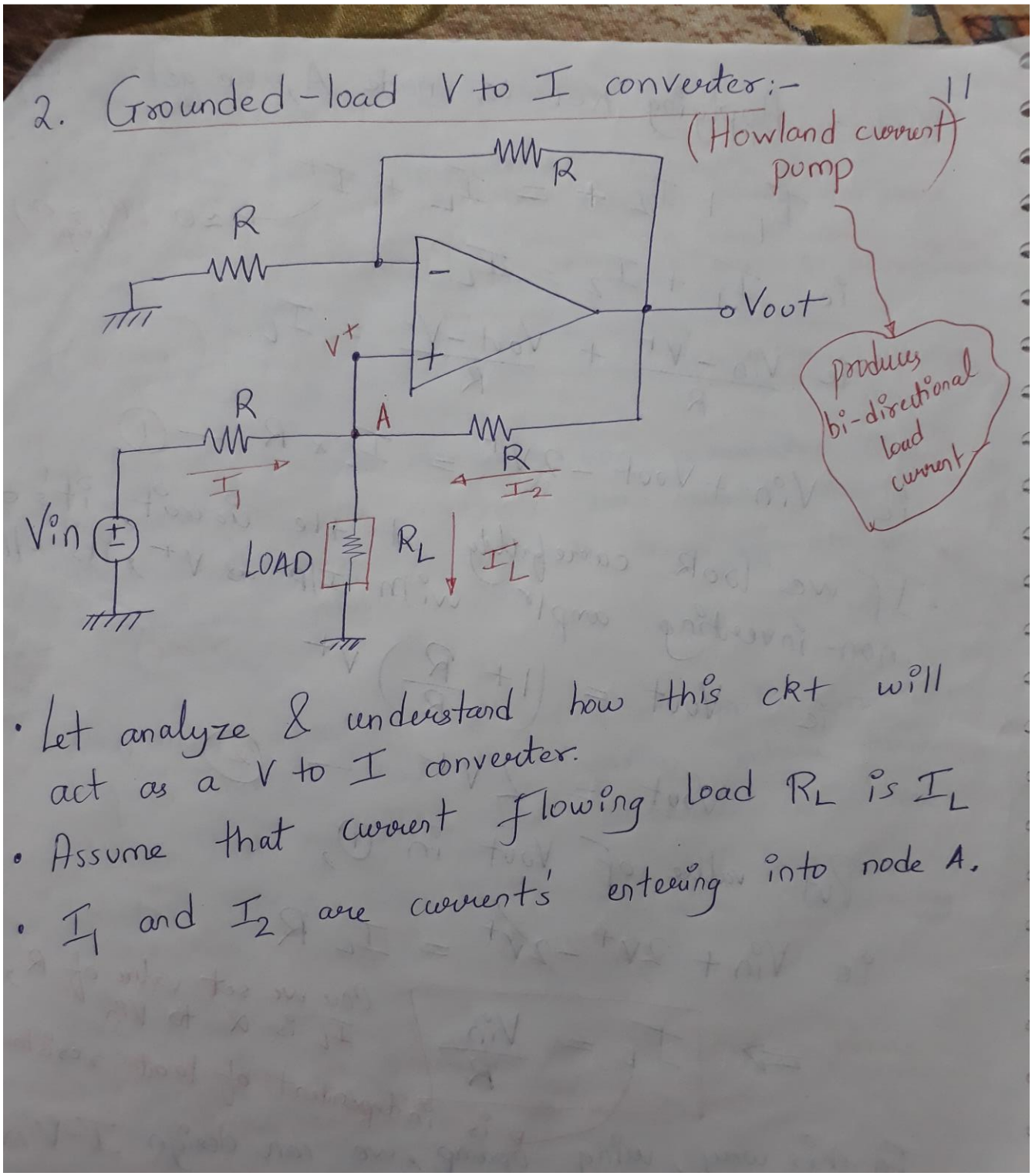
LICD lecture 12 dated 03-08-2018

Topics Covered: Grounded load V to I converter using OPAMP and verification of concept using simulation, Non-inverting comparator concept explained by simulating the circuit first, observing results in simulation real time, and interpretating them on green board, explaining the transfer characteristics of non-inverting comparator.



