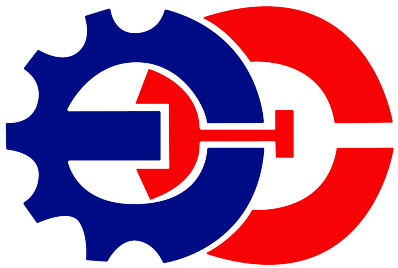
Comparator

TE201414 - Rangkaian Elektronika 2

Electrical Engineering



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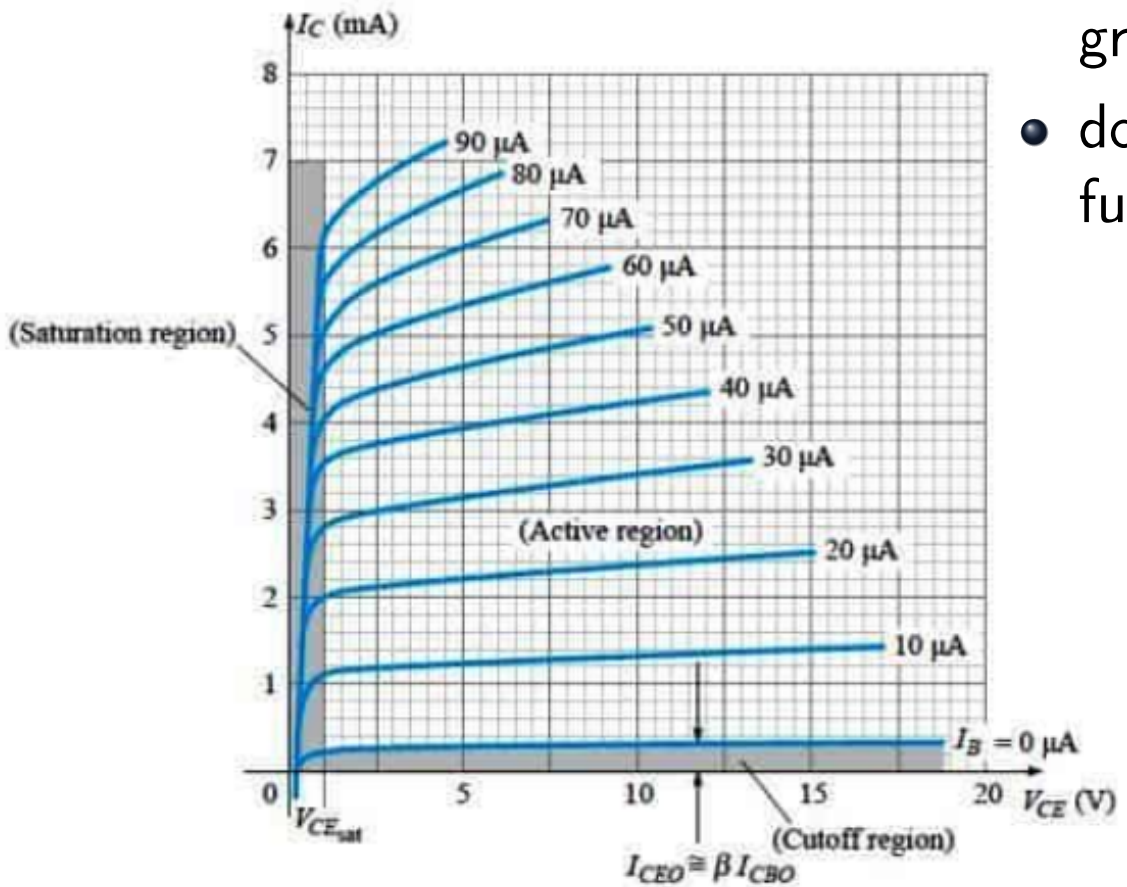
February 17, 2025

