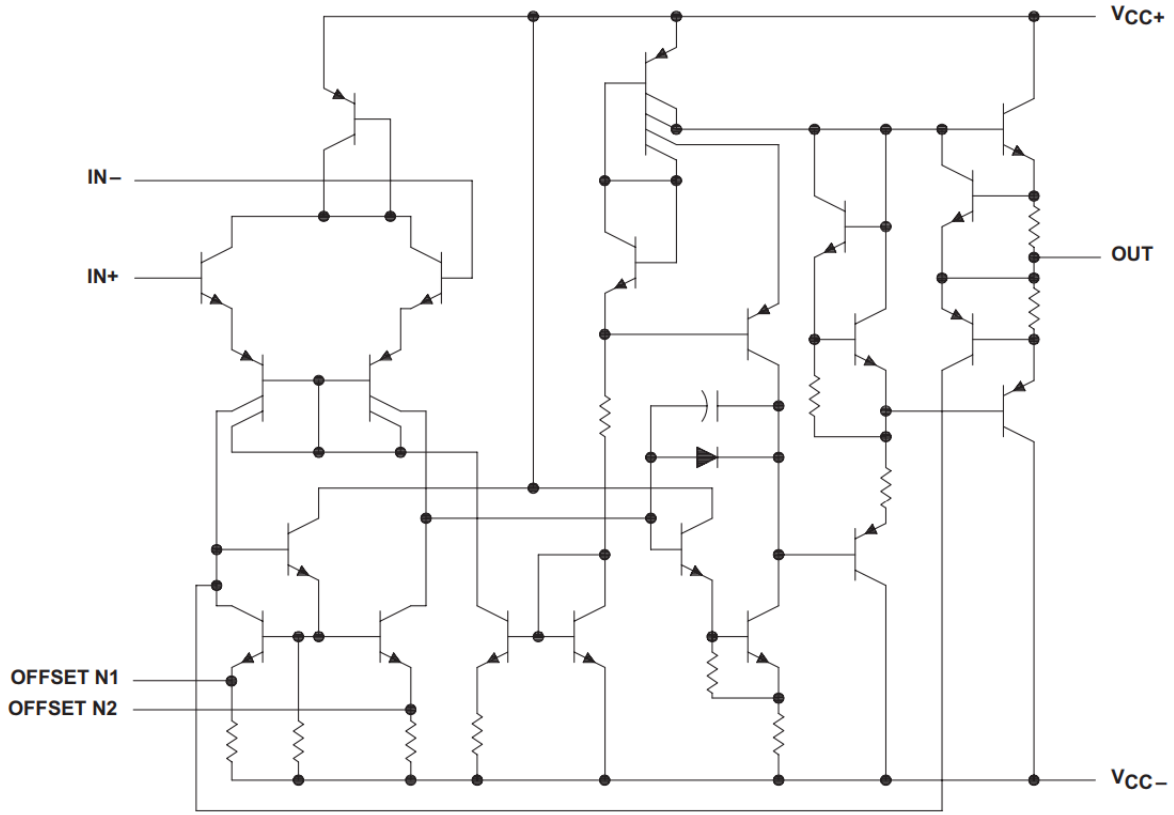
Lecture22:
Operational amplifier (1)

Sung-Min Hong (smhong@gist.ac.kr)

Semiconductor Device Simulation Lab.
School of Electrical Engineering and Coumputer Science
Gwangju Institute of Science and Technology

