Indian Institute of Information Technology, Sri City, Chittoor
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OP-AMP based Waveform Generators

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Content

- Comparator: inverting and non-inverting comparators
- Applications: zero crossing detector, window detector
- Schmitt trigger
- square wave generator (Astable multivibrator)
- Monostable Multivibrator
- sine wave generator
- 555 timers: functional diagram and Monostable operation

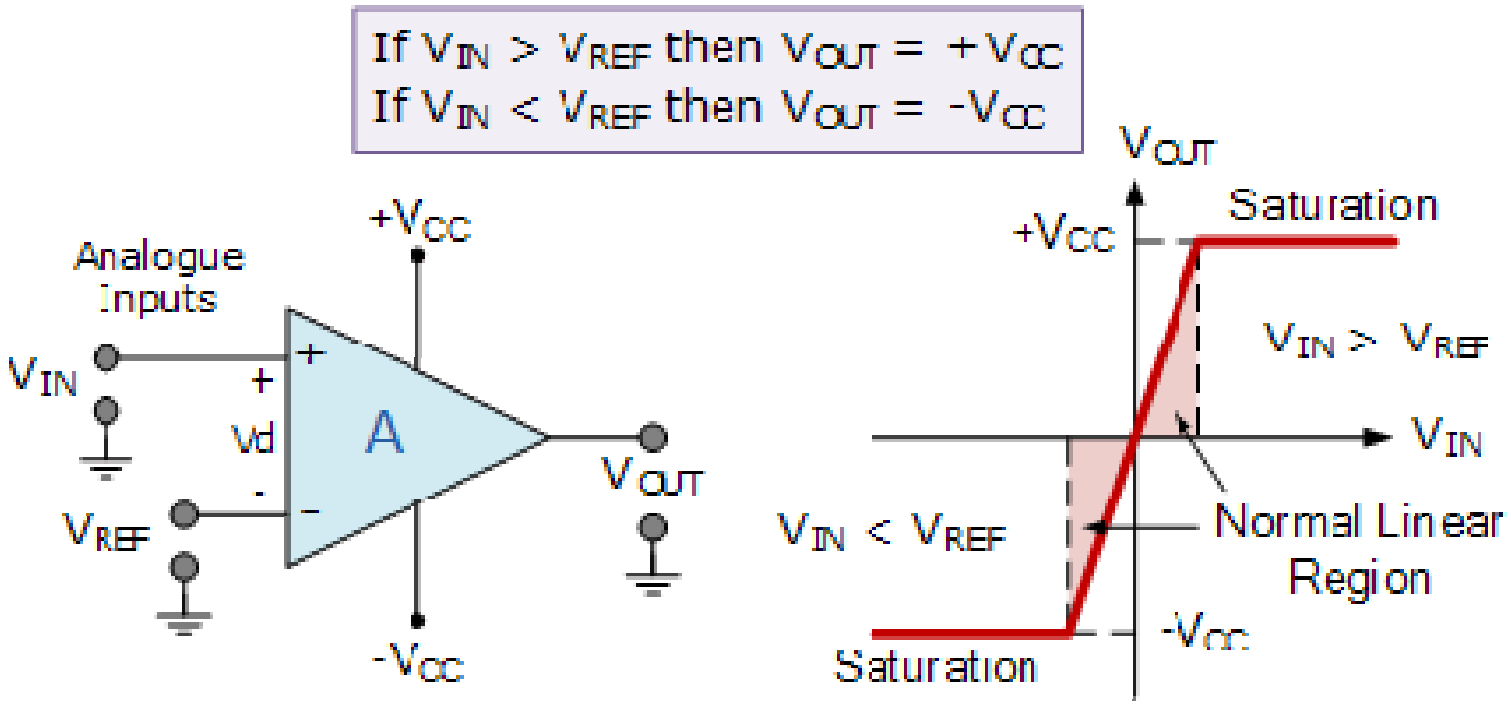
Comparator

- The op-amp voltage comparator compares the magnitudes of two voltage inputs and determines which is the largest of the two.

