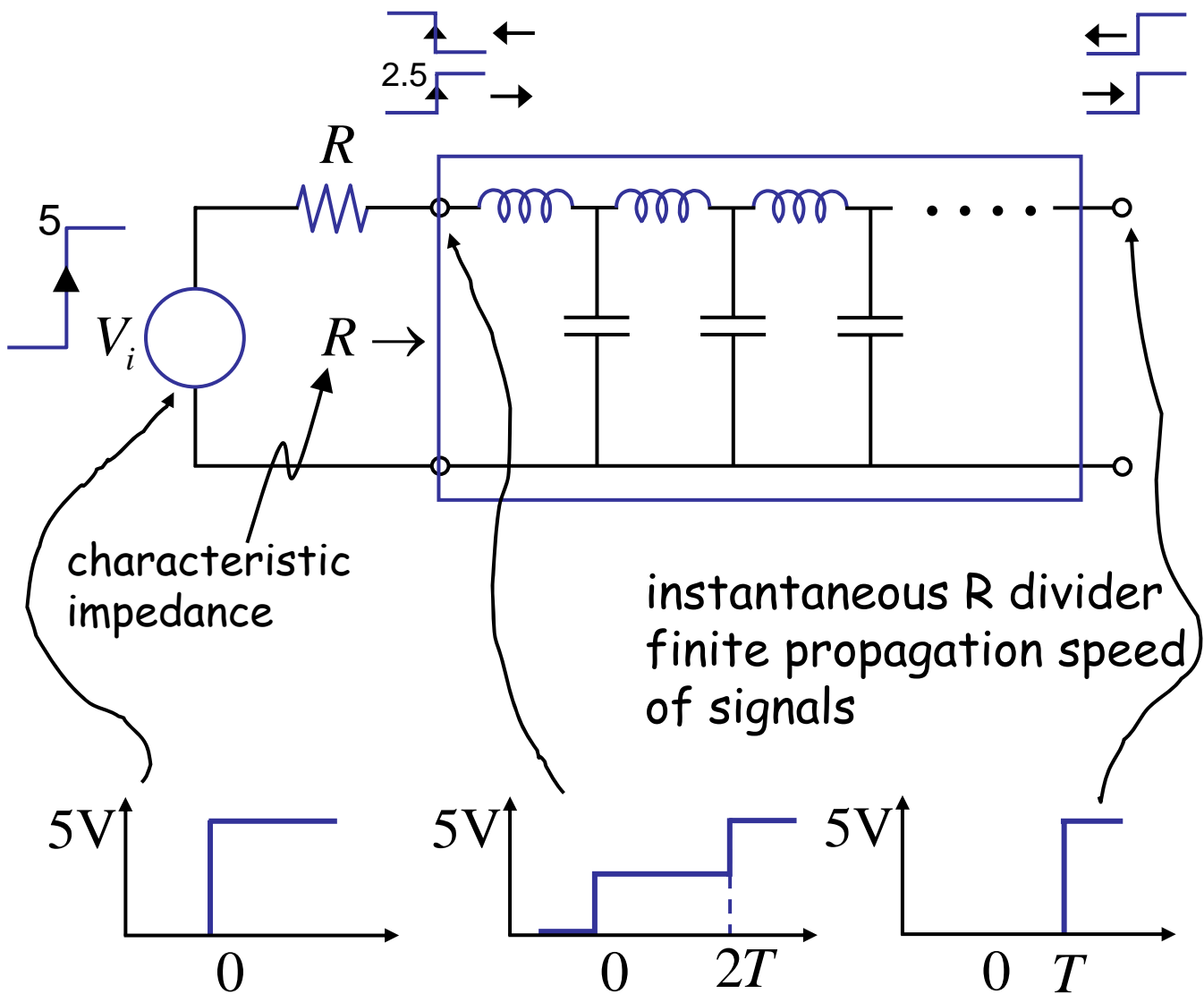


b.3



b.2



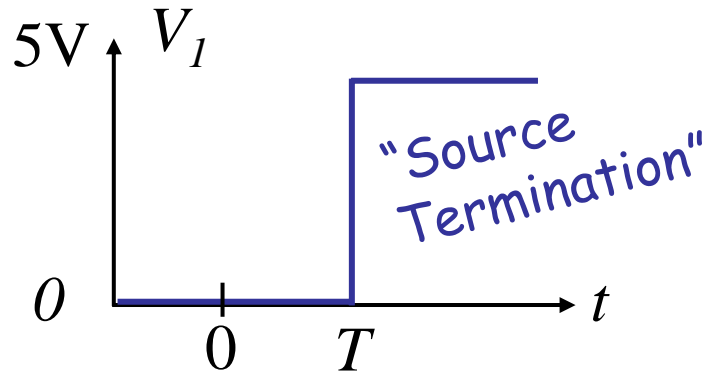


Cite as: Anant Agarwal and Jeffrey Lang, course materials for 6.002 Circuits and Electronics, Spring 2007. MIT OpenCourseWare (<http://ocw.mit.edu/>), Massachusetts Institute of Technology. Downloaded on [DD Month YYYY].