Applying KCL at node A, we get

$$I_1 + I_2 = I_L + I^+$$

$I^+ \approx 0$ ($R_i \approx \infty$ v. high)

ie $I_1 + I_2 = I_L$

ie $\frac{V_{in} - V^+}{R} + \frac{V_{out} - V^+}{R} = I_L$

ie $V_{in} + V_{out} - 2V^+ = I_L \times R$ — (1)

If we look carefully at the circuit, it's a non-inverting ampl^r with I/P as V^+, it's o/p is

ie $V_{out} = \left(1 + \frac{R}{R}\right) V^+$

$V_{out} = 2V^+$ — (2)

Put value of V_{out} in (1),

ie $V_{in} + 2V^+ - 2V^+ = I_L R$

$\Rightarrow \boxed{I_L = \frac{V_{in}}{R}}$

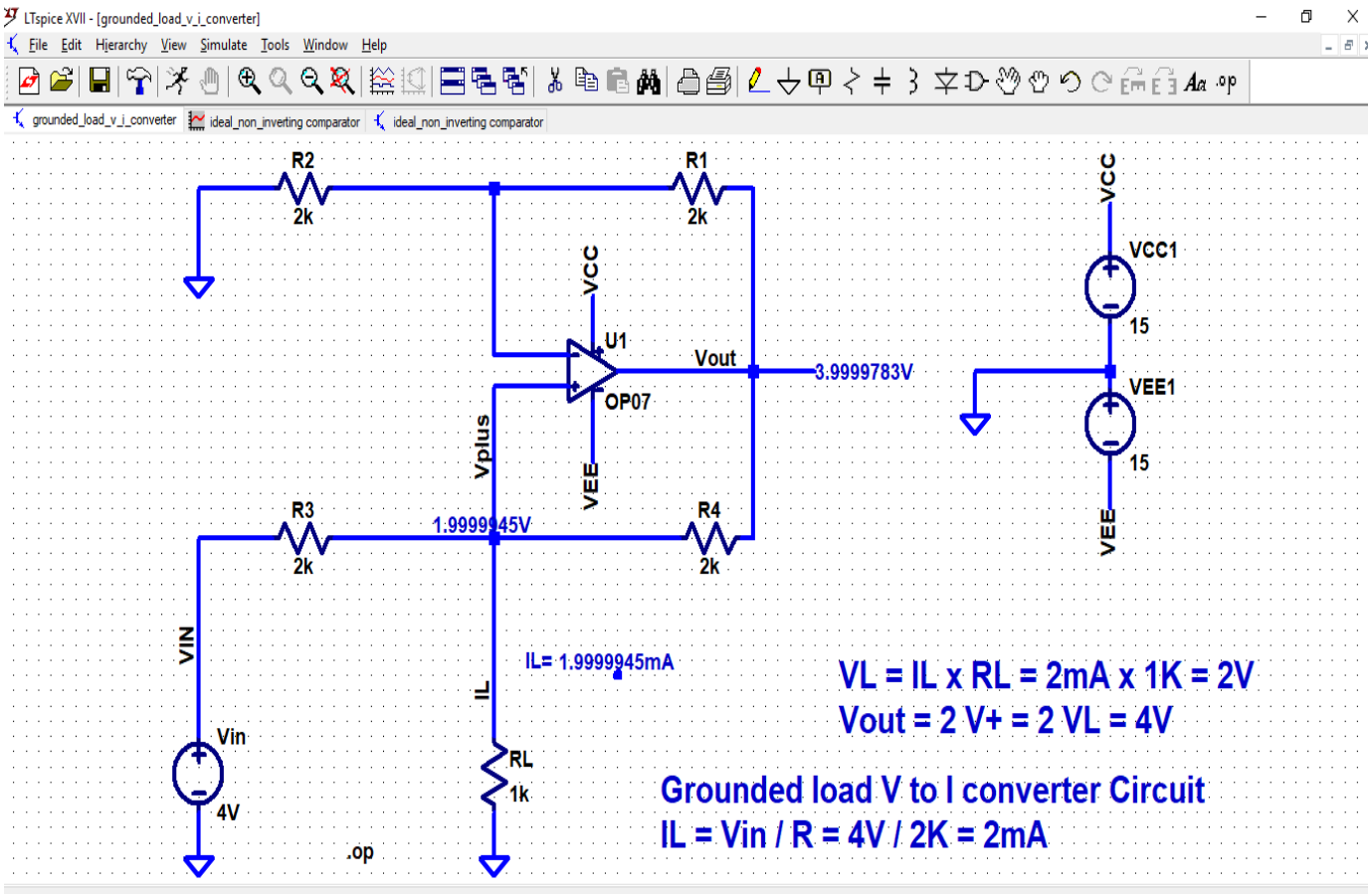
Once we set value of R, the I_L is $\propto$ to V_{in}