Review

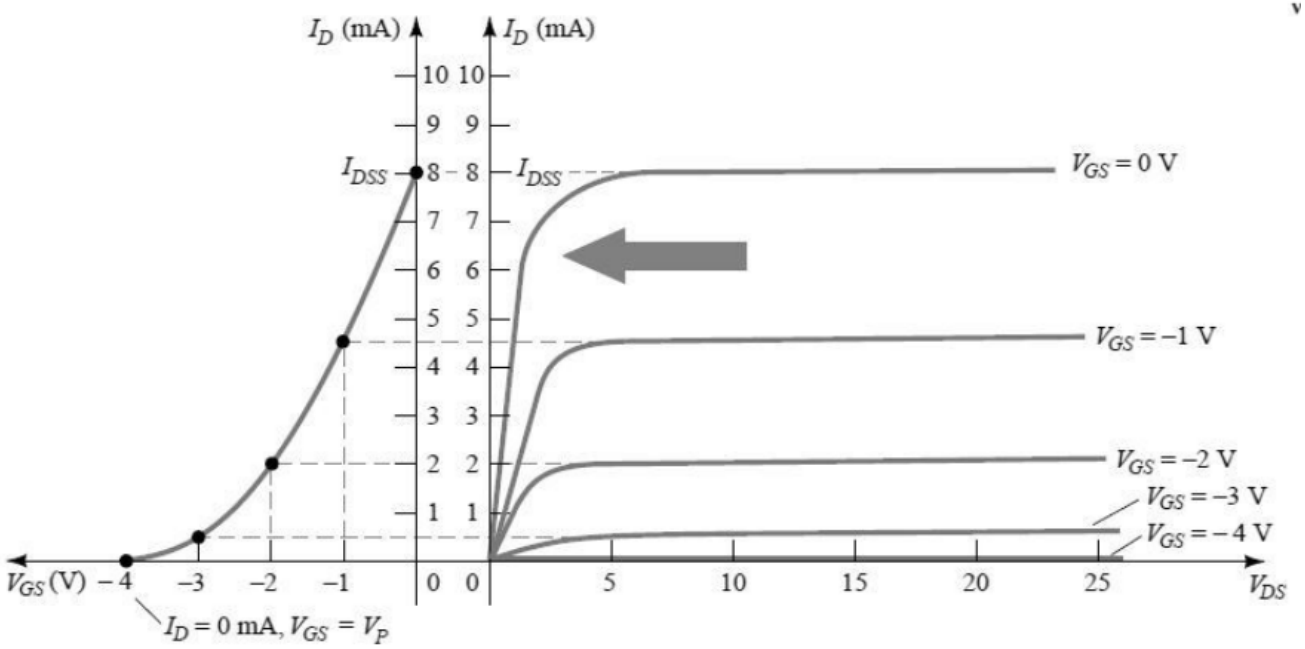
In electronics 1 course, we learnt several semiconductor devices including transistor. We met graphic that showed below as well.



- do you still remember what graphic is this?
- do you still remember the function of the graph?

Review

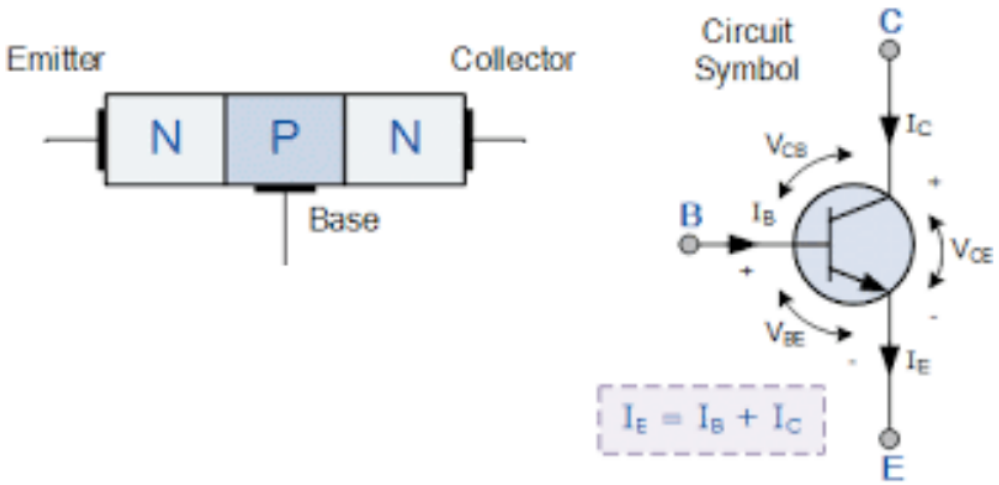
We also met the charateristic curve that showed below.



- which transistor which use this characteristic curve?
- could you show to us where are the saturation, cutoff, and active region?

Review

a BJT transistor is composed by 3 layer semiconductor material as depicted below.