Question: So why did our circuits work?

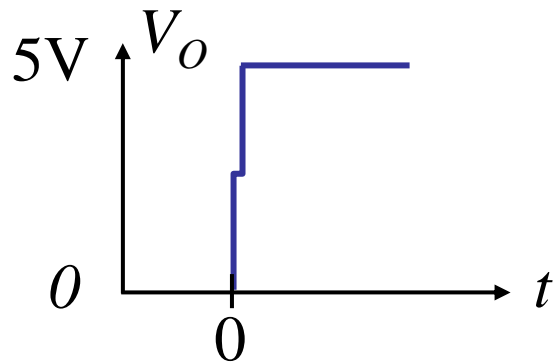
1. Look only at V_I

DEMO



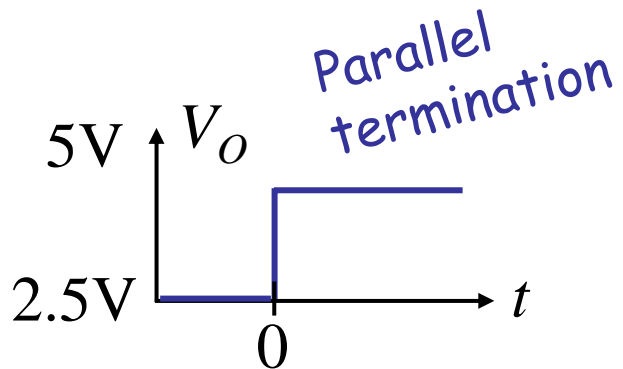
2. Keep wires short

DEMO
use small wire



3. Termination

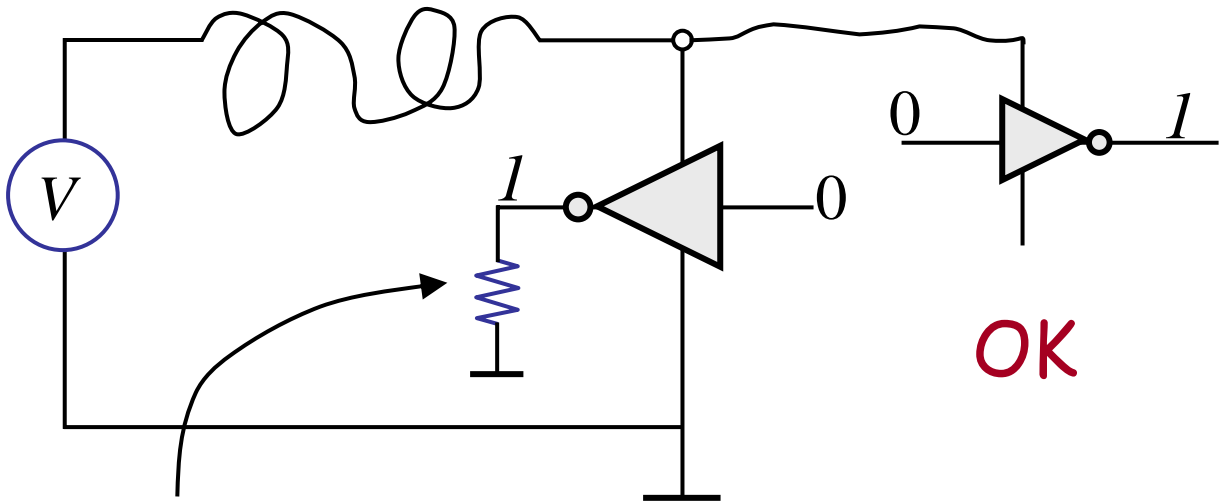