I_L is independent of load resistance R_L

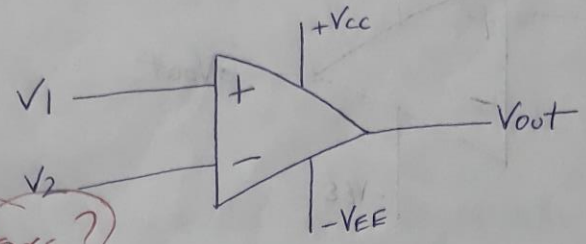
In this way, using opamp, we can design I-V converter

Simulation was carried out in LT Spice and simulation results were discussed Live in class

Topics: Grounded Load V to I Converter circuit, with value of R=2kΩ and RL=1KΩ was discussed



Comparators



Why comparators?

- Many, times in electrical and electronic circuit, it is required to compare the two voltage levels.

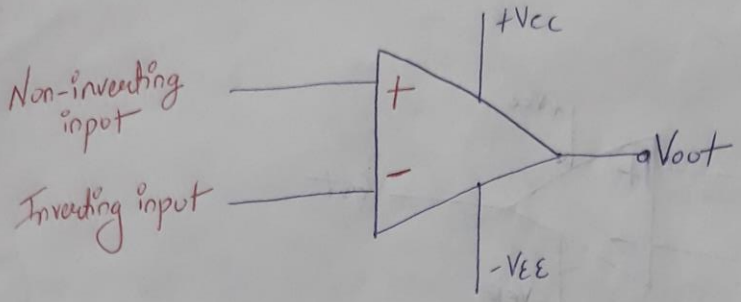
For eg:- We are measuring the temperature of a room using temperature sensor

Assome that o/p of sensor is in terms of voltage

→ Task : Compare this voltage with some reference voltage.

So, whenever the room temperature goes beyond certain value then → we can take some action. (Like turning ON some buzzers or activating relays)

- This can be done by using comparator.



. Comparator uses two inputs, inverting and the non-inverting input. It has one digital output.

{ Digital o/p means → the o/p can have two states either High or low }

. State of the o/p depends upon which i/p is higher.

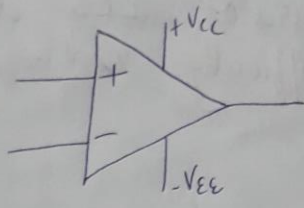
eg lets say if voltage at non-inverting terminal is higher than the inverting input terminal → then the output of the comparator will be HIGH

ie. $V^+ > V^- \rightarrow V_O = \text{HIGH}$

Similarly, if $V^- > V^+ \rightarrow V_O = \text{LOW}$

So, as we can feel, this comparator acts like a 1 bit of analog to digital converter.

AHA → This comparators are used in ADCs (So, useful they can be)



Schematic of comparator (similar to opamp)

- Opamp can be used as a comparator, whenever it is used in the open-loop condition.

Comparator concept

$V_o = A_{OL} \times V_{id}$

A_{OL} : open-loop gain of opamp — value is very high ($\sim 10^5$)

V_{id} : differential i/p voltage $= (V^+ - V^-)$

$\therefore$ V_{id} will be +ve if $V^+ > V^-$

V_{id} will be -ve if $V^- > V^+$

Understand this, and You understand Comparator !!

