Lecture 07: Op Amp Speed

0. Review
1. Op Amp Speed
2. Gain Bandwidth
3. Slew Rate

Textbook reading:

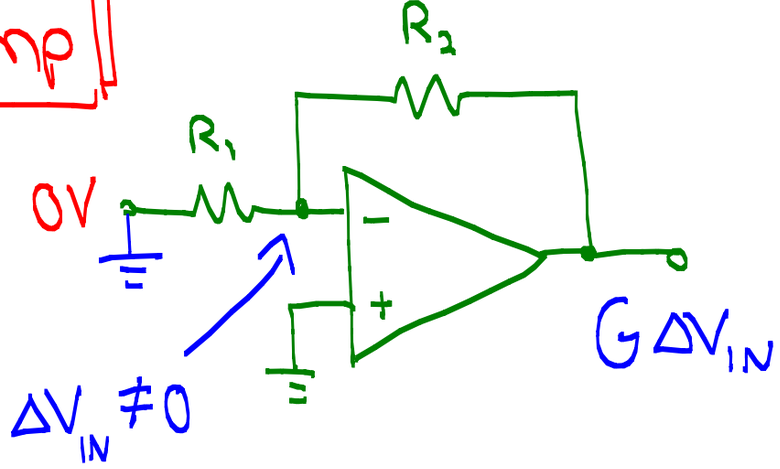
14-1 Amplifier Freq Response
14-9 Rise Time-BW relationship
16-2 The 741 Op Amp
(Slew rate sub-section)

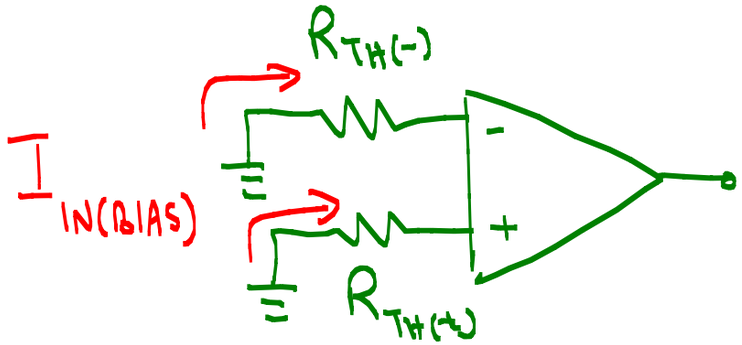
- PreLab 3: Multisim schematic + AC sweep
- HW3 due next Fri (Oct 11) in box outside my office.
  → No class Oct 8 + 10
  Finish Lab 3 on your own (see handout)
- Quiz 3 (Oct 15)
- Exam #1 (Oct 17)
  → HW1, 2, 3
  → QZ1, 2, 3
  → Sample exam on course website