DEMO
add R at the end



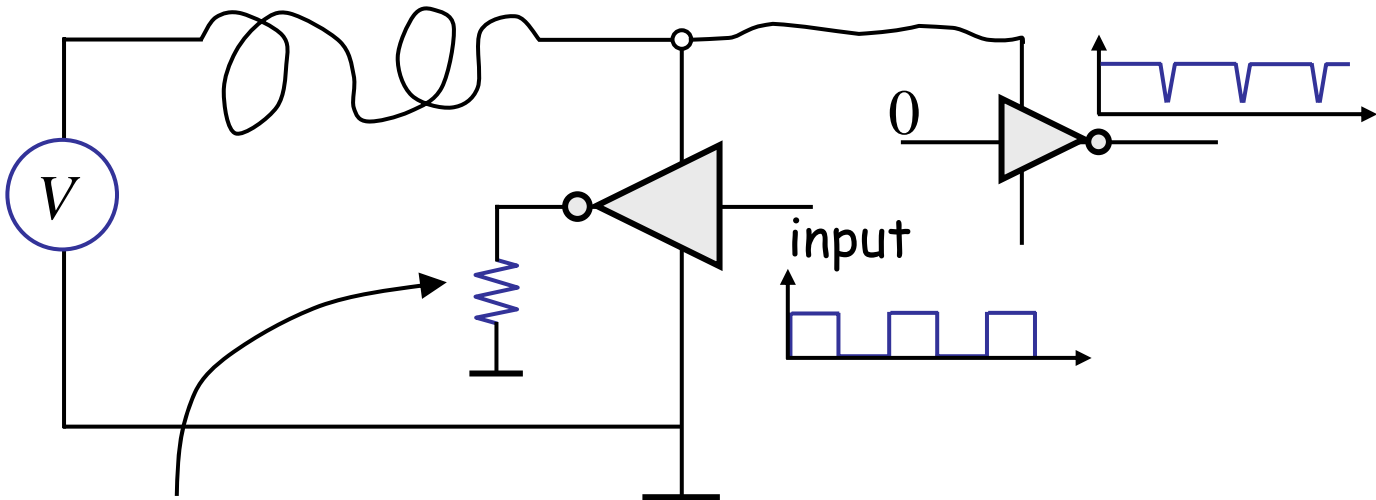
More in 6.014

Case 2: The Double Dip

Problem → strange spikes on supply



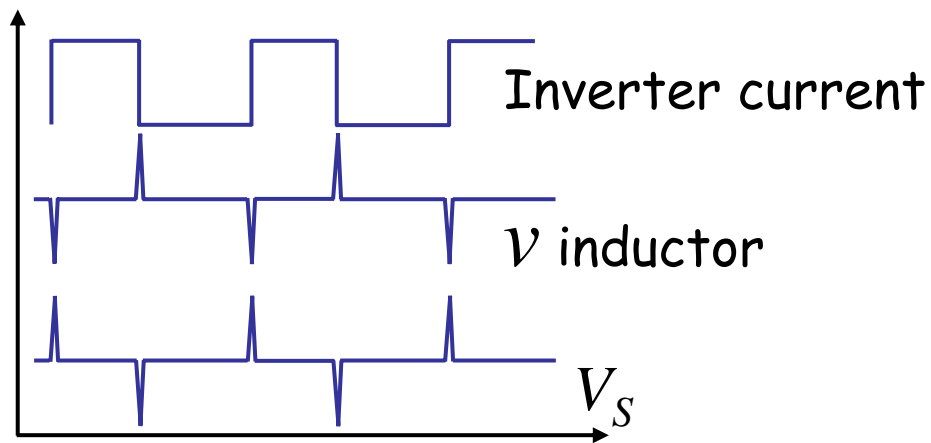
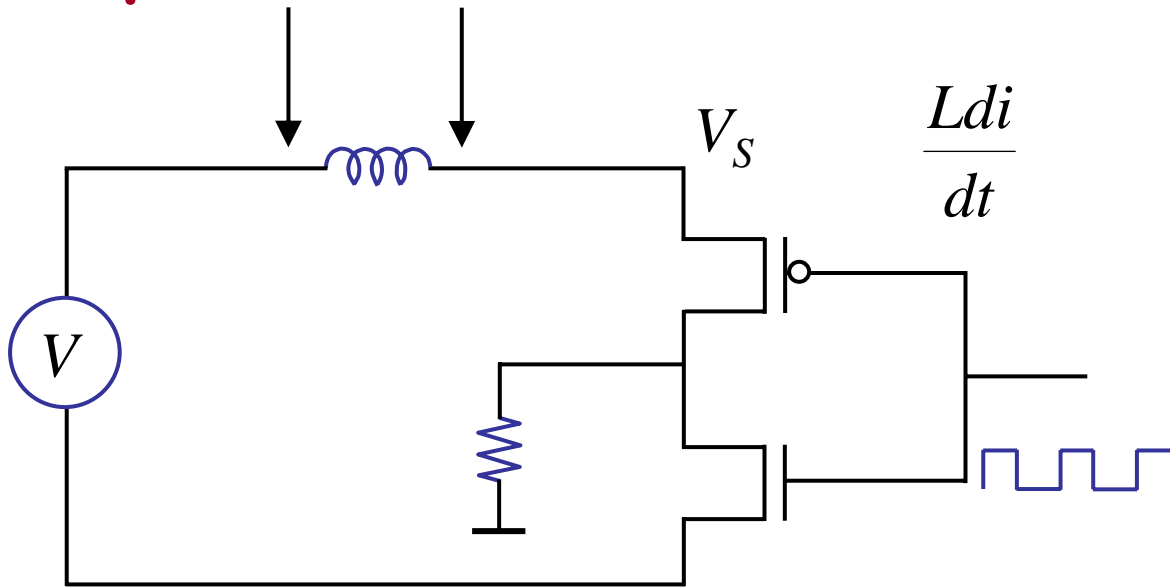
driving a 50 Ω resistor!



