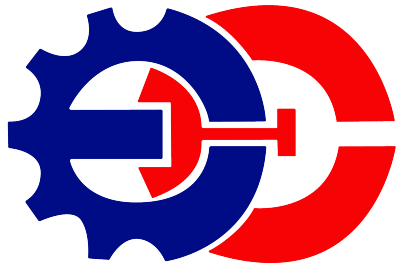
Comparator Design

TE201414 - Rangkaian Elektronika 2

Program Studi Teknik Elektro



Institut Teknologi Kalimantan
agung.nursyeha@lecturer.itk.ac.id
miftanurfarid@lecturer.itk.ac.id

March 4, 2025

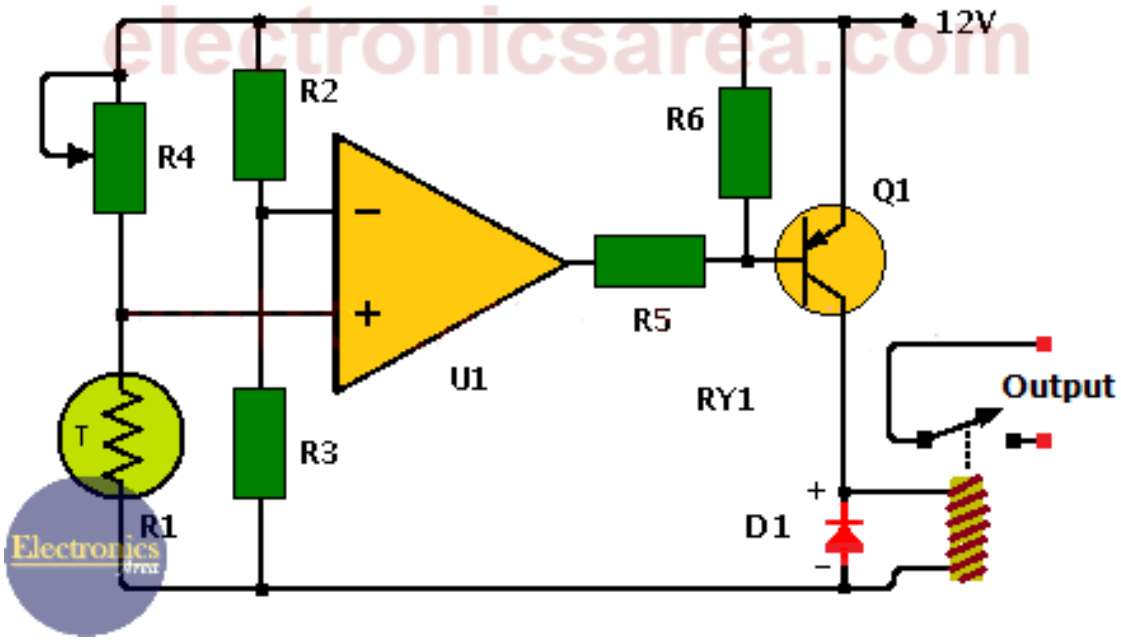
Comparator

Comparator play a vital role in modern electronics, enabling devices to make real-time decisions based on voltage levels.

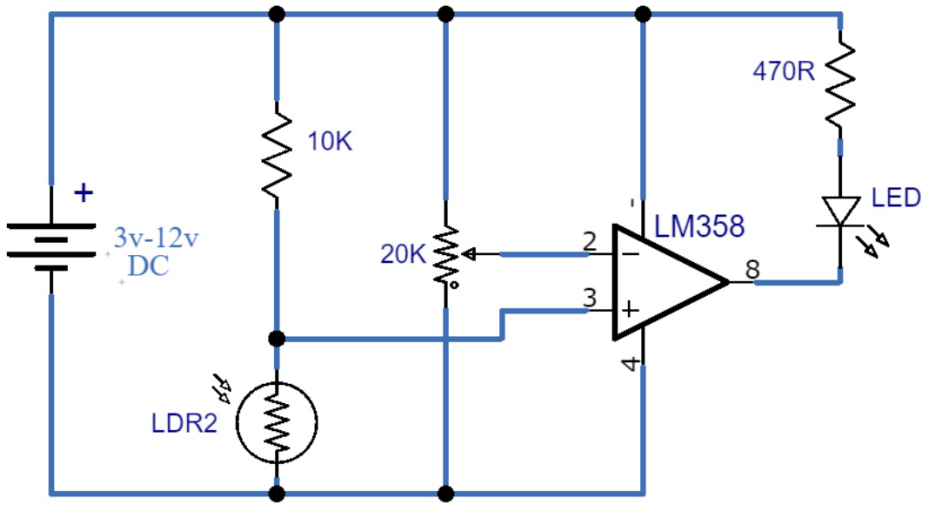
- Temperature monitoring (Thermostat)
- Light sensing
- Battery level indicator
- Zero crossing detector (for AC waveform)
- Sound level detector (Clap switch)
- Water level controller
- Digital logic shifter