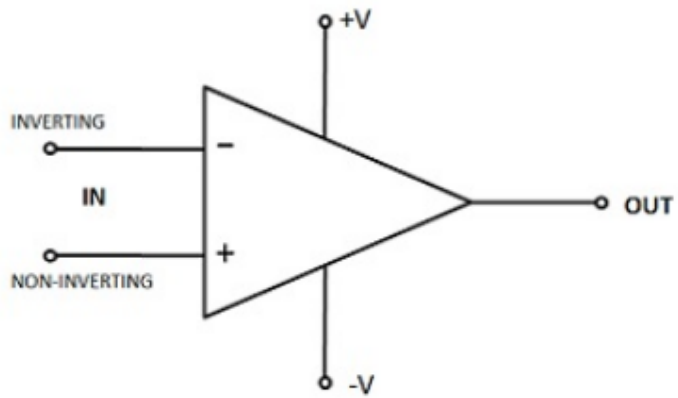


- if BJT transisor is working in saturation state, which bias is occured between Base-Emitter and Collector-Base?
- if BJT transisor is working in cutoff state, which bias is occured between Base-Emitter and Collector-Base?
- if BJT transisor is working in active state, which bias is occured between Base-Emitter and Collector-Base?

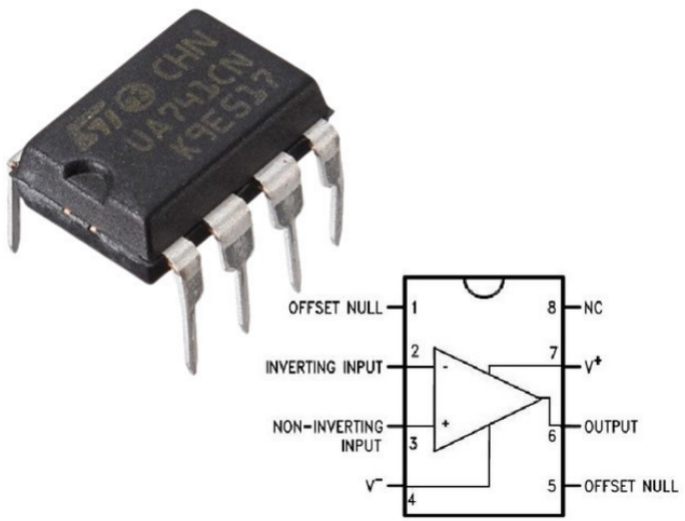
Introduction to Operasional Amplifier

In this course we will get to know another semiconductor device which has similar function as transistor, Operational Amplifier (Op-amp). Moreover, Op-amp operation is not limited as switch and amplifier, but also can execute arithmetic operation.

Symbol of Op-amp:



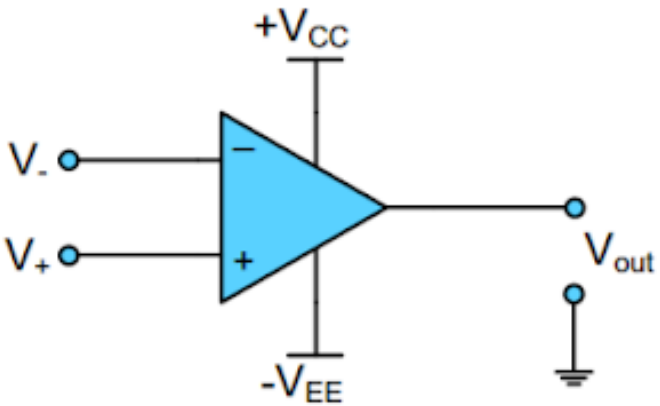
Op-amp as Integrated Circuit (LM741):



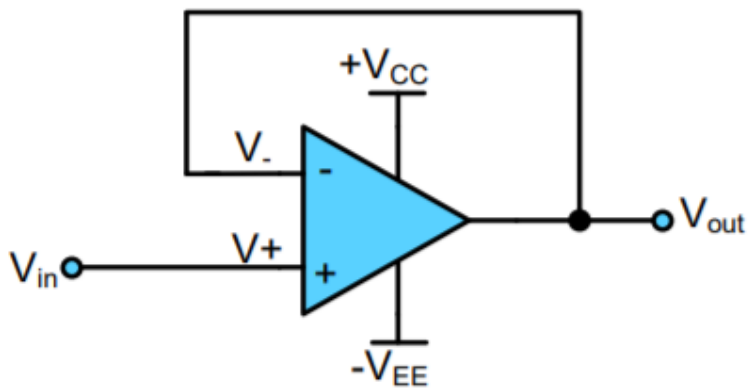
Basic Operation on Op-amp

Op-amp as switch and op-amp as amplifier are the basic operation of op-amp. the appearance of feedback connecting between output and input is used to determine the operation of op-amp.