driving a 50 Ω resistor!

Why?

Drop across inductor

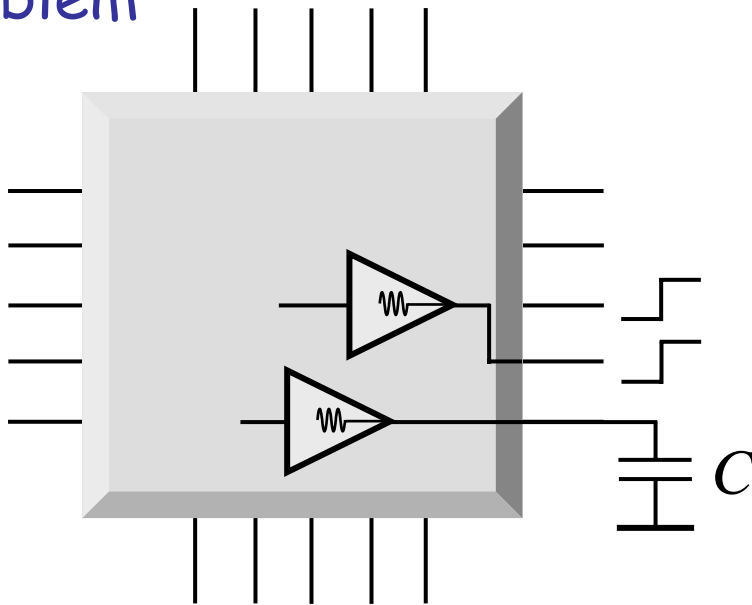


solution

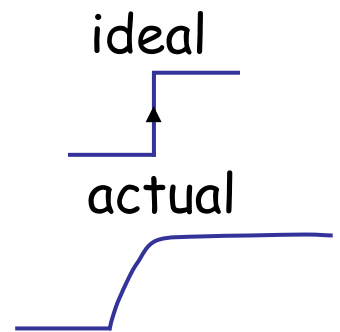
1. short wires
2. low inductance wires
3. avoid big current swings

Case 3: The Double Team, or, Slower may be faster!