Operational amplifier

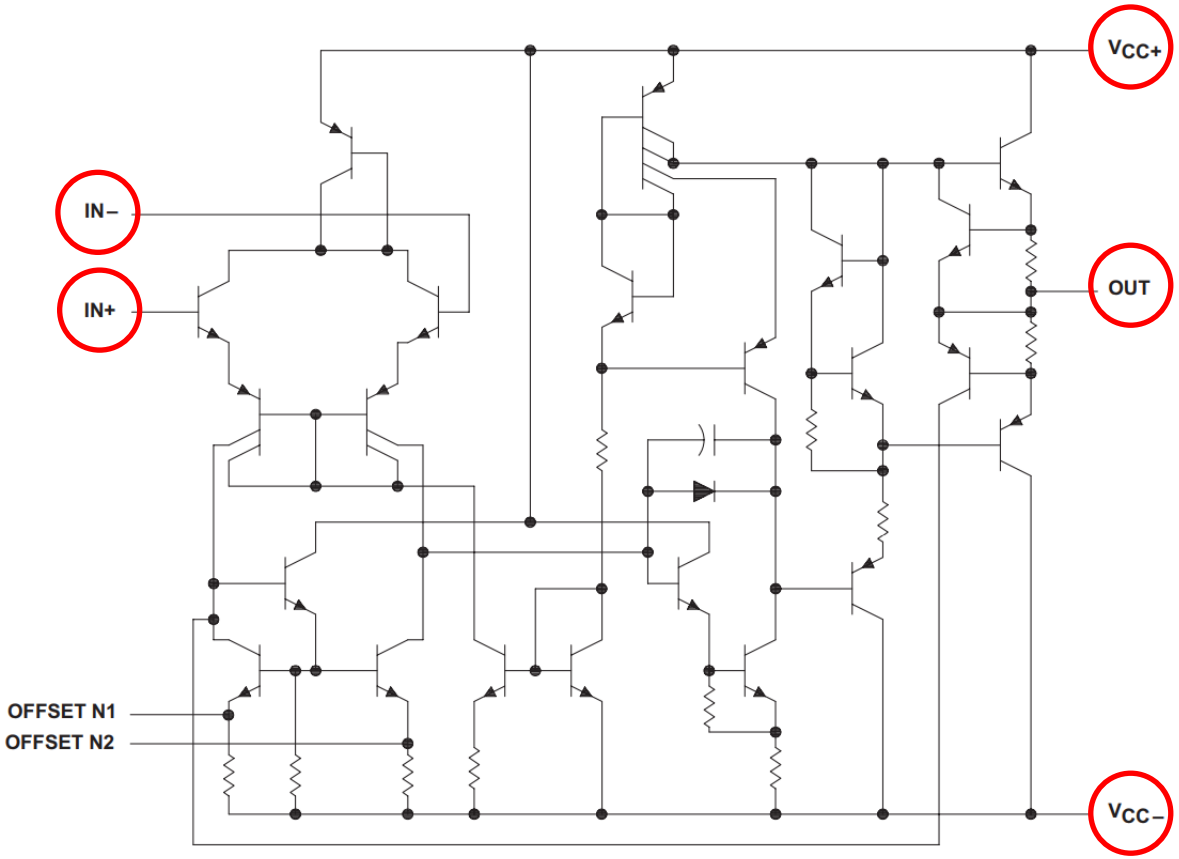
- As a black box
  - We will follow Razavi's book.
- Its inside

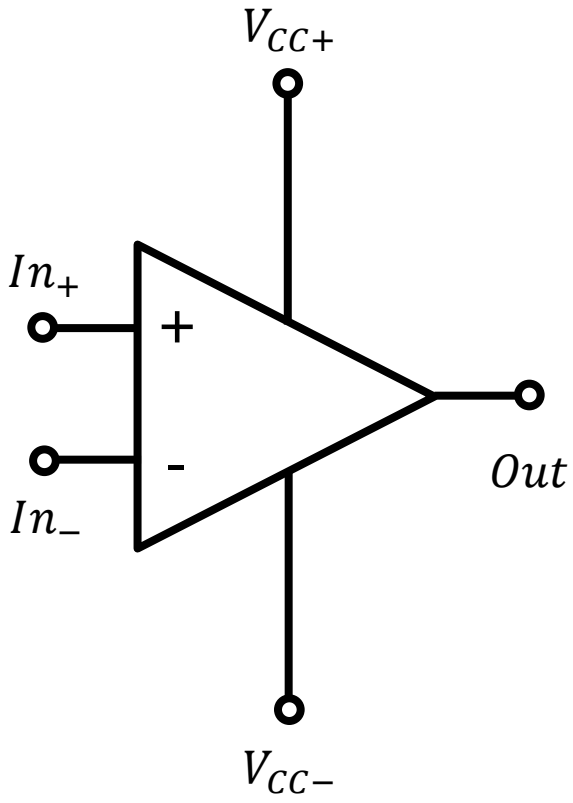


Circuit schematic of a 741 op amp (Texas Instruments)