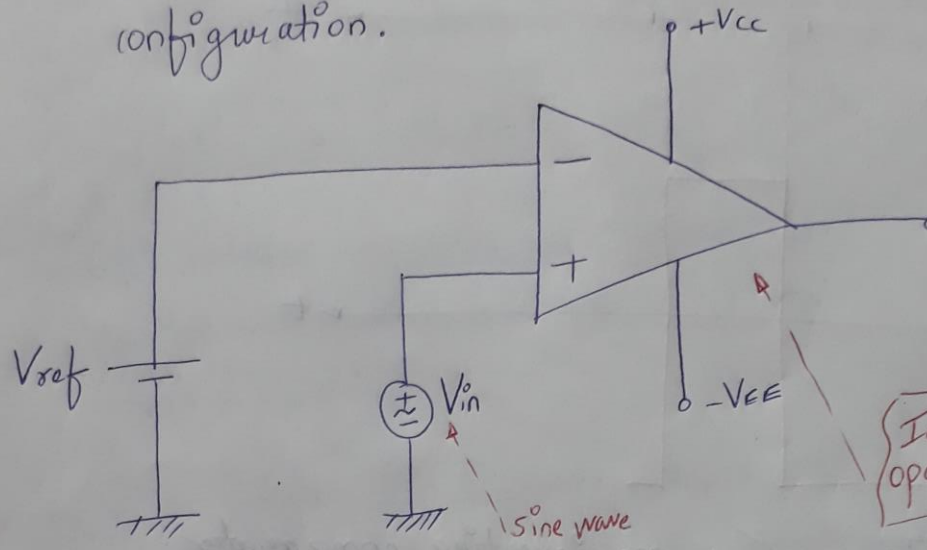
If $V^+ > V^-$, V_{id} +ve, then o/p of opamp is equal to the positive saturation voltage ($+V_{sat}$) of opamp

Likewise, if $V^- > V^+$, V_{id} -ve, then o/p is equal to the negative saturation voltage ($-V_{sat}$) of opamp

This manner, opamp can be used as comparator in open-loop condition.

• Non-inverting comparator:-

Let consider, an opamp in it's open-loop configuration.



Circuit 1.1

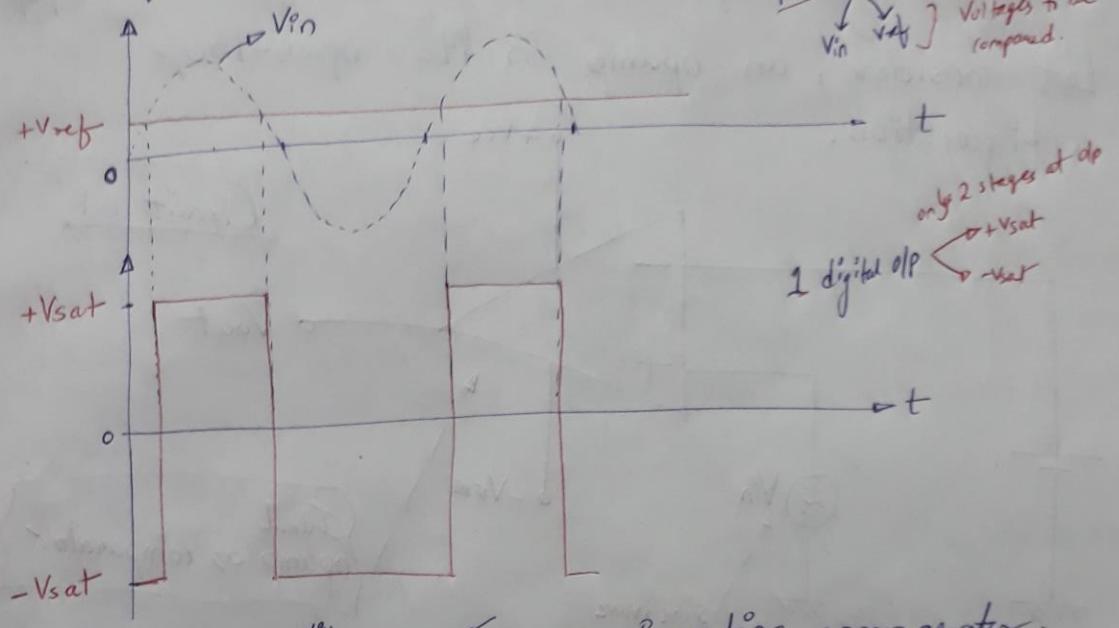
Ideal opamp as comparator

Observations:-

- Above comparator is an open-loop op-amp, with two analog inputs and a digital output.
- When input ac signal is applied to non-inverting terminal and reference voltage is applied at the inverting terminal, then circuit is called as "non-inverting comparator".
- Circuit 1.1 shows the circuit diagram of ideal non-inverting comparator.

Note: Comparator compares any arbitary input signal with a known fixed reference voltage.

Waveforms:-



Two analog i/p's
Vin, Vref] Voltages to be compared.

only 2 stages of o/p
1 digital o/p → +Vsat, -Vsat

I/P - O/P waveforms for non-inverting comparator.