Thermostat

A thermostat is a device that regulates temperature by automatically turning heating or cooling systems on or off to maintain a desired temperature range. It is widely used in homes, vehicles, industrial equipment, and appliances.

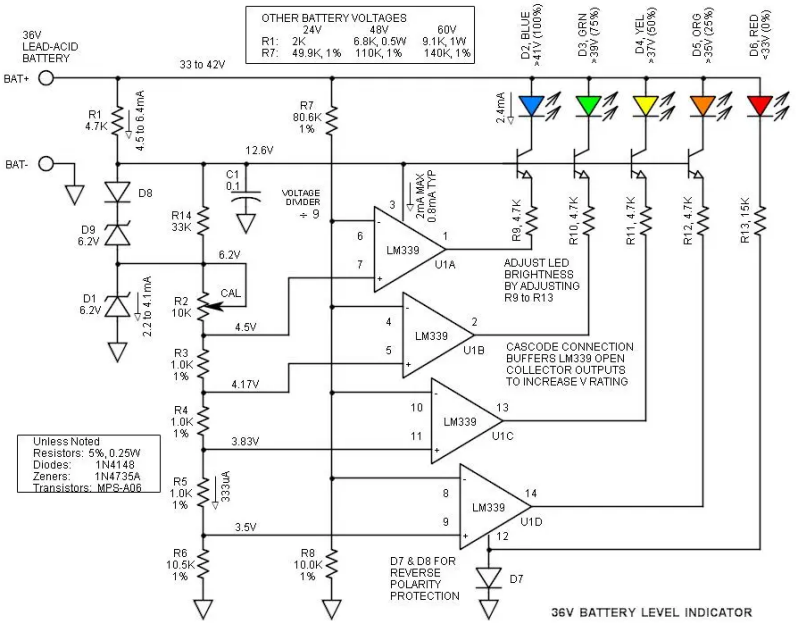


Light Sensing



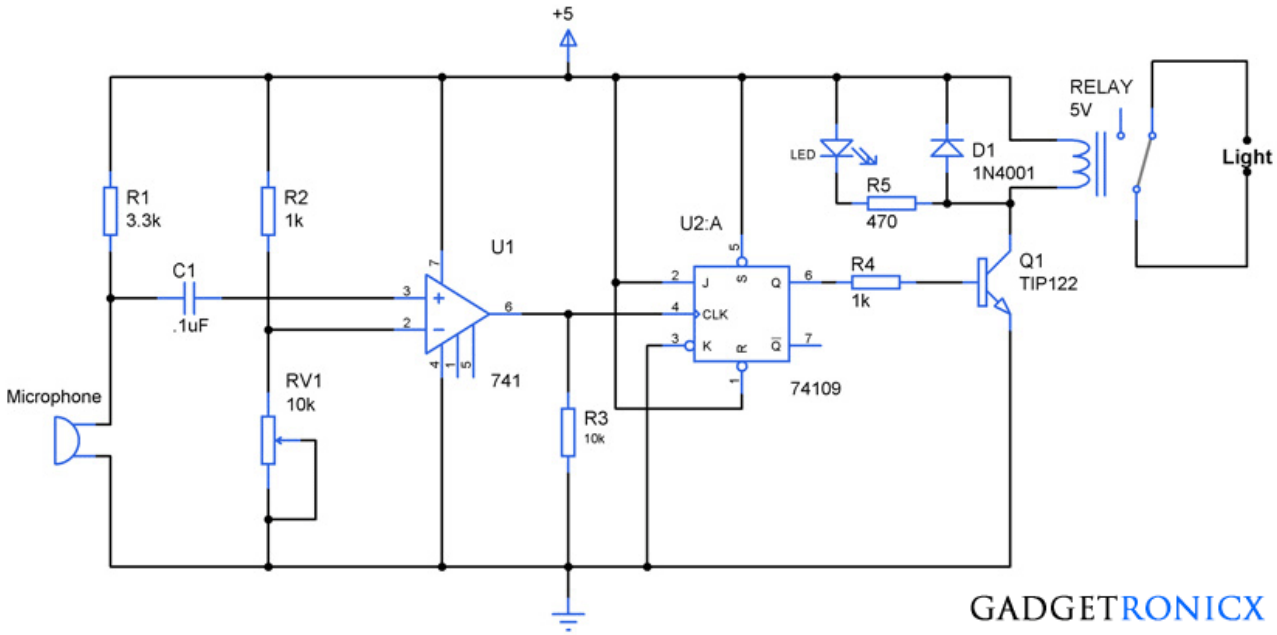
Light sensing using an op-amp comparator is widely used in automatic lighting systems. The core component of this system is a Light Dependent Resistor, or LDR, which changes its resistance based on the surrounding light intensity. When the light level decreases, the LDR resistance increases, affecting the voltage in a voltage divider circuit. This voltage is then compared with a fixed reference voltage using an operational amplifier in comparator mode.

Battery Level Indicator