Symbol

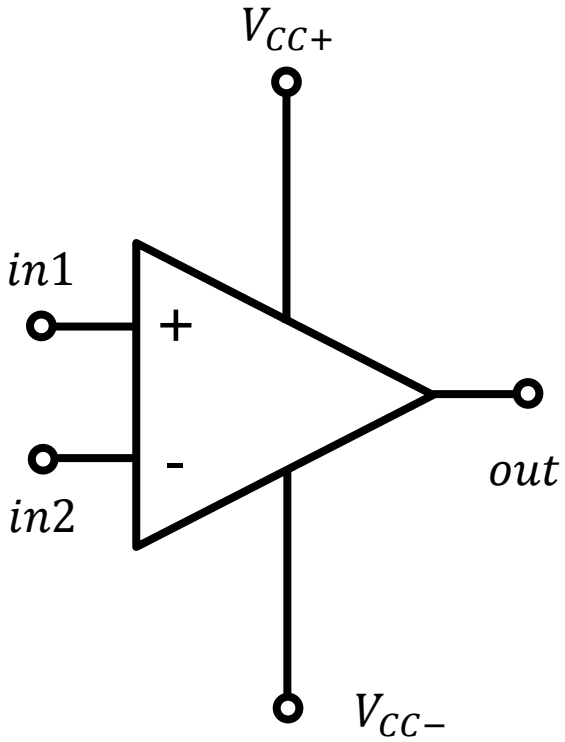
- It is a differential amplifier with a single output.





Operating condition

- In order to operate it,
  - The supply voltage is required.



			MIN	MAX	UNIT
V_{CC+}	Supply voltage		5	15	V
V_{CC-}			–5	–15	
T_A	Operating free-air temperature	µA741C	0	70	°C

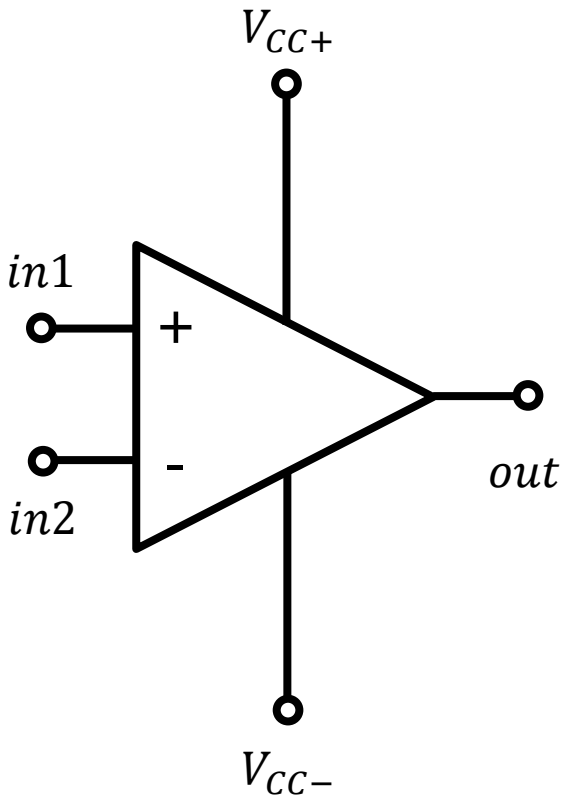
Recommended operating conditions (Texas Instruments)

Open-loop gain

- The open-loop gain, A_0
  - The output voltage is given by

$$V_{out} = A_0(V_{in1} - V_{in2})$$

  - Noninverting input: V_{in1}
  - Inverting input: V_{in2}



PARAMETER		TEST CONDITIONS(1)		MIN	TYP	MAX	UNIT
A_{VD}	Large-signal differential voltage amplification	$R_L \geq 2\ k\Omega$	25°C	20	200		V/mV
		$V_O = \pm 10\ V$	Full range	15			

Open-loop gain of a 741 op amp (Texas Instruments)