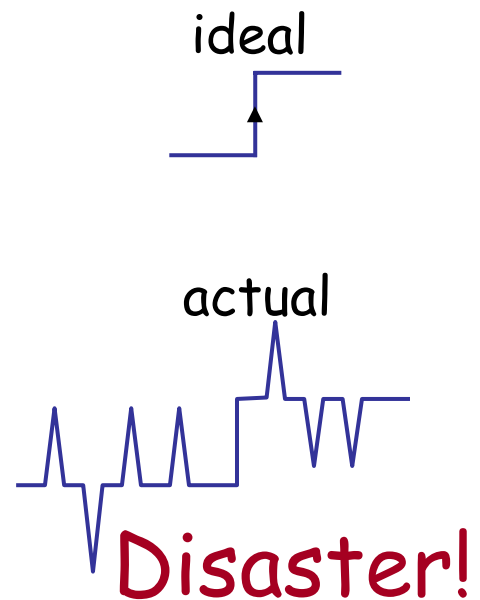
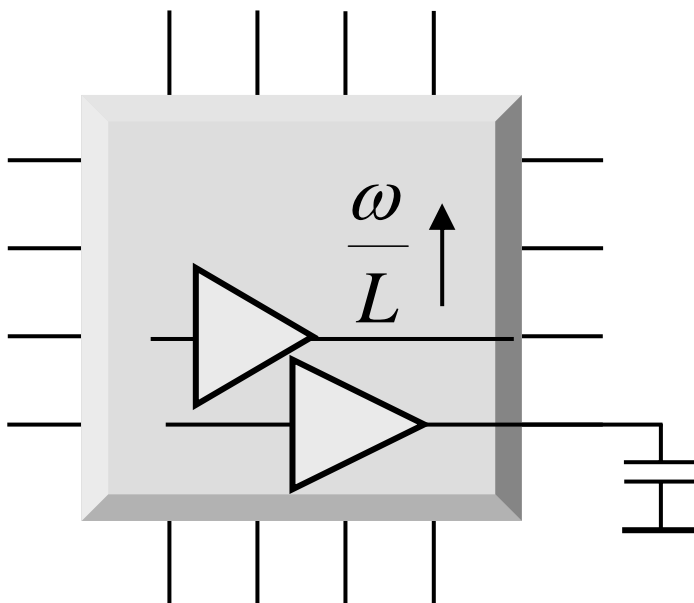
Problem



a given chip worked, but was slow.

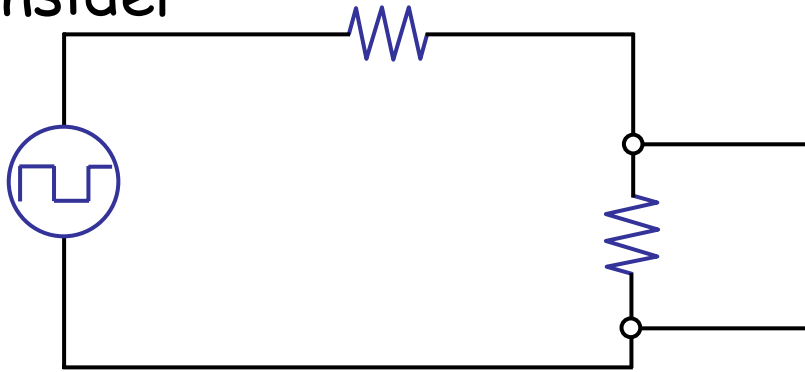


Let's try speeding it up by using stronger drivers

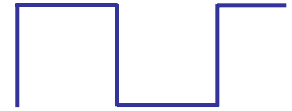


Why?