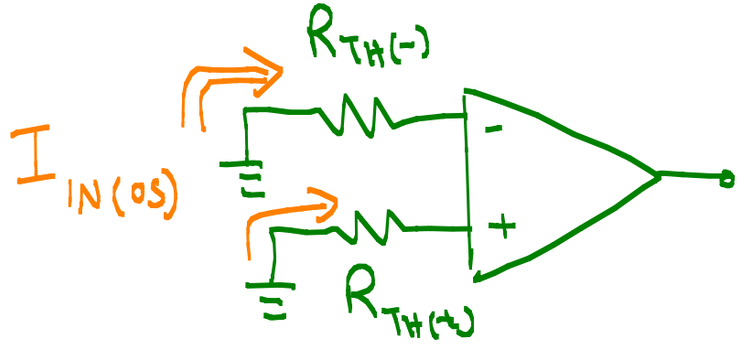
0. Review

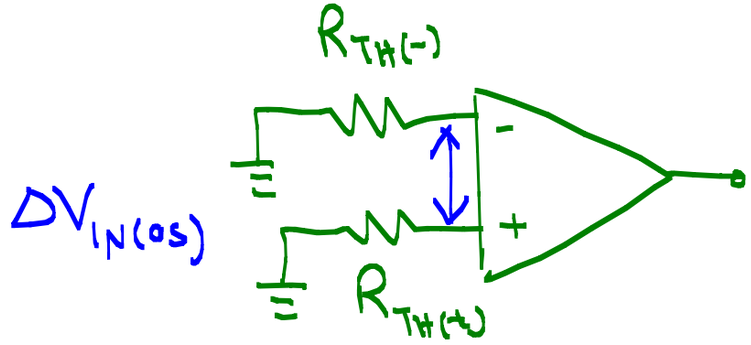
- Output Voltage Error

Real op Amp









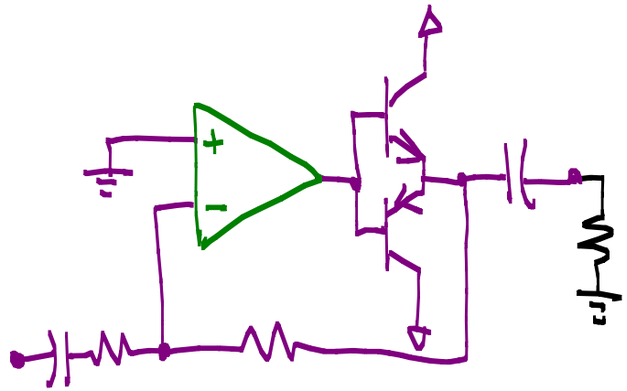
① Input bias current : $I_{IN(BIAS)} * \left[R_{TH(-)} - R_{TH(+)} \right]$

② Input offset current : $I_{IN(OS)} * \frac{R_{TH(-)} + R_{TH(+)}}{2}$

③ Input offset voltage : $V_{IN(OS)}$

1. Op Amp Speed

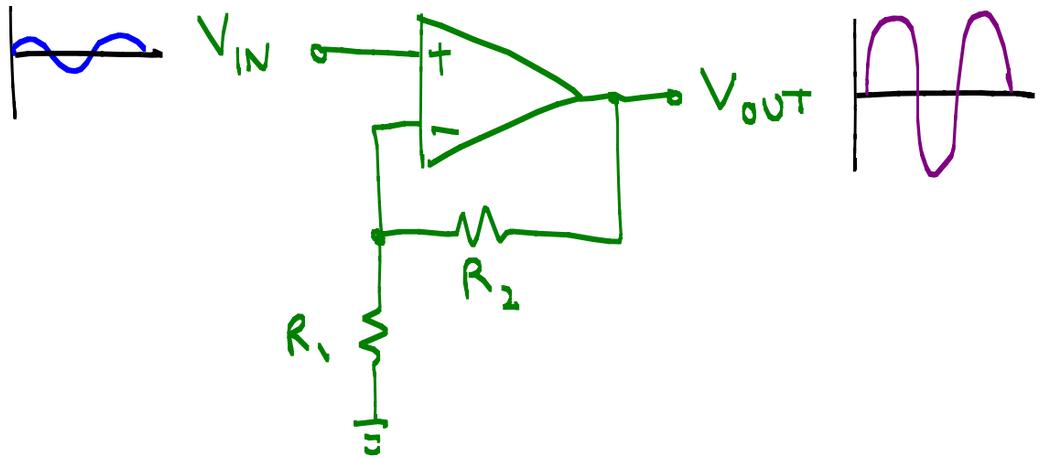
- In Lab2, crossover distortion would be much worse at MHz freq



Q: What limits the op amp speed?

A: Depends on ...

2. Gain-Bandwidth Product



- Consider our non-inverting amplifier.

Q: What is its <u>bandwidth</u>?

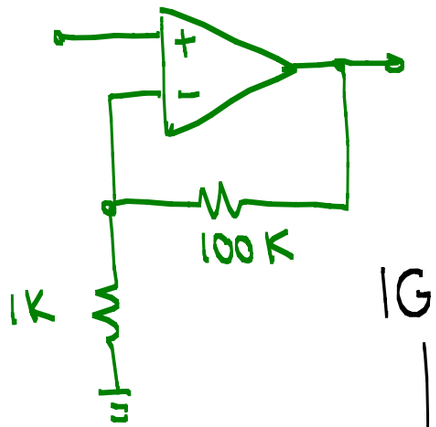
A:

- GBW product depends on the op amp!