An op-amp comparator is used in battery level indicators to monitor voltage and signal when charging or replacement is needed. The battery voltage is compared with a reference voltage, and if it drops below a certain threshold, the op-amp output changes state. This triggers an LED or alarm to indicate a low battery. In some circuits, multiple comparator are used to show different charge levels, ensuring proper battery management in devices like laptops, smartphones, and power banks.

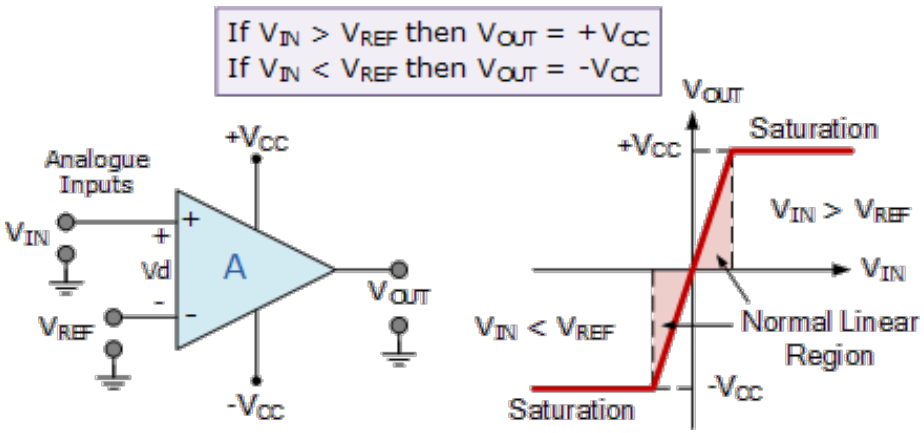
Sound Level Detector (Clap Switch)



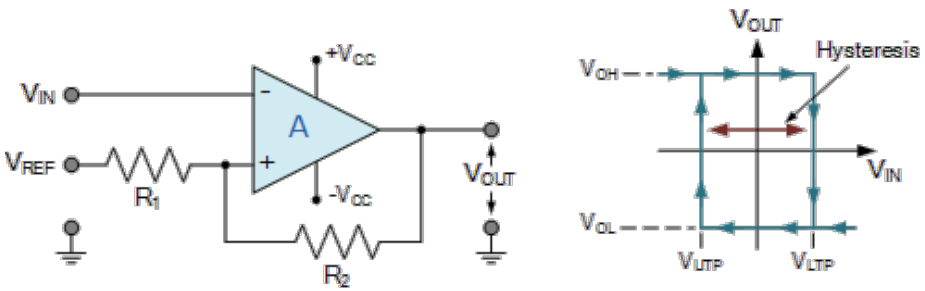
op-amp as comparator is used in clap switch to turn on/off lamp by using sound. a microphone is used as a mechanical wave (sound) then filtered by high pass filter. signal that passes through filter as comparator input to be compared with sensitivity adjustment. an oscillation output signal from comparator output is used to be an JK flip-flop clock to maintain the state of relay triggering.