- *Voltage comparators* use either positive feedback or no feedback at all (open-loop mode) to switch its output between two saturated states.

- The open-loop op-amp comparator is an analogue circuit that operates in its non-linear region as changes in the two analogue inputs, V+ and V- causes it to behave like a digital *bistable* device.

OP-AMP Comparator Circuit



Operation

- lets first assume that V_{IN} is less than the DC voltage level at V_{REF}, ($V_{IN} < V_{REF}$):
  - As the non-inverting (positive) input of the comparator is less than the inverting (negative) input, the output will be LOW and at the negative supply voltage -Vcc resulting in a negative saturation of the output.

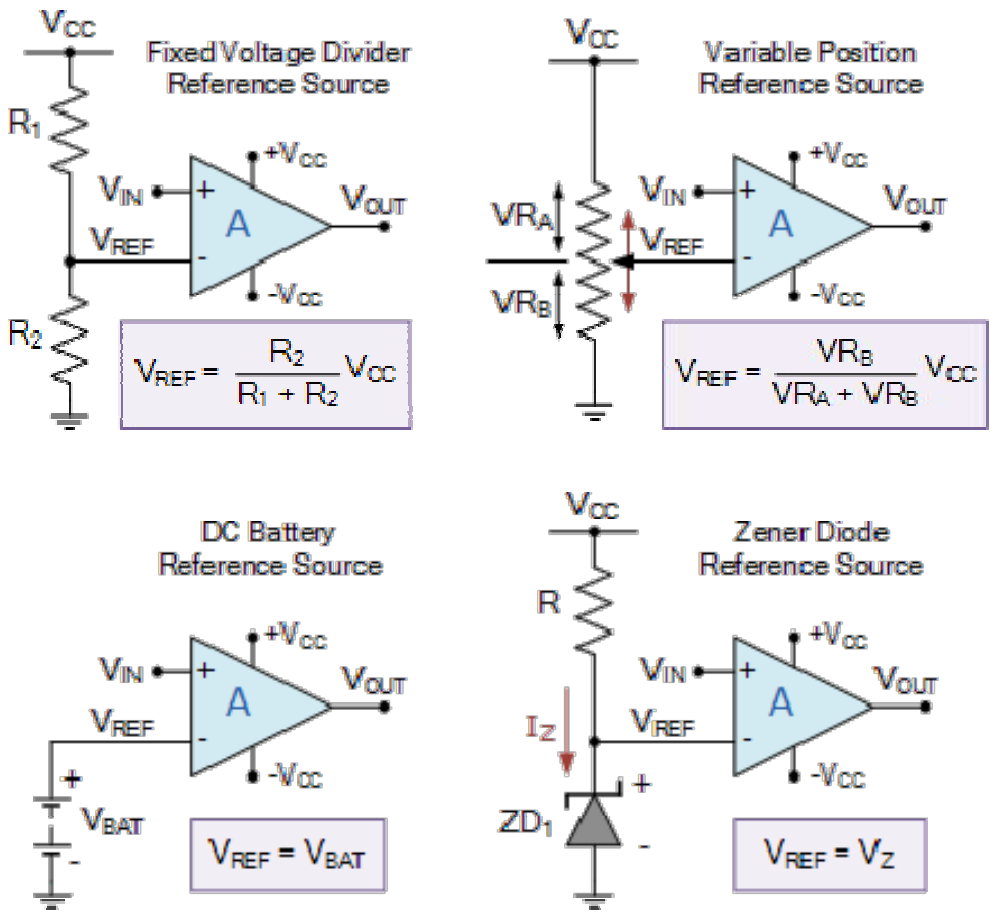
- If we now increase the input voltage, V_{IN} :
  - so that its value is greater than the reference voltage V_{REF} on the inverting input, the output voltage rapidly switches HIGH towards the positive supply voltage, +Vcc resulting in a positive saturation of the output.