- Let's analyze, these waveforms :-

O/p voltage V_{out} is given as, let $\boxed{V_{id} = V^+ - V^-}$

$$V_o = A(V^+ - V^-)$$

$$\boxed{V_o = A(V_{in} - V_{ref})}$$

Let's consider 3 cases, to understand operation of ckt better.

Case ① $V_{in} < V_{ref}$

Case ② $V_{in} > V_{ref}$

Case ③ $V_{in} \simeq V_{ref}$

Case 1:- When V_{in} is less than V_{ref}, V_{id} is less than zero ie V_{id} is negative; then o/p will go to -ve saturation level,

ie $V_{out} = A(V_{id})$

$\therefore$ $\boxed{V_{out} = -V_{sat}}$

(A → v. high, V_o switches to $-V_{sat}$)

→ O/P voltage remains at $-V_{sat}$ ie negative saturation level as long as $V_{in} < V_{ref}$.

(eg if $V_{cc} \to +15V$, $V_{EE} \to -15V$, $\pm V_{sat}$ is $\pm 13V$)

Case ②:- When V_{in} is more than V_{ref}, V_{id} is +ve then o/p will go to +ve saturation level.

$V_{out} = A(V_{in} - V_{ref}) = A V_{id}$

$V_{id} = +ve$

ie $\boxed{V_{out} = +V_{sat}}$

→ O/P voltage V_{out} will remain at $+V_{sat}$ ie positive saturation level as long as $V_{in} > V_{ref}$.

These two cases, we can observe it clearly in the i/p - o/p waveforms.

Case (3):-

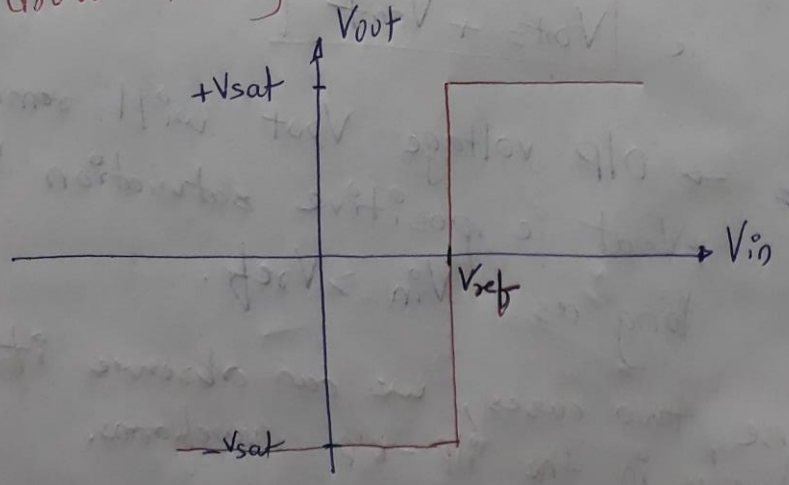
- When V_{in} is approaching very close to V_{ref}, then o/p voltage V_{out} ⟹ switches from one saturation level to another ie in this case o/p voltage V_{out} switches from $-V_{sat}$ to $+V_{sat}$ then from $+V_{sat}$ to $-V_{sat}$

This is also evident from waveforms.

∴ From o/p waveforms, it is clear that, whether input voltage is less than or greater than or equal to V_{ref}, circuit act as a comparator.

→ It is also called as "Voltage-level detector" becoz for a desired level of V_{ref}, the vtg level of V_{in} can be detected.

Let's draw transfer characteristics (from I/P-O/P waveforms)