Comparator Design

no hysteresis:



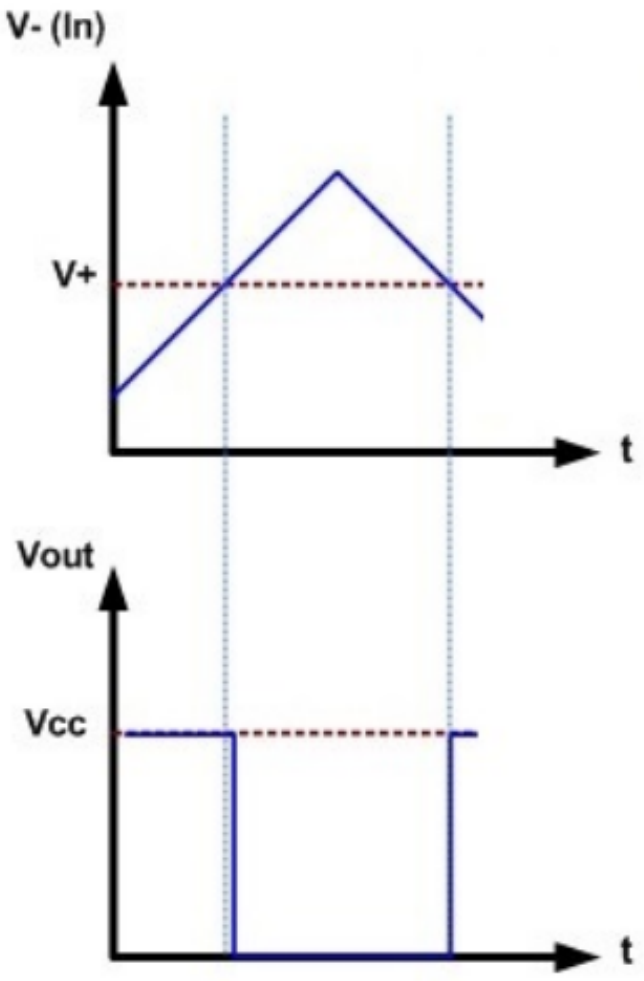
hysteresis:



When selecting a comparator circuit, consider the noise level in the system:

- Noiseless System: A basic comparator is sufficient, as there are no unwanted fluctuations in the signal.
- Noisy System: A hysteresis comparator (Schmitt Trigger) is required to prevent false triggering caused by small signal variations.