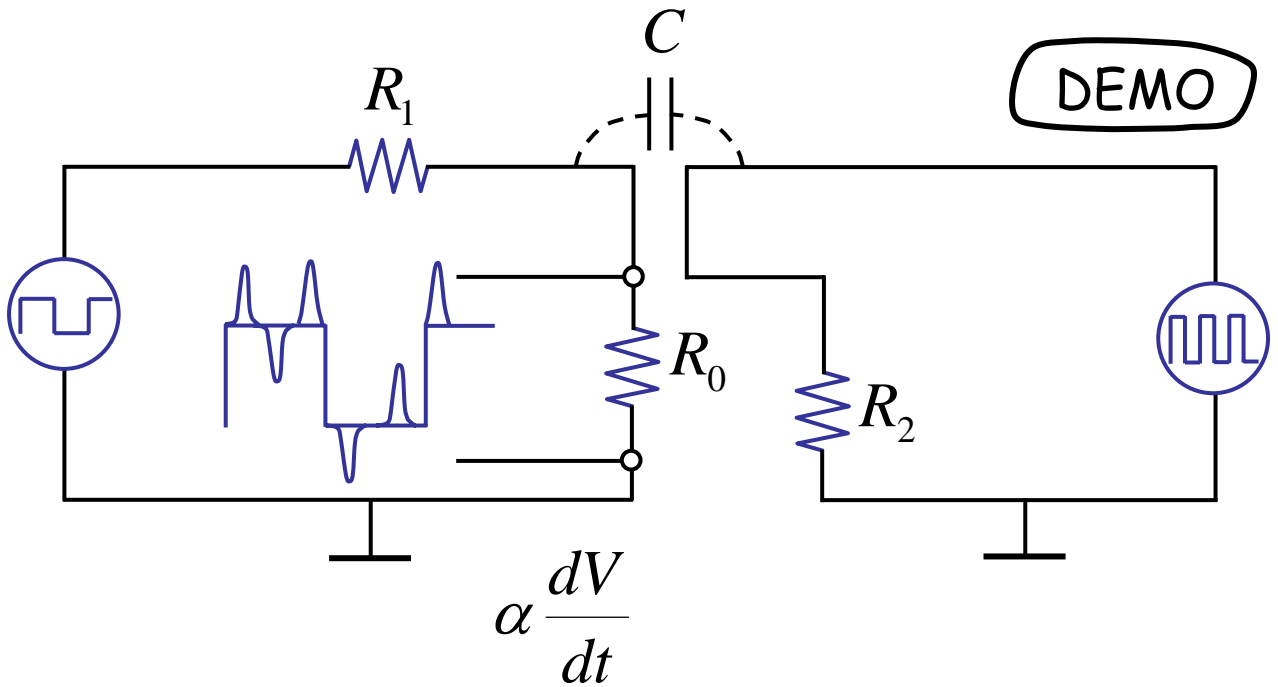
Consider



DEMO



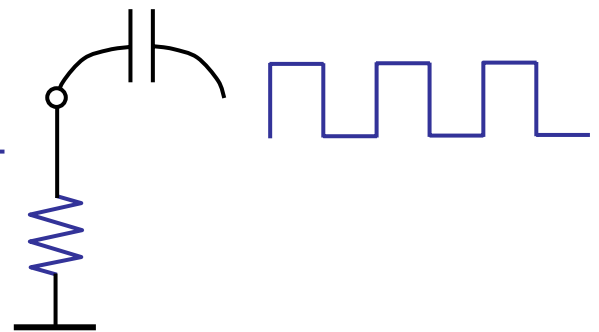
ok



DEMO

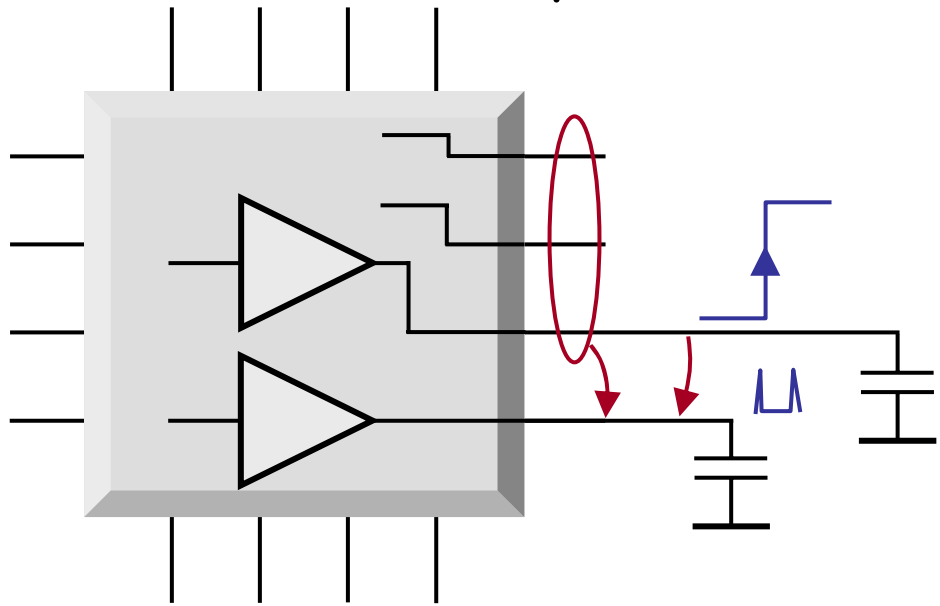
$$C \frac{dV}{dt}$$

A graph showing the derivative of a square wave, which consists of sharp positive and negative spikes at the rising and falling edges of the square wave.