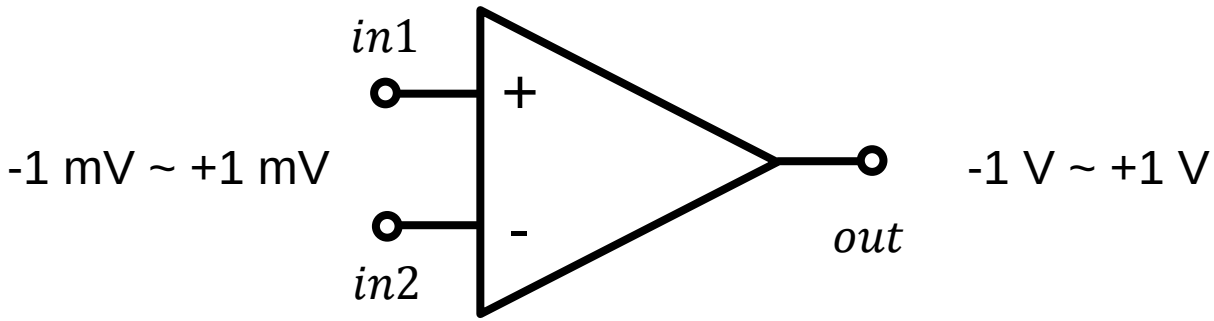
Very large open-loop gain

- If the output voltage is bounded,
  - The difference between two inputs is also bounded.

$$V_{out} = A_0(V_{in1} - V_{in2})$$

  - Since the open-loop gain is very large,

$$V_{in1} - V_{in2} = \frac{V_{out}}{A_0} \approx 0$$



An example) Open-loop gain of 1000

Input/output resistances

- Input resistance
  - It is very large.
- Output resistance
  - It is very small.

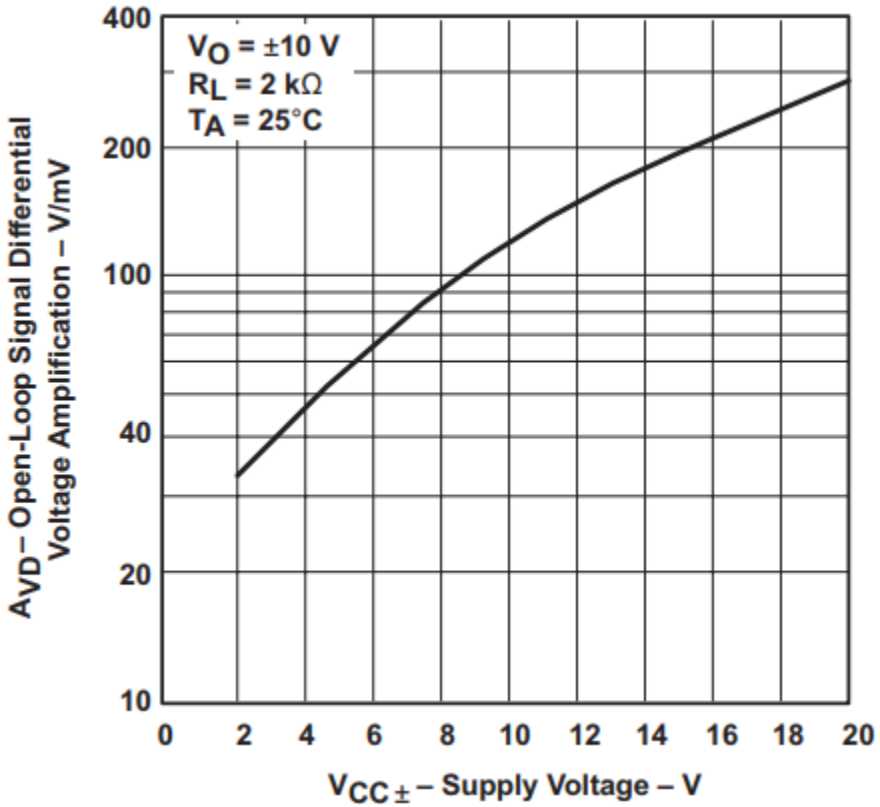
PARAMETER		TEST CONDITIONS[1]		MIN	TYP	MAX	UNIT
r_i	Input resistance	25°C		0.3	2		MΩ
r_o	Output resistance	V_O = 0; see[2]	25°C		75		Ω