Summary

- The op-amp voltage comparator is a device whose output is dependent on the value of the input voltage, V_{IN} with respect to some DC voltage level as the output is HIGH when the voltage on the non-inverting input is greater than the voltage on the inverting input, and LOW when the non-inverting input is less than the inverting input voltage.
- This condition is true regardless of whether the input signal is connected to the inverting or the non-inverting input of the comparator.

Comparator reference voltages

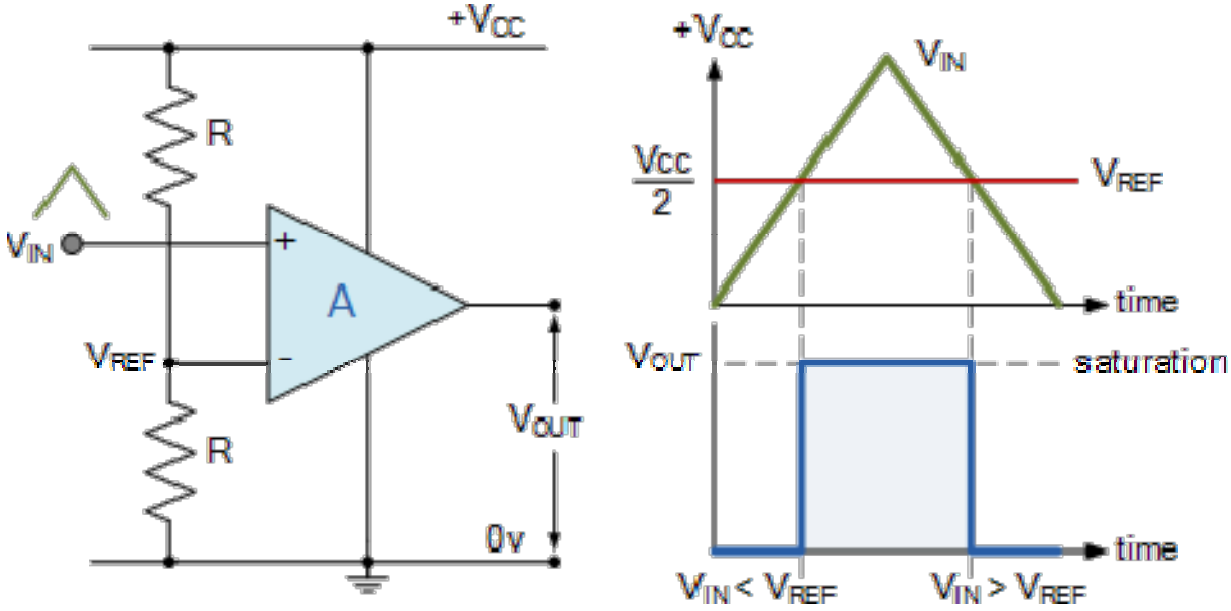
A resistive voltage divider is used to set the input reference voltage of a comparator, but a battery source, zener diode or potentiometer for a variable reference voltage can all be used as shown.



Non-Inverting Comparator

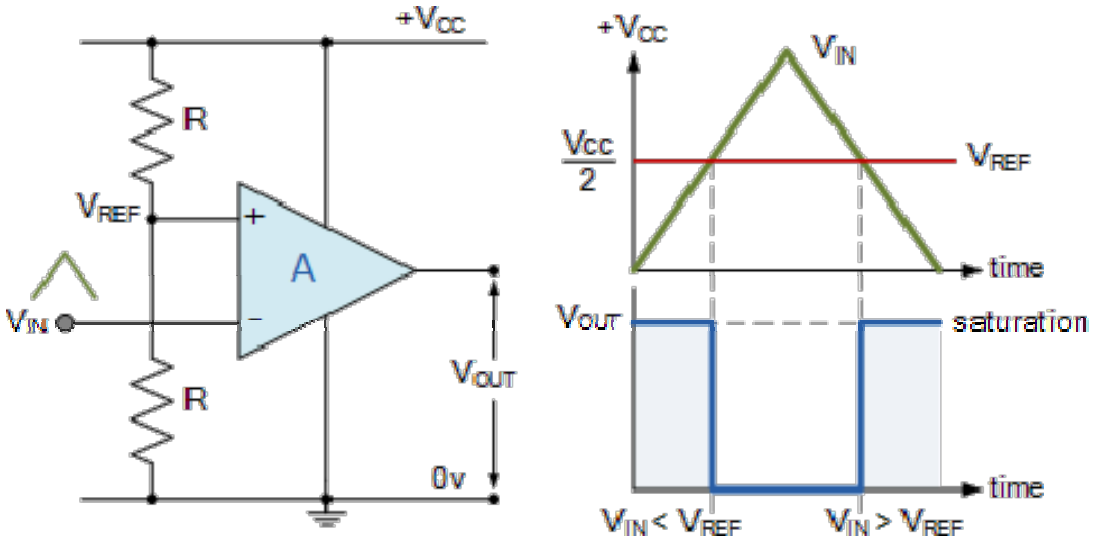
When V_{IN} is greater than V_{REF}, the op-amp comparators output will saturate towards the positive supply rail, Vcc.