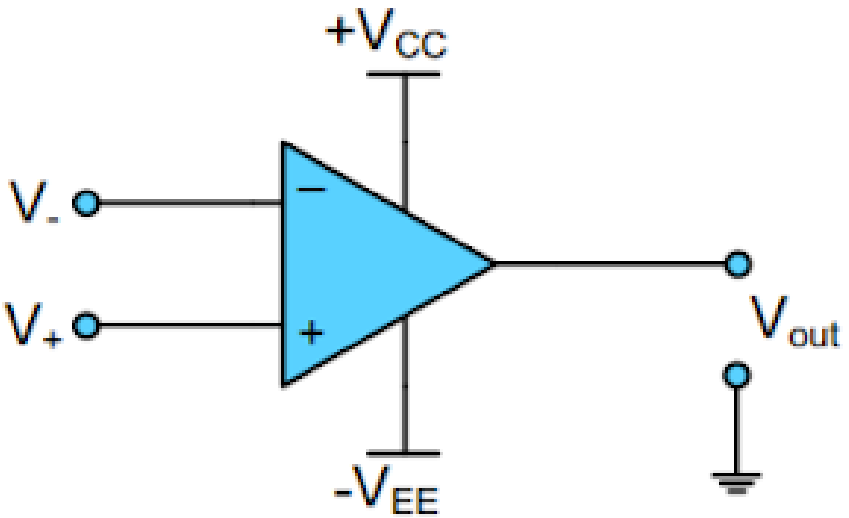
Op-amp as switch (Comparator):



Op-amp as amplifier:



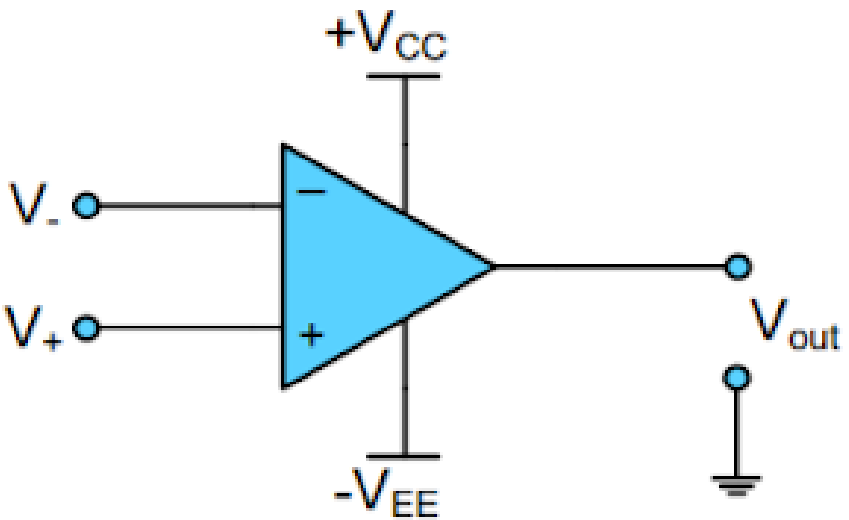
Op-amp as Comparator



as comparator, Op-amp compare the voltage difference between non-inverting (V_+) input and inverting input (V_-). the difference voltage is multiplied by open loop gain (A_{OL}) of op-amp. the open loop gain of op-amp is undefined ($A_{OL} \simeq \infty$)