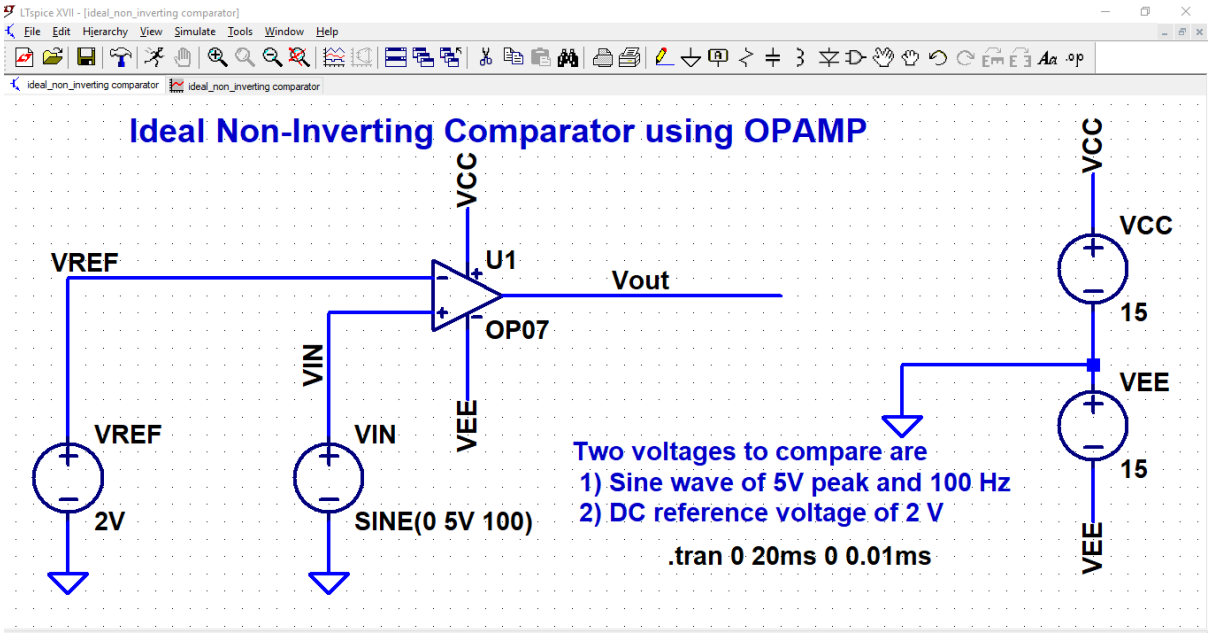
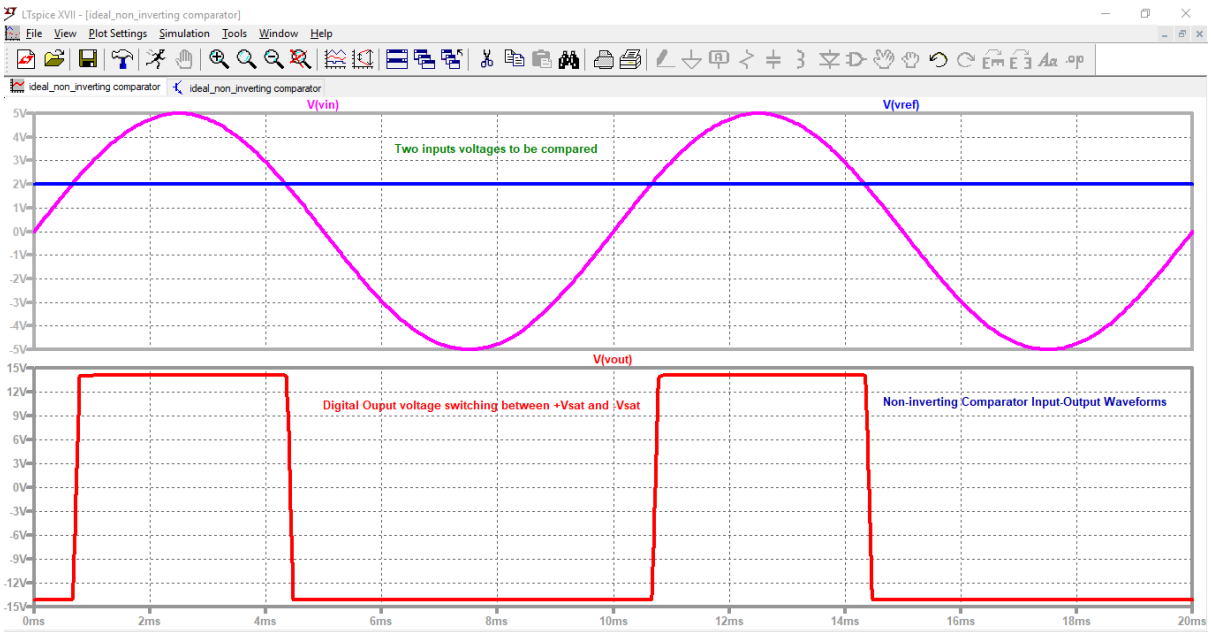


VTC curve for ideal non-inverting comparator

Simulation was carried out in LT Spice and simulation results were discussed Live in class

Topics: Ideal Non-Inverting Comparator using Opamp with Vref= 2V and Vin is a sine wave of 5V peak and 100Hz frequency

Circuit of Non-inverting Comparator



Input-Output Waveforms :