When V_{IN} is less than V_{REF} the op-amp comparators output will change state and saturate at the negative supply rail, 0v as shown.

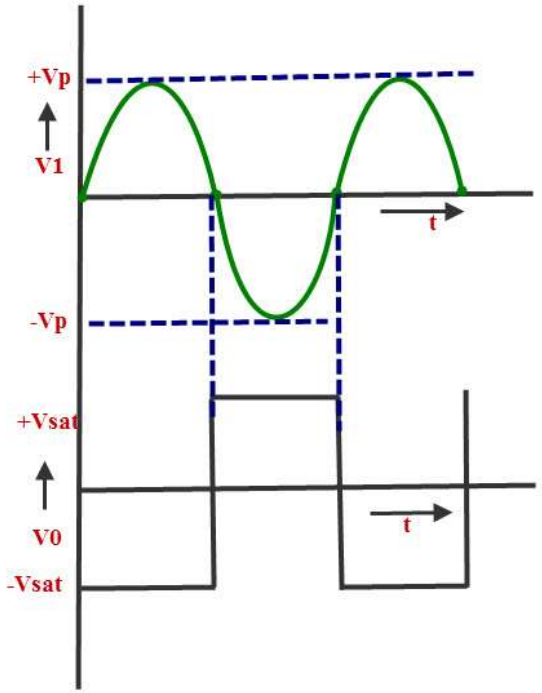


Inverting Comparator

In the inverting configuration, the reference voltage is connected to the non-inverting input of the operational amplifier while the input signal is connected to the inverting input. Then when V_{IN} is less than V_{REF} the op-amp comparators output will saturate towards the positive supply rail, V_{cc}.