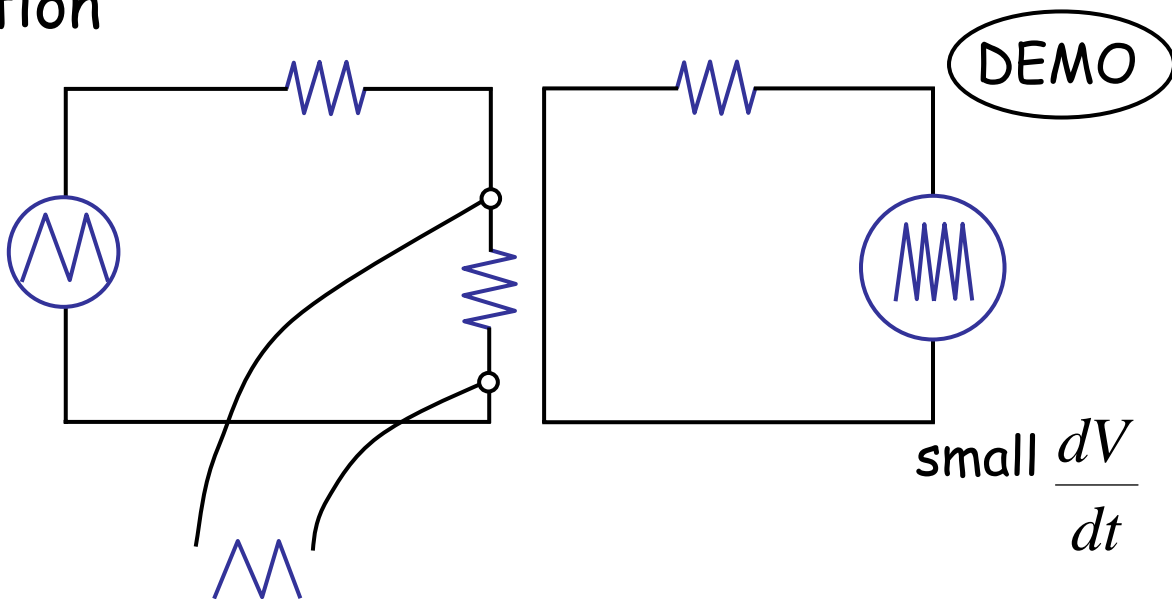


crosstalk!

How does this relate to chip?