$$V_{out} = (V_+ - V_-)A_{OL}$$

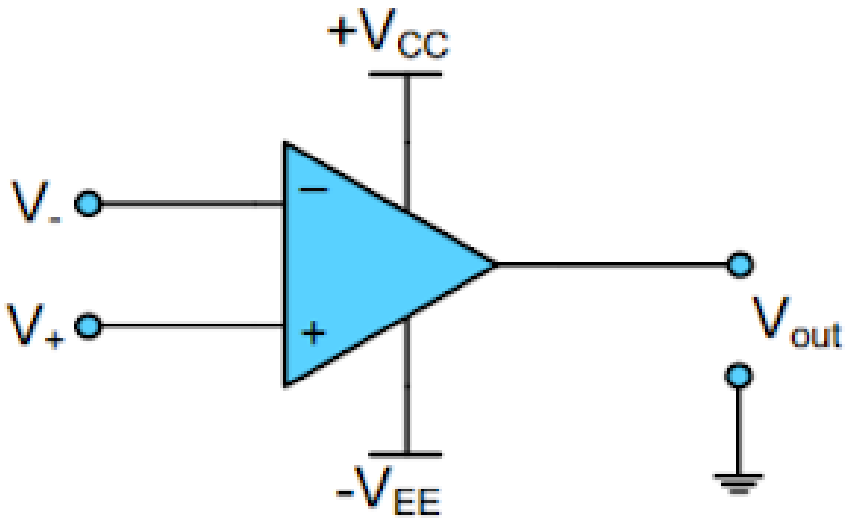
Op-amp as Comparator



the output voltage (V_{out}) is limited by its suplly, then:

$$V_{out} = \begin{cases} +V_{CC}, & V_+ - V_- > 0 \\ -V_{EE}, & V_+ - V_- < 0 \end{cases}$$

Example



Find the output voltage (V_{out}) while given,

- $V_- = 0.5V$
- $V_+ = 0.8V$
- $+V_{CC} = 5V$
- $-V_{EE} = -6V$

Example

answer:

$$V_{out} = (V_+ - V_-)A_{OL}$$

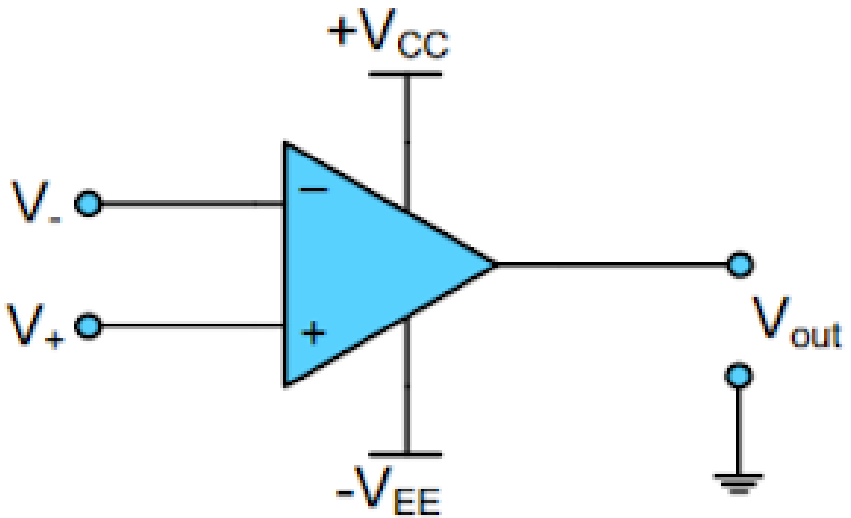
$$V_{out} = (0.8 - 0.5)A_{OL}$$

$$V_{out} = (+0.3)A_{OL}$$

$A_{OL} = \infty$, maximum positive supply is $+V_{CC} = +5V$, then:

$$V_{out} = +5V$$

Example



Find the output voltage (V_{out}) while given,

- $V_- = -0.5V$
- $V_+ = -0.8V$
- $+V_{CC} = 5V$
- $-V_{EE} = -6V$

Example

answer:

$$V_{out} = (V_+ - V_-)A_{OL}$$

$$V_{out} = (-0.8 - (-0.5))A_{OL}$$

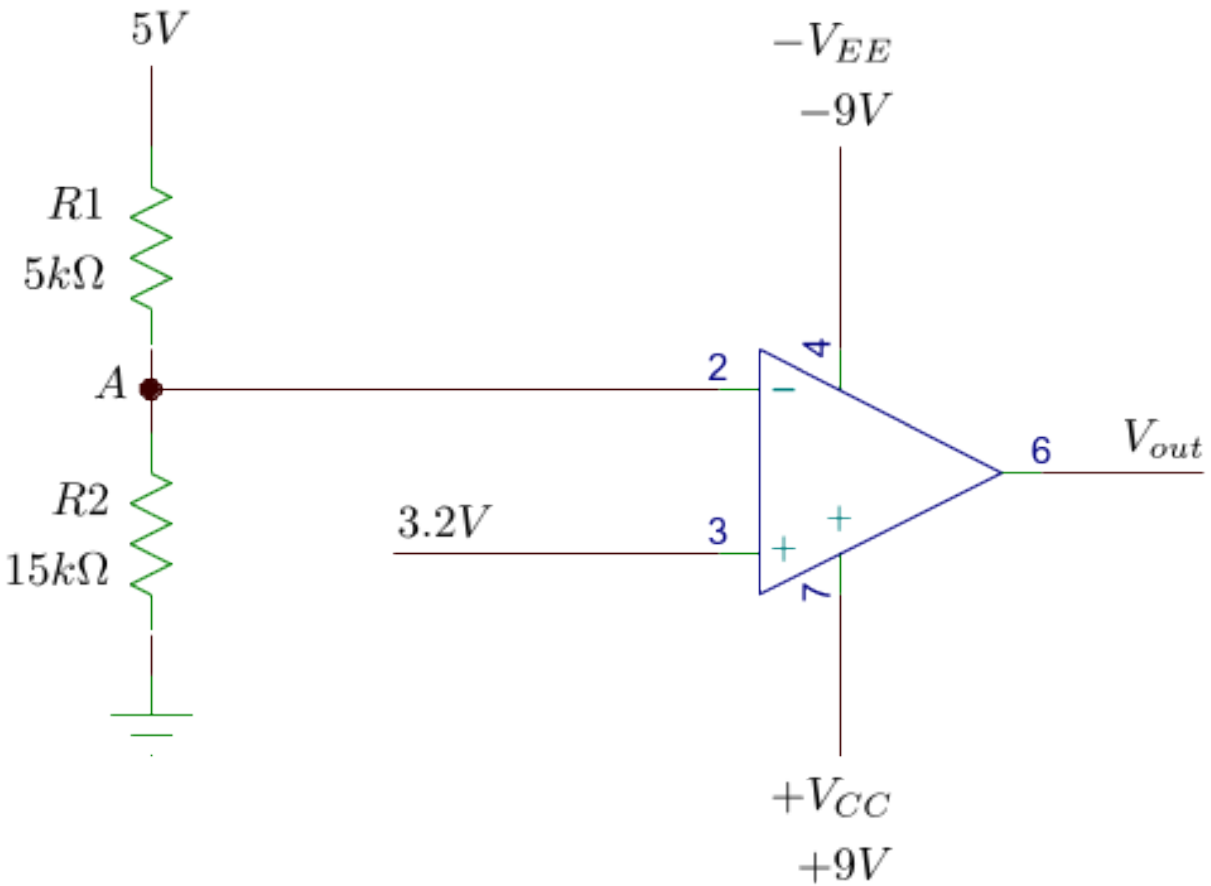
$$V_{out} = (-0.3)A_{OL}$$

$A_{OL} = \infty$, however the minimum negitve supply is $+V_{EE} = -6V$, then:

$$V_{out} = -6V$$

Op-Amp sebagai Komparator

Find the output voltage V_{out}, while given circuit as follow!



Op-Amp sebagai Komparator

inverting input voltage V_A:

$$V_A = \frac{R2}{R1 + R2} 5V$$

$$V_A = \frac{15k\omega}{5k\Omega + 15k\Omega} 5V$$

$$V_A = 3.75V$$

output voltage V_{out}

$$V_{out} = (V_+ - V_-)A_{OL}$$

$$V_{out} = (V_+ - V_-)A_{OL}$$

$$V_{out} = (3.2V - V_A)A_{OL}$$

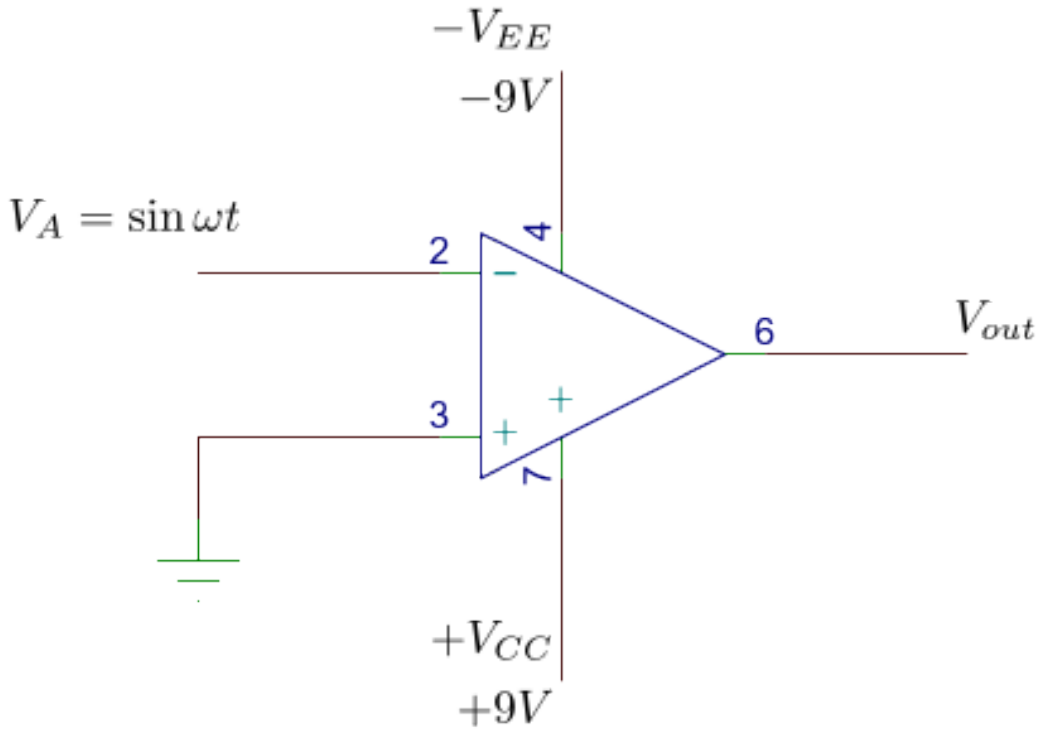
$$V_{out} = (3.2V - 3.75V)A_{OL}$$

$$V_{out} = (-0.5V)A_{OL}$$

$$V_{out} = -9V$$

Op-Amp sebagai Komparator

Find output voltage V_{out} while given op-amp circuit as follow!



Op-Amp sebagai Komparator

while $0 < t < \pi$, voltage difference between 2 input $(V_+ - V_-)$ always in negative.