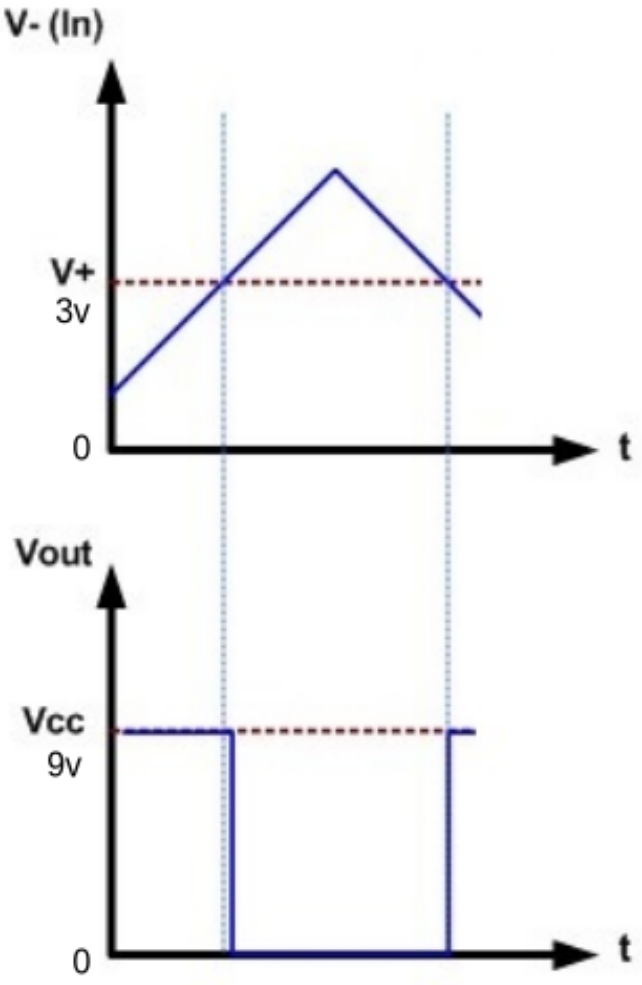
Basic Comparator



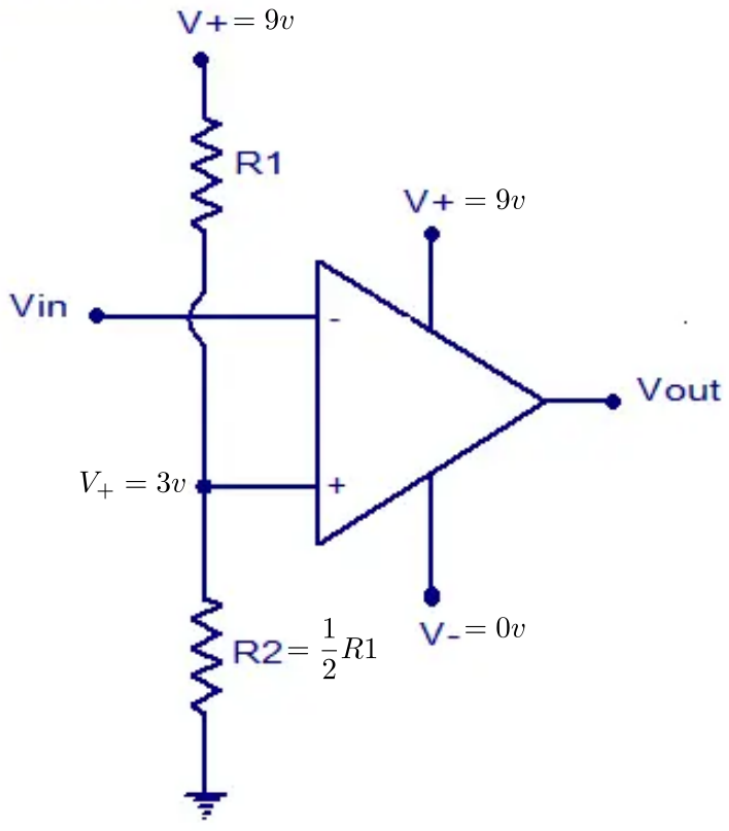
to solve problem with basic comparator,

- define desired output: an inverted output signal expected, connect the input signal to the inverting input, else connect to the non-inverting input.
- define threshold: place constant voltage to another input.