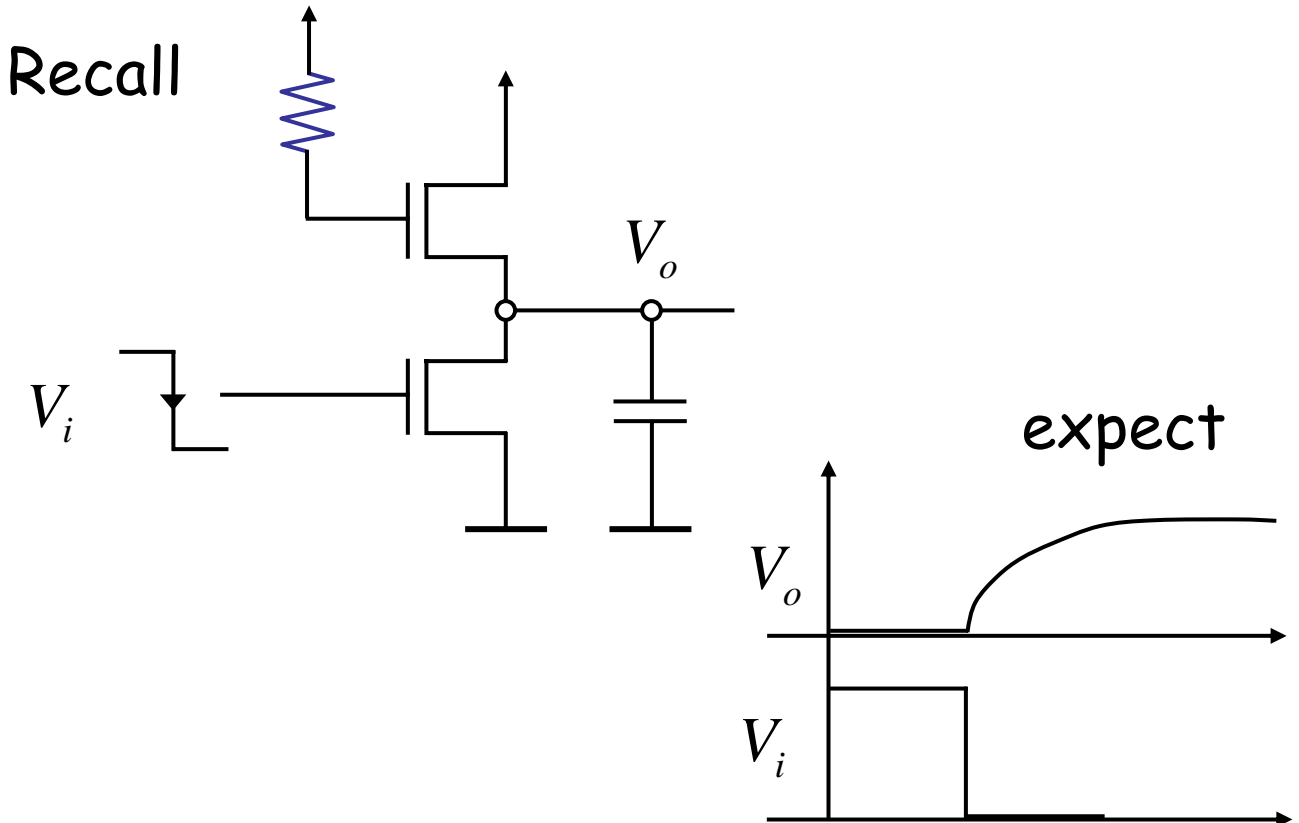
Solution



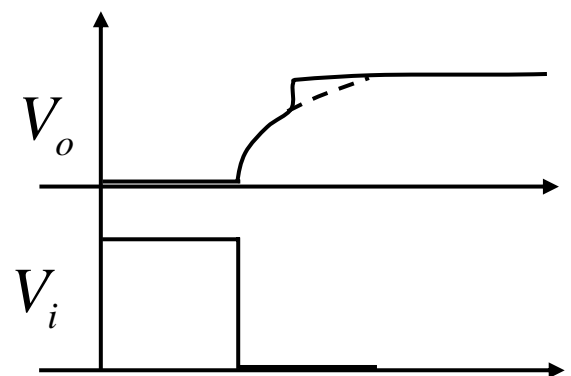
- Load output!
- put cap on outputs of chip
 - jitter edges
 - slew edges

Case 4: The Double Jump

Careful abstraction violation for the better...

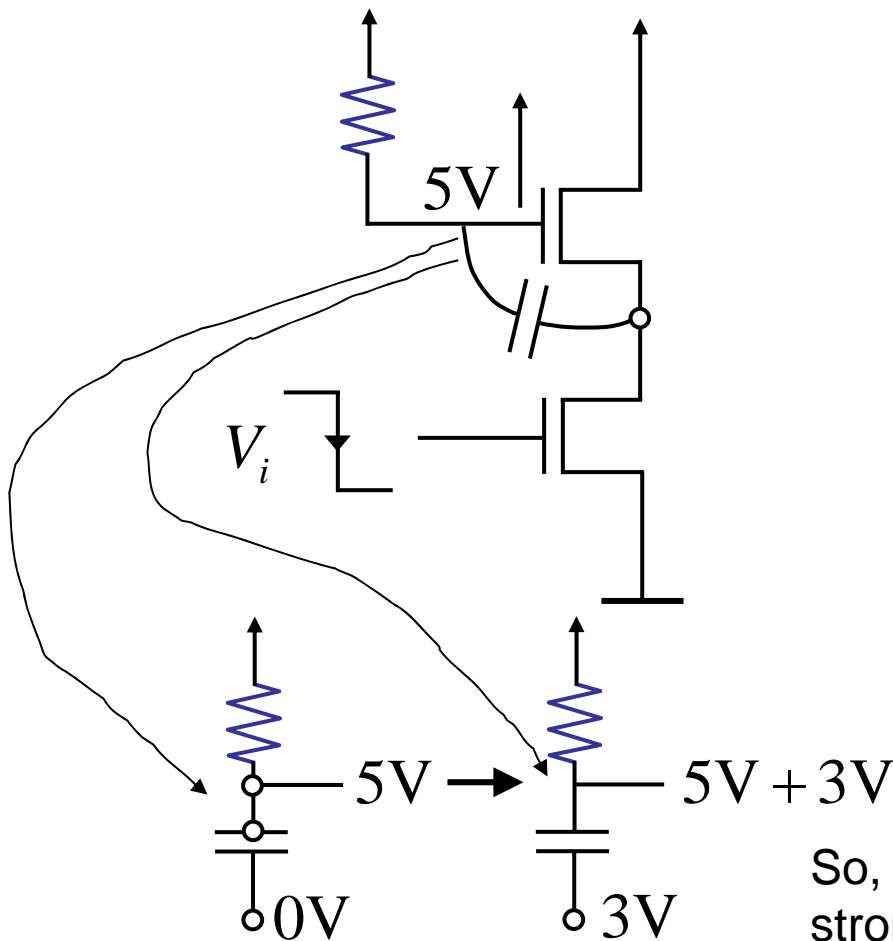


but, observe



Case 4: The Double Jump

Careful abstraction violation for the better...



So, pullup has stronger drive as output rises