$$V_{out} = (V_+ - V_-)A_{OL}$$

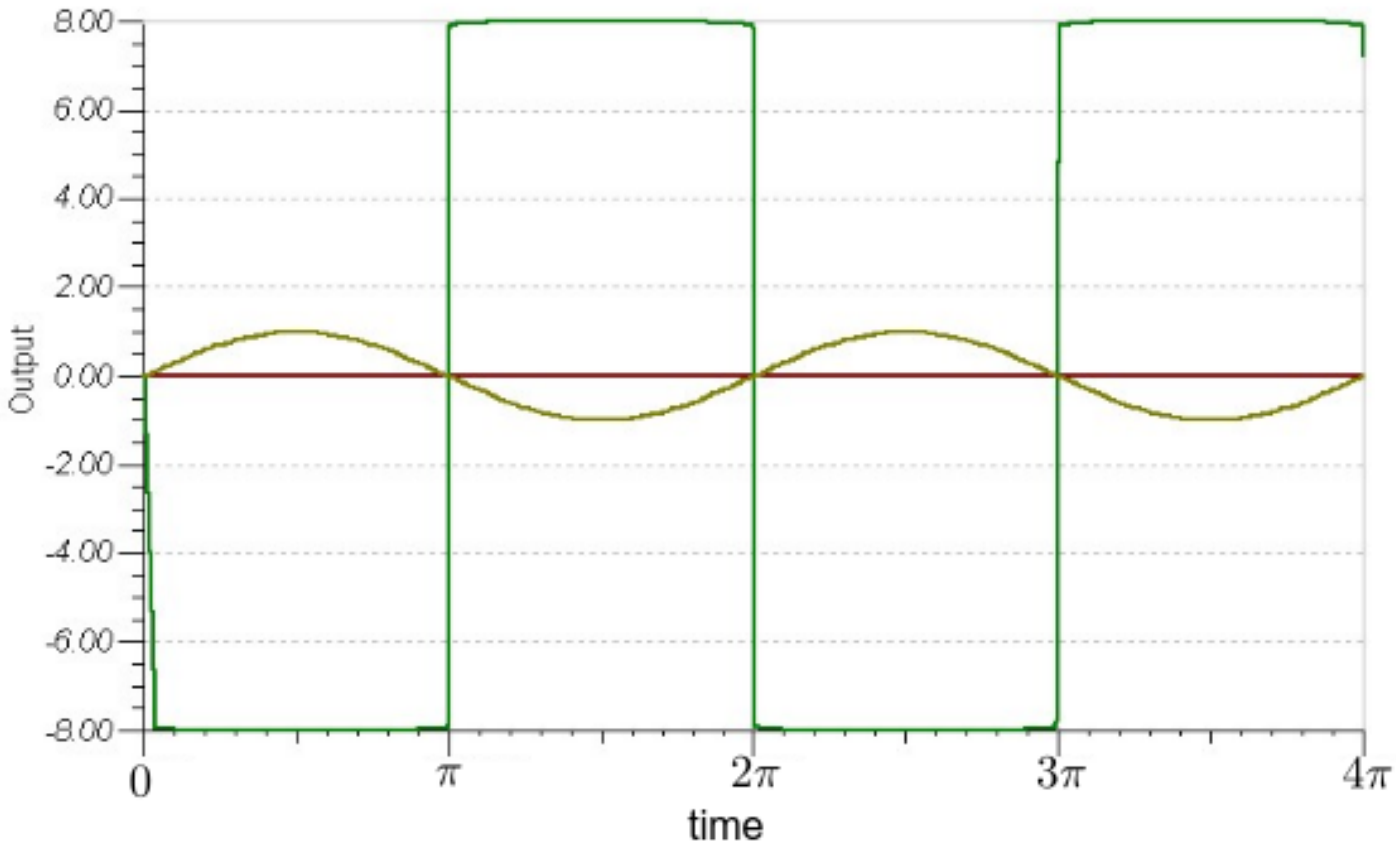
$$V_{out} = -9V$$

while $\pi < t < 2\pi$, voltage difference between 2 input $(V_+ - V_-)$ always in positive.

$$V_{out} = (V_+ - V_-)A_{OL}$$

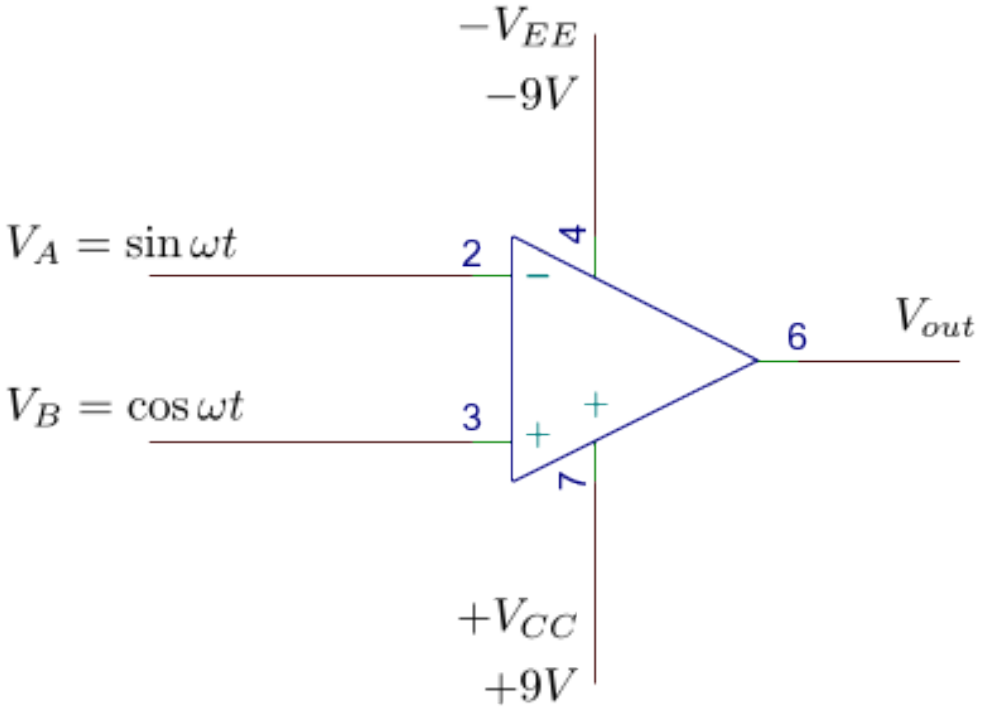
$$V_{out} = +9V$$

Op-Amp sebagai Komparator



Op-Amp sebagai Komparator

find the output voltage V_{out}!



References

Boylestad,R. L., Nashelsky, L., Electronic Devices and Circuit Theory, Pearson, 2014.

Malvino, A., Bates, D., Electronic Principles, McGraw-Hill Education, 2016.

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