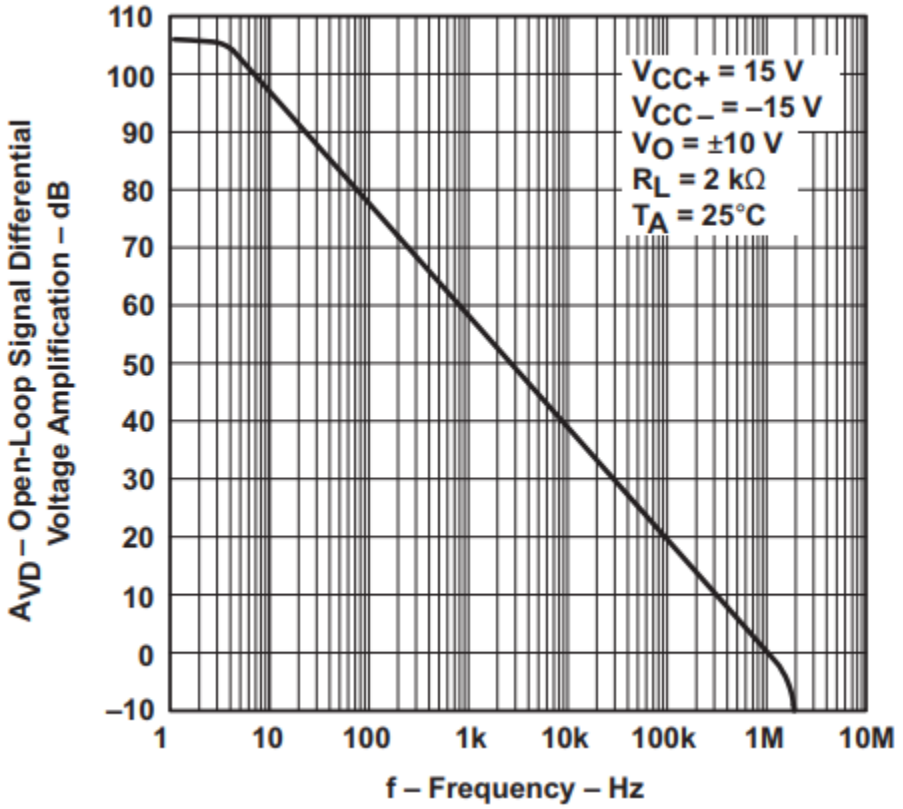
Input/output resistances of a 741 op amp (Texas Instruments)

- "Ideal" op amp
  - Infinite voltage gain
  - Infinite input impedance
  - Zero output impedance
  - Infinite speed

Typical characteristics

- Graphs taken from the Texas Instruments' datasheet.

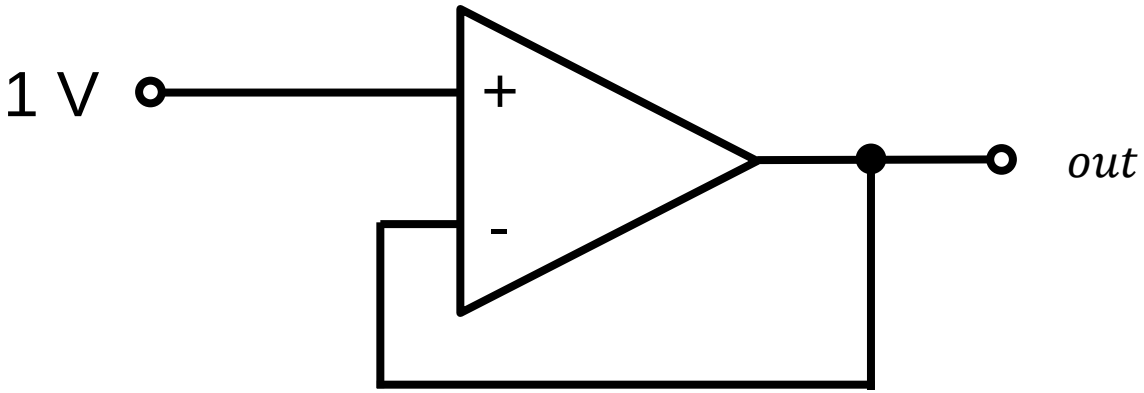




Example 8.1

- "Unit-gain" buffer
  - What is V_{out}?

$$V_{out} = A_0(1 - V_{out})$$



Homework#10 (Last one)

- Due: 09:00, June 4
- Solve the following problems of the final exam in 2017.
  - P44
  - P45
  - P46
  - P47
  - P48
  - P49
  - P50