Op Amp	GBW
LM741	
LF411	
LF356	
LT1128	

Example

741



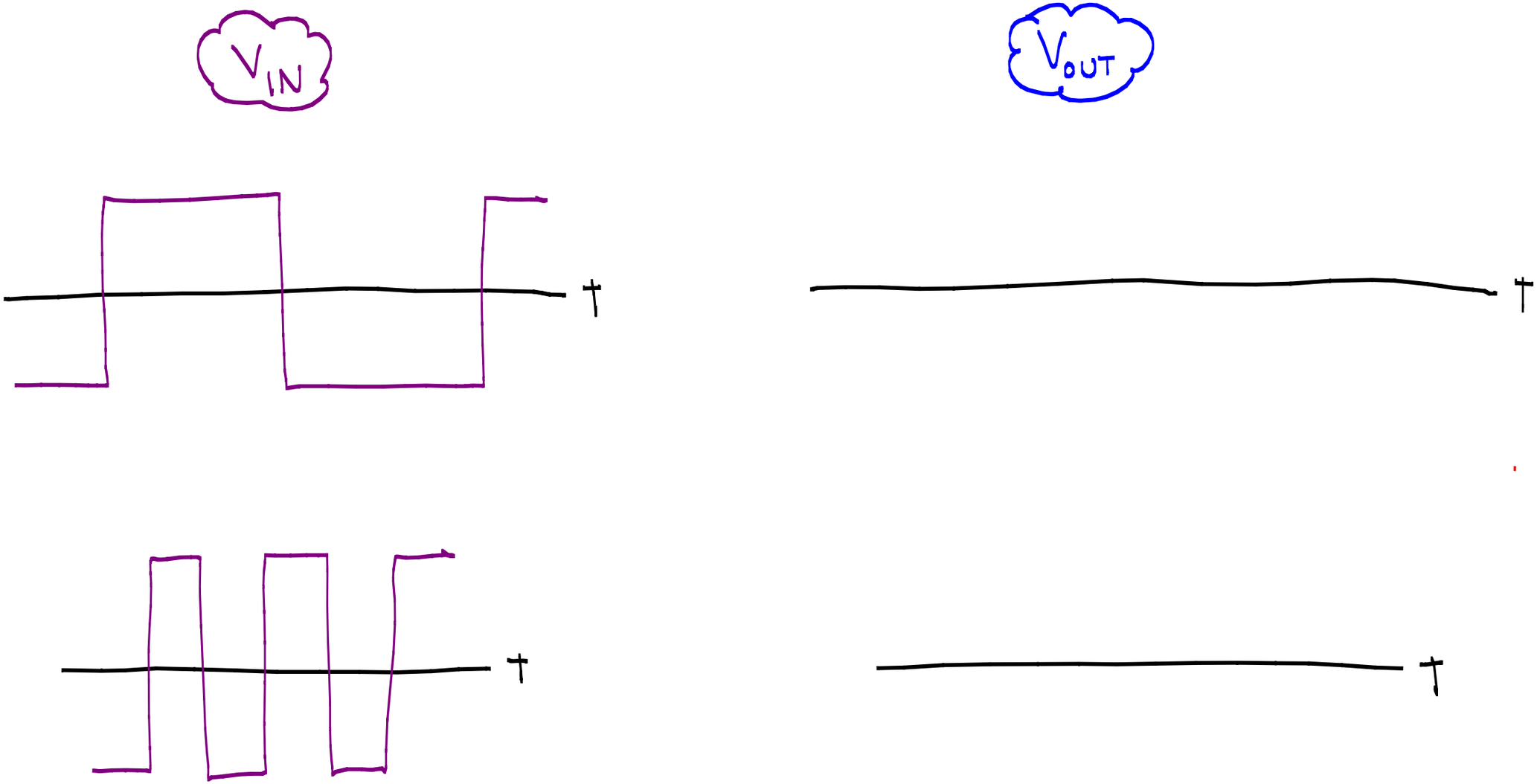
BW =

LF356

G =

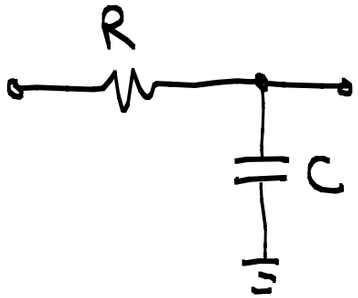
BW =

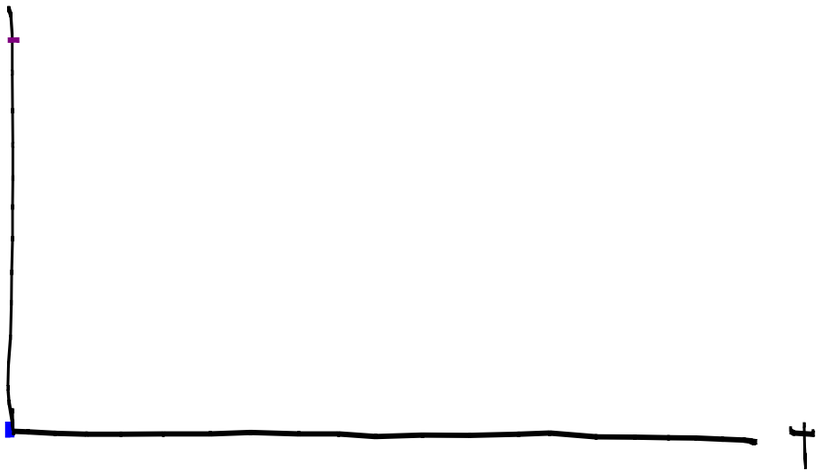
- For many non-sinusoidal signals (e.g. square wave), time-domain response is more meaningful.