Application: Zero Crossing Detector

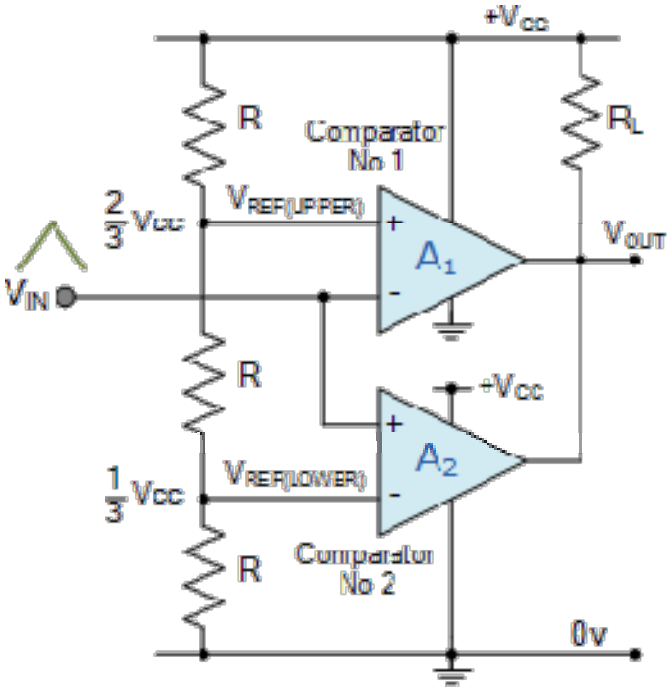


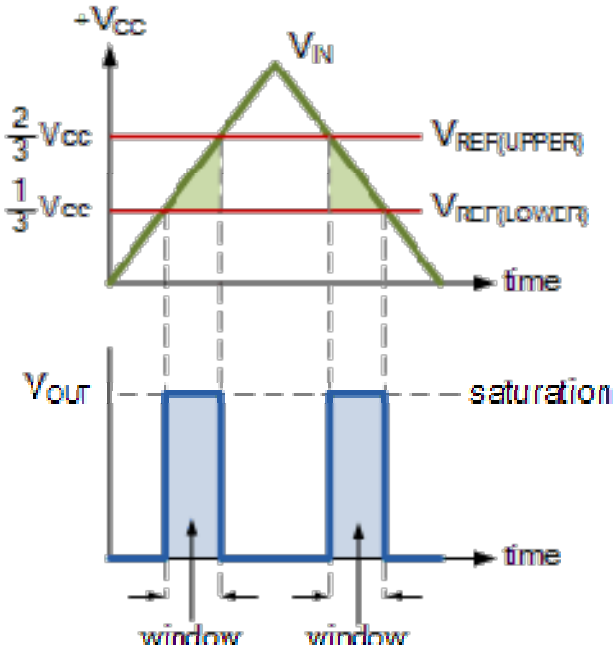
Applications: Window Comparator

- is basically the combination of inverting and the non-inverting comparators into a single comparator stage.
- The window comparator detects input voltage levels that are within a specific band or *window* of voltages, (instead of indicating whether a voltage is greater or less than some preset or fixed voltage reference point).
- i.e. instead of having just one reference voltage value, a window comparator will have two reference voltages implemented by a pair of voltage comparators.
- One which triggers an op-amp comparator on detection of some upper voltage threshold, $V_{REF(UPPER)}$ and one which triggers an op-amp comparator on detection of a lower voltage threshold level, $V_{REF(LOWER)}$. Then the voltage levels between these two upper and lower reference voltages is called the "window".

Window Comparator Circuit

- Using a voltage divider network, if we now use three equal value resistors so that R1 = R2 = R3 = R we can create a very simple window comparator circuit as shown. Also as the resistive values are all equal, the voltage drops across each resistor will also be equal at one-third the supply voltage, $1/3V_{cc}$. Then in this simple example, we can set the upper reference voltage to $2/3V_{cc}$ and the lower reference voltage to $1/3V_{cc}$.





Operation

- When V_{IN} is below the lower voltage level, $V_{REF(LOWER)}$ which equates to $1/3V_{cc}$, the output will be LOW. When V_{IN} exceeds this ($1/3V_{cc}$) lower voltage level, the first op-amp comparator detects this and switches the output HIGH to V_{cc}.
- As V_{IN} continues to increase it passes the upper voltage level, $V_{REF(UPPER)}$ at $2/3V_{cc}$ and the second op-amp comparator detects this and switches the output back LOW. Then the difference between $V_{REF(UPPER)}$ and $V_{REF(LOWER)}$ (which is 2/3Vcc – 1/3Vcc in this example) creates the switching window for the positive going signal.

Operation

- Lets now assume that V_{IN} is at its maximum value and equal to V_{cc}. As V_{IN} decreases it passes the upper voltage level $V_{REF(UPPER)}$ of the second op-amp comparator which switches the output HIGH. As V_{IN} continues to decrease it passes the lower voltage level, $V_{REF(LOWER)}$ of the first op-amp comparator once again switching the output LOW.
- Then the difference between $V_{REF(UPPER)}$ and $V_{REF(LOWER)}$ creates the window for the negative going signal. So we can see that as V_{IN} passes above or passes below the upper and lower reference levels set by the two op-amp comparators, the output signal V_{OUT} will be HIGH or LOW.