Basic Comparator

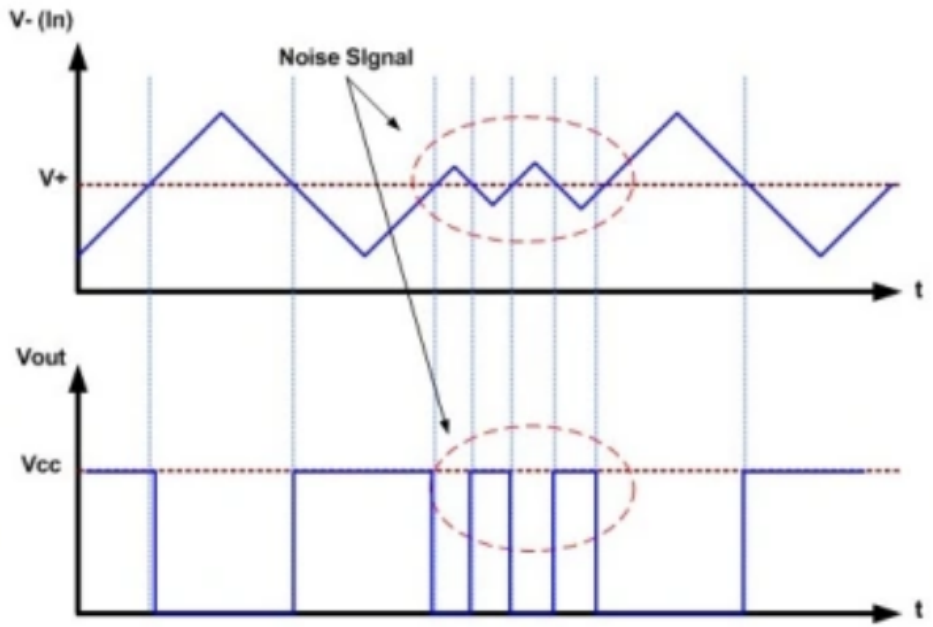


circuit realization:



Hysteresis Comparator

while input signal is noisy as follow:

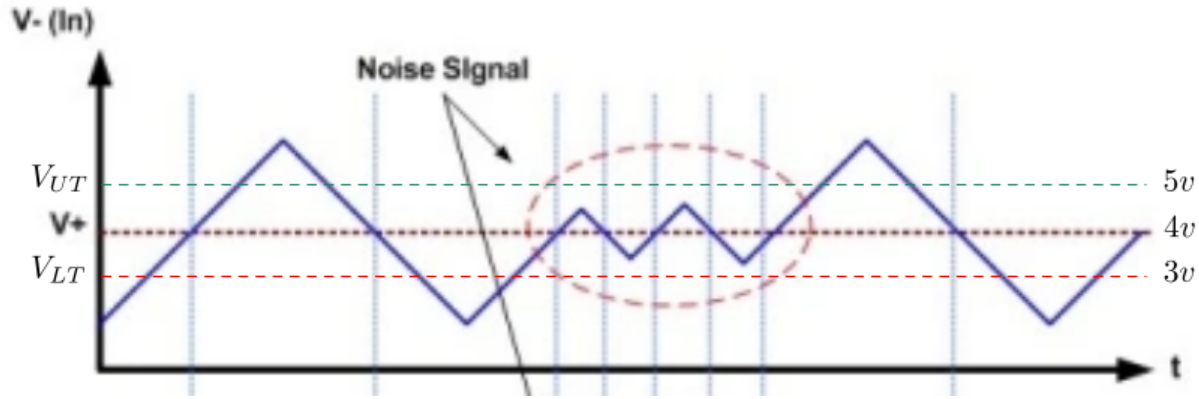


to solve problem with hysteresis comparator,

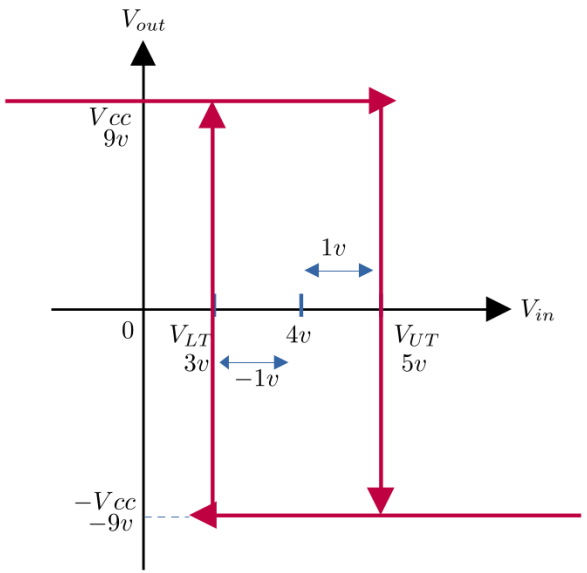
- define upper threshold V_{UT} and lower threshold V_{LT}
- define output voltage
- draw hysteresis diagram

Hysteresis Comparator

define upper threshold V_{UT} and lower threshold V_{LT}:

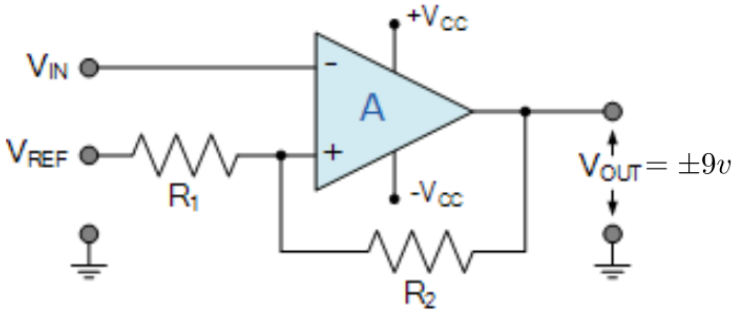


define the output voltage $V_{out} = \pm 9v$, then hysteresis diagram can be showed:

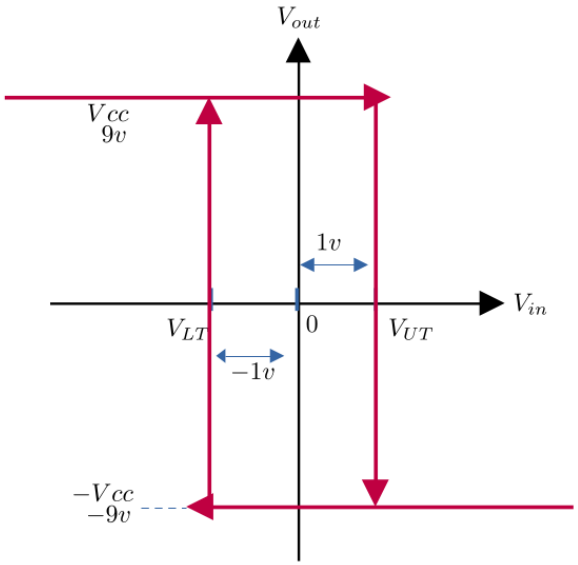


Hysteresis Comparator

hysteresis comparator circuit:



bias voltage $V_{REF} = 0$ to get voltage swing voltage between threshold.



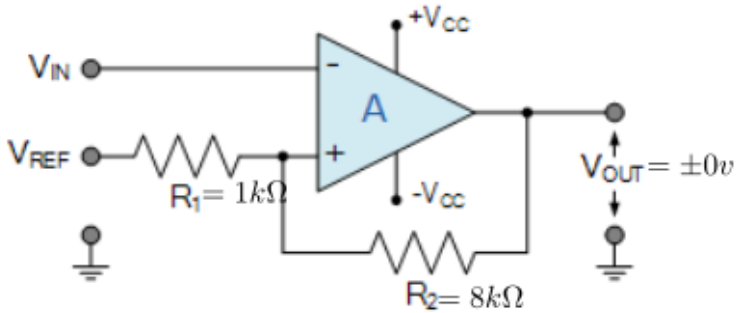
non-inverting input voltage
$V_+ = +1v$ while $V_{out} = +9v$ and
$V_+ = -1v$ while $V_{out} = -9v$, then:

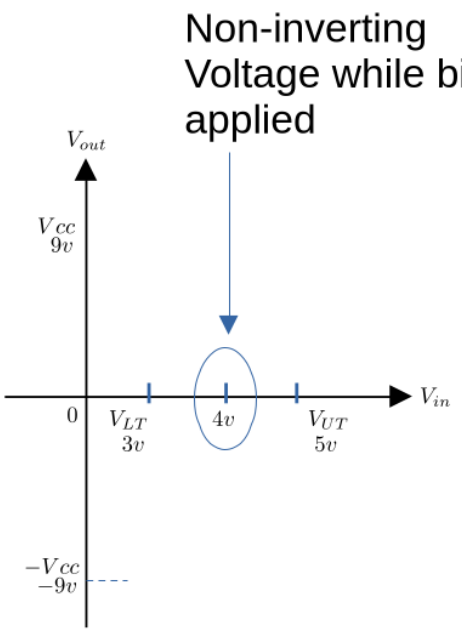
$$R_1 : R_2 = 1 : 8$$

assume that $R_1 = 1k\Omega$, so $R_2 = 8k\Omega$

Hysteresis Comparator

hysteresis comparator circuit:





find bias voltage V_{REF}:

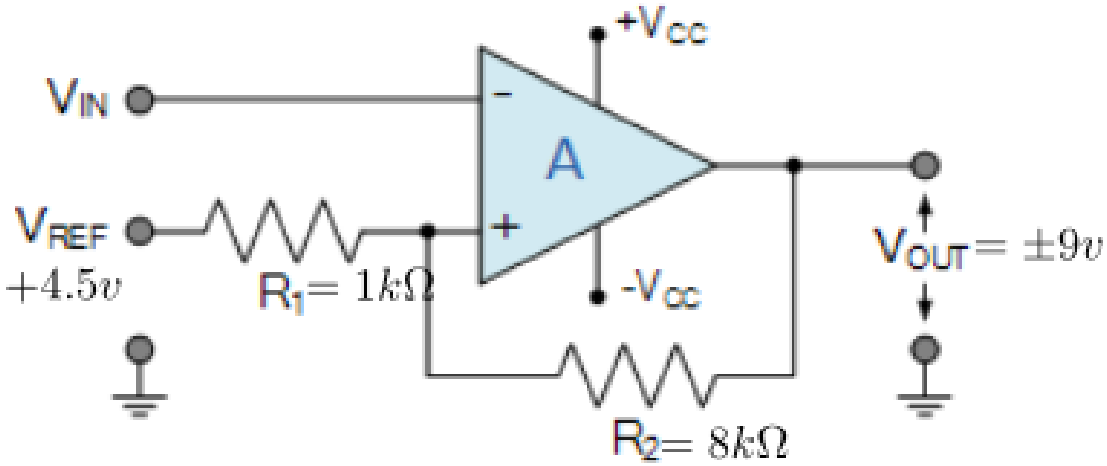
$$V_+ = \frac{R_2}{R_2 + R_1} V_{REF}$$

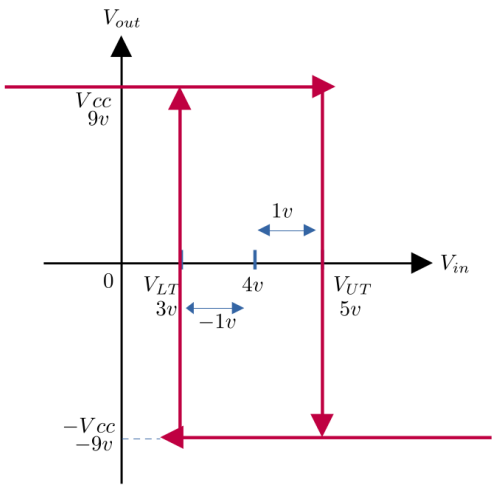
$$4v = \frac{8k\Omega}{8k\Omega + 1k\Omega} V_{REF}$$

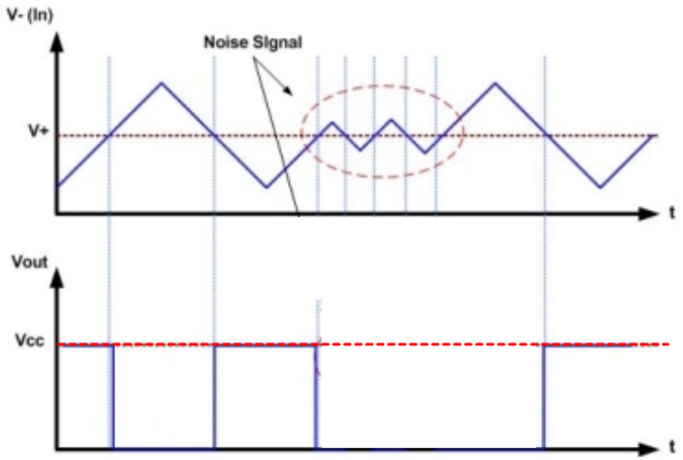
$$V_{REF} = 4.5v$$

Hysteresis Comparator

hysteresis comparator circuit:







References

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

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

Terima Kasih