- Rise Time T_R =

Example





→ Rise Time : T_R =

3. Slew Rate (SR)

Slew Rate =

If op amp is SR limited,

Example: Op amp: GBW = 2 MHz

$S_R = 1\ V/\mu s$

Input: $V_{IN} = 0.5 \cdot H(t)$ ← step fn

$G = 10$

Ideal

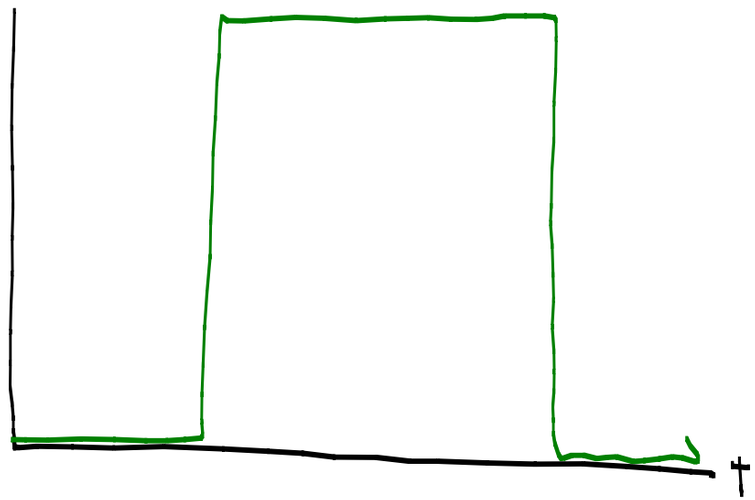
Actual V_{OUT} is limited by BW or SR

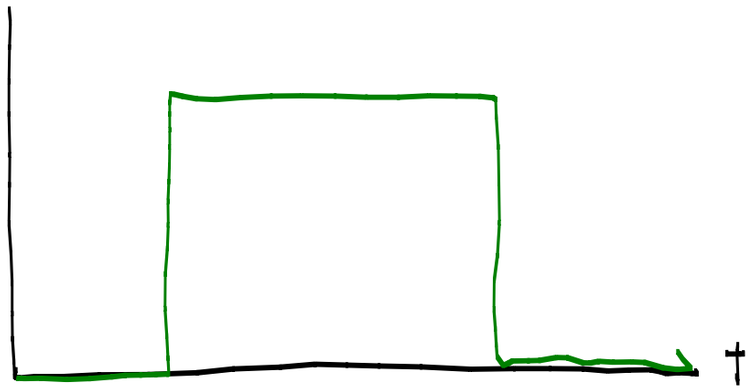
(1)

(2)

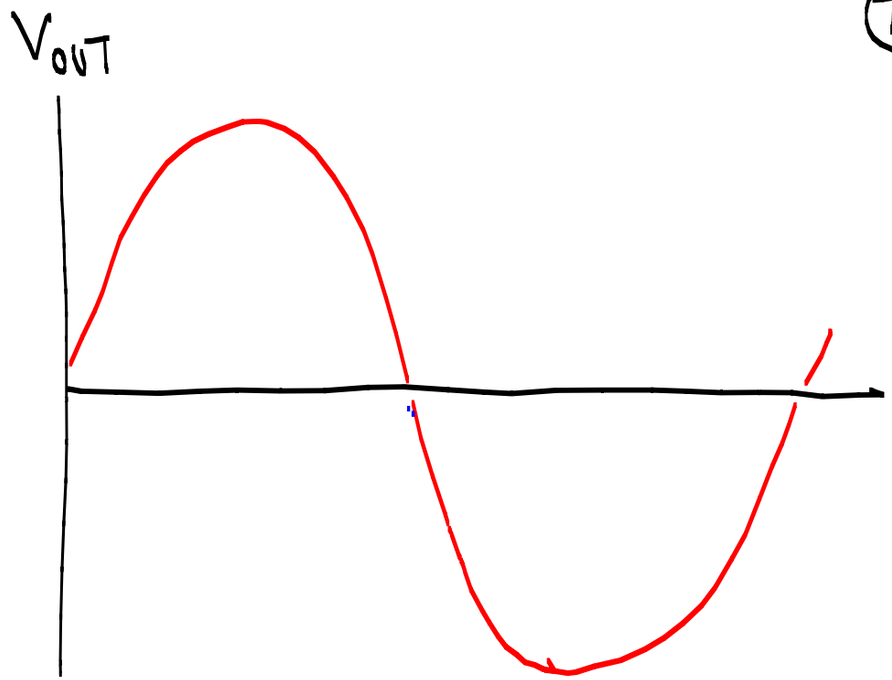
- Bandwidth vs. Slew Rate

Example





③ For sine waves, SR limitation causes distortion.



- Power Bandwidth:

Example Op amp: GBW = 2 MHz

SR = 1 V/μs

Signal: $V_{IN} = \sin 2\pi f_o t$

$f_o = 100$ kHz

$G = 10$

① Check f_o vs. BW:

② Check f_o vs. power bandwidth: