Operational Amplifier

I

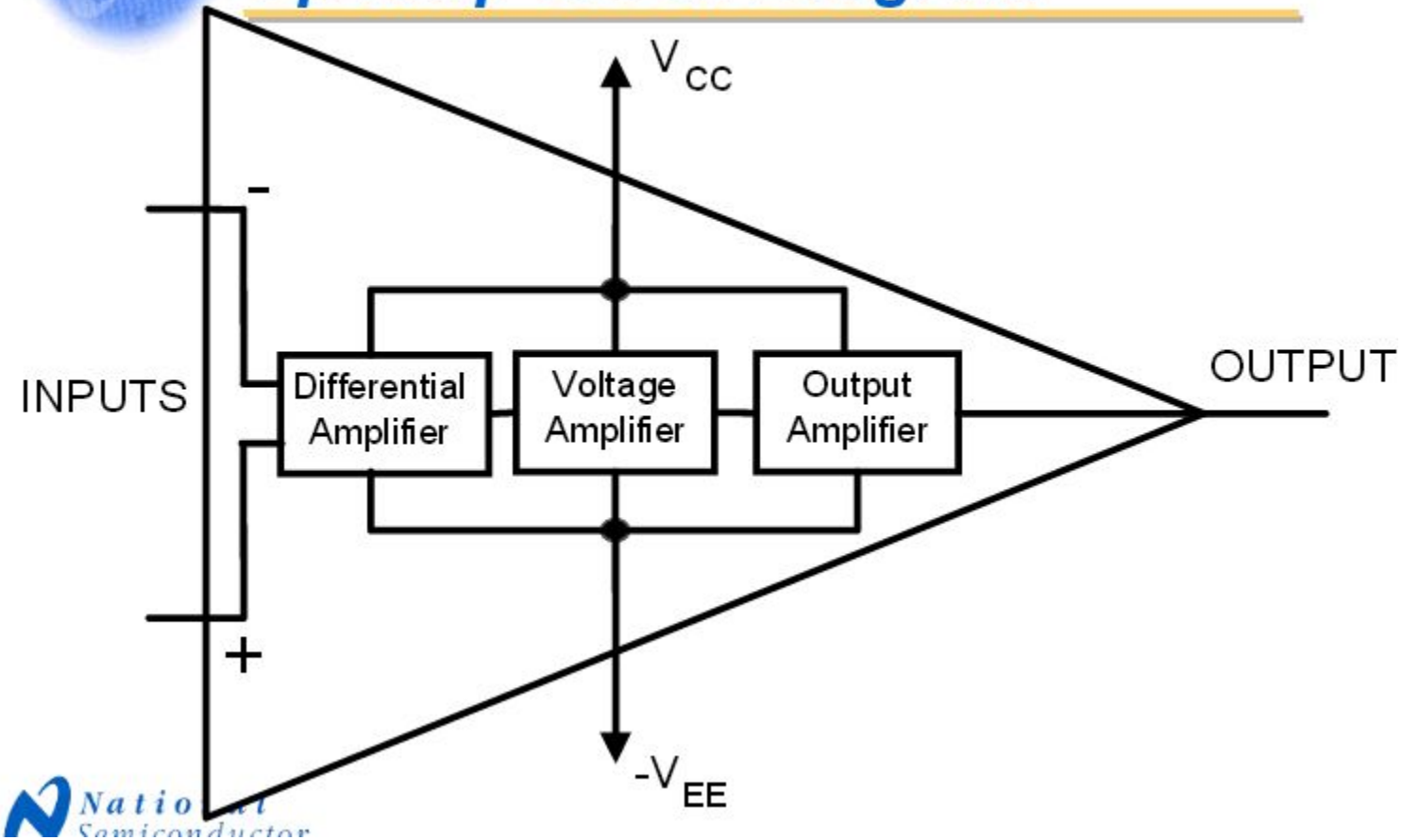
Introduction

- An op-amp is a direct coupled high-gain amplifier usually consisting of one or more differential amplifier and usually followed by a level translator and an O/P stage.

- Used to amplify DC as well as AC I/P signal and was originally designed for performing mathematical operation such as:
  - Addition
  - Subtraction
  - Multiplication
  - Integration

- Also used as active-filter, oscillator, comparator etc…..

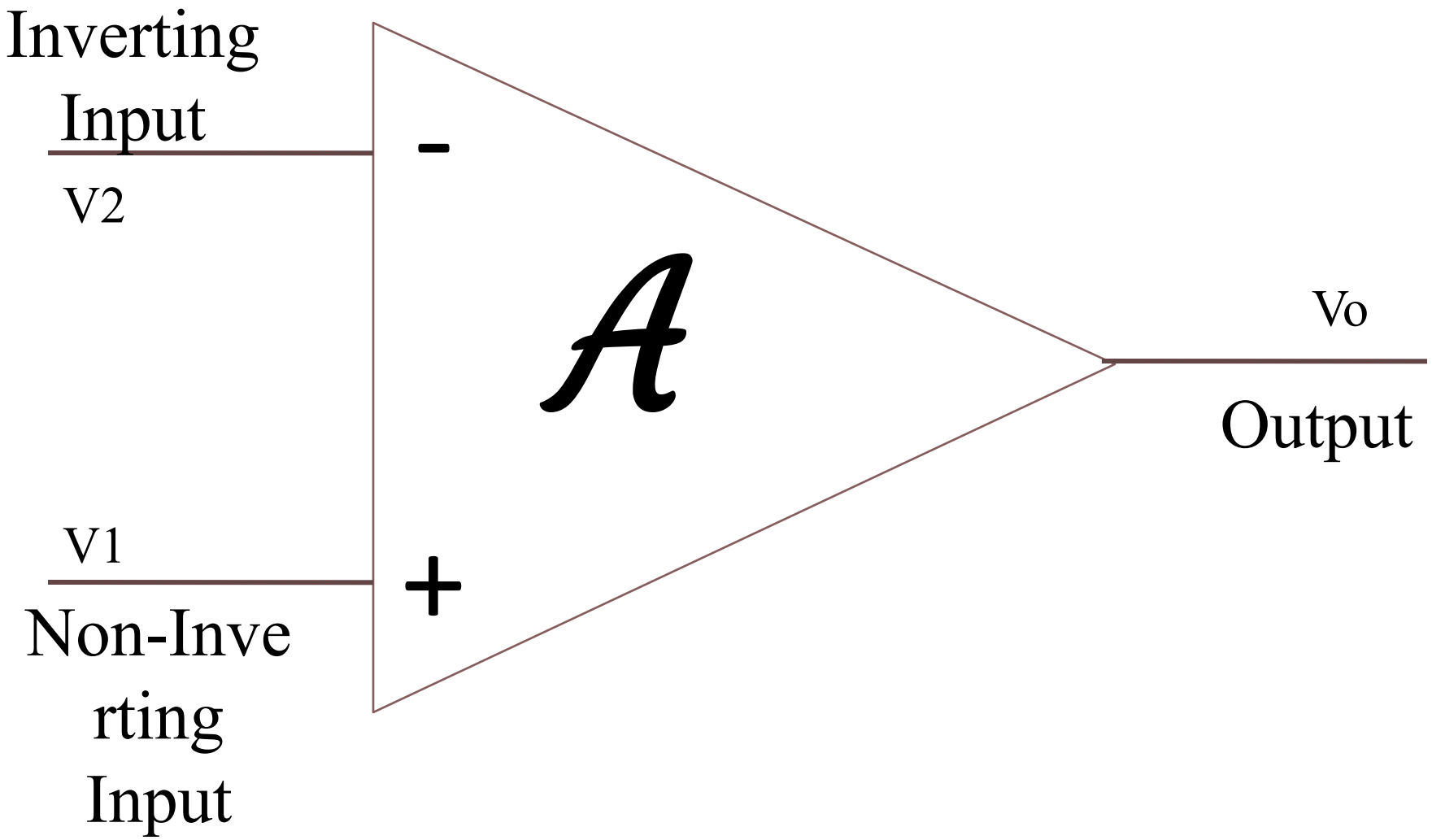
Op-Amp Block Diagram



OPAMP Block Diagram

- The input stage of an *OP-Amp is a differential amplifier (DA) and the output stage is* typically a class *B push-pull emitter follower.*
- The internal stages of an *OP-Amp are direct-coupled i.e., no coupling capacitors are used.*The direct coupling allows the *OP-Amp to amplify d.c. as well as a.c. signals*
- An OP-Amp has *very high input resistance (ideally infinite).*The effect of high input impedance is that the amplifier will draw a very small current (ideally zero) from the signal source.

Schematic Symbol



$\mathcal{A}$ = large signal voltage gain

The op-amp has the following characteristics:

- It is basically a "three terminal" amplifier with two inputs and an output. It is a differential amplifier with very high gain

$$v_{out} = A(v_+ - v_-)$$

  where A is typically 10^4 – 10^5, and the two inputs are known as the *non-inverting* (v_+) and *inverting* (v_-) inputs respectively. In the ideal op-amp we assume that the gain A is infinite.

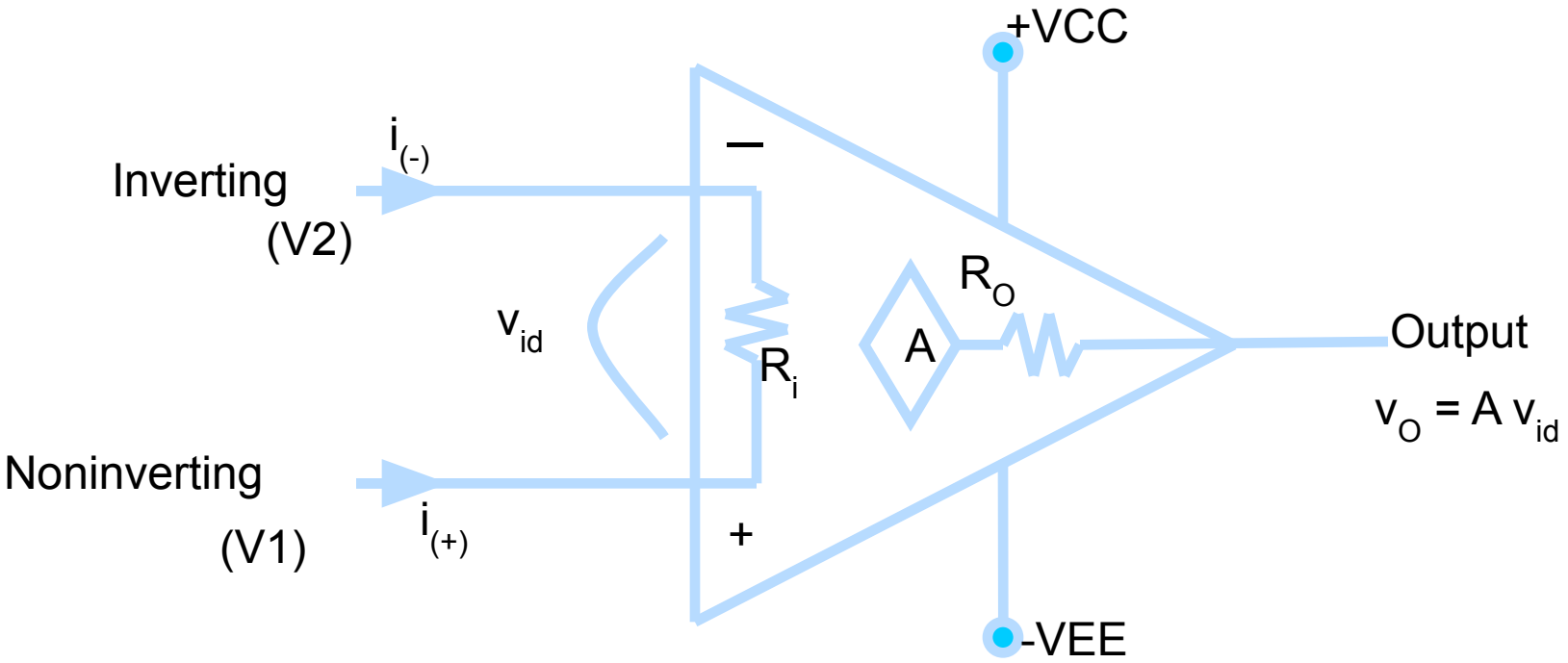
- In an ideal op-amp no current flows into either input, that is they are voltage-controlled and have infinite input resistance. In a practical op-amp the input current is in the order of pico-amps (10^{-12}) amp, or less.

- The output acts as a voltage source, that is it can be modeled as a Thevenin source with a very low source resistance.

IDEAL OP-AMP CHARACTERISTICS

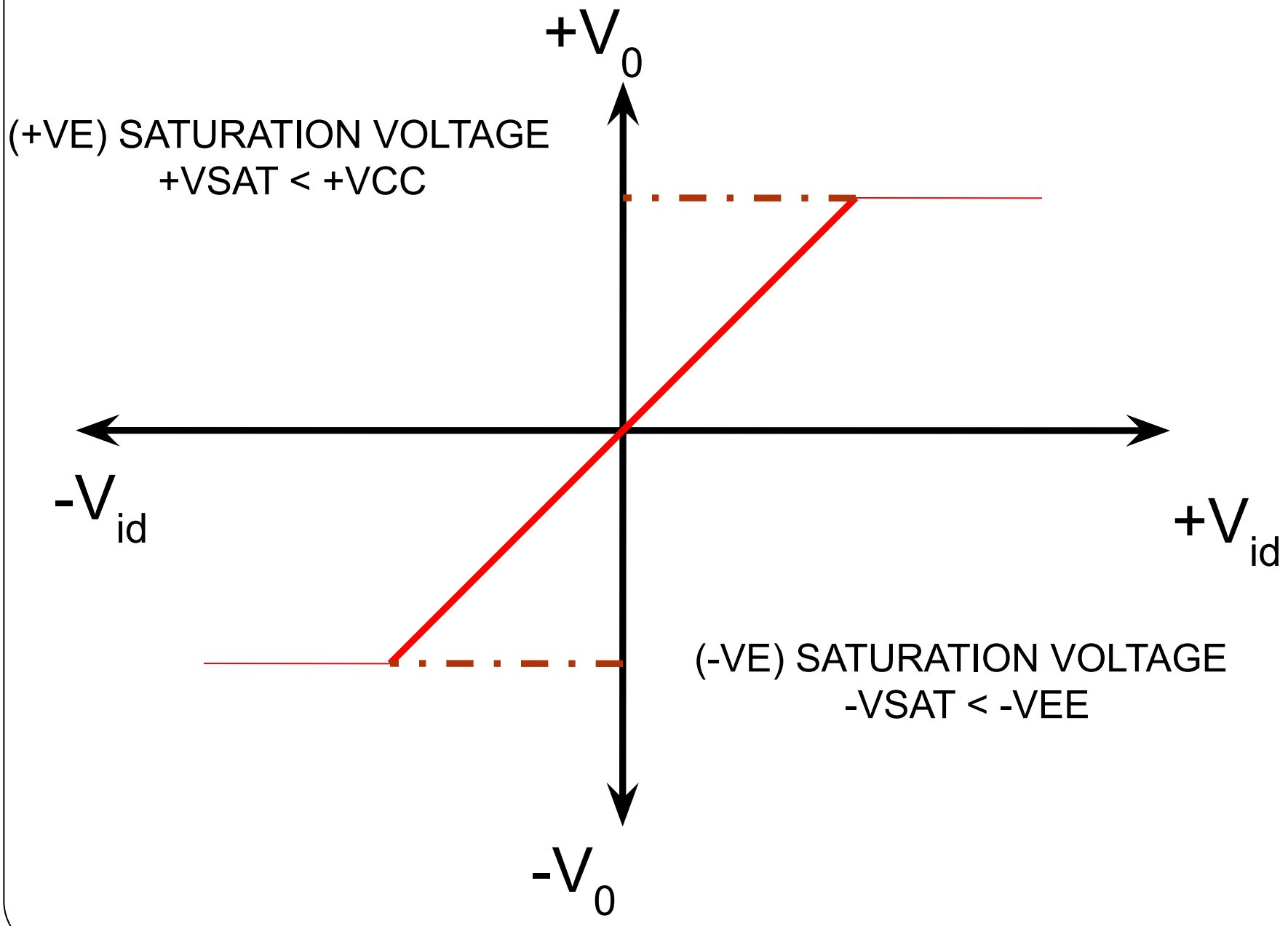
- Infinite voltage gain (A)
- Infinite input resistance (Ri) . So that almost any signal source can drive it and there is no loading of the preceding stage.
- Zero output resistance (Ro) so that the output can drive an infinite no. of other device.
- Zero output voltage when input voltage is zero.
- Infinite bandwidth, so that any frequency signal from 0 to ∞Hz can be amplified without attenuation.
- Infinite CMRR so that the output Common mode noise voltage is zero.
- Infinite Slew rate so that output voltage changes occurs simultaneously with input voltage changes.

EQUIVALENT CIRCUIT OF AN OP-AMP



$$V_{io} = AV_{id} = A\,(V_1 - V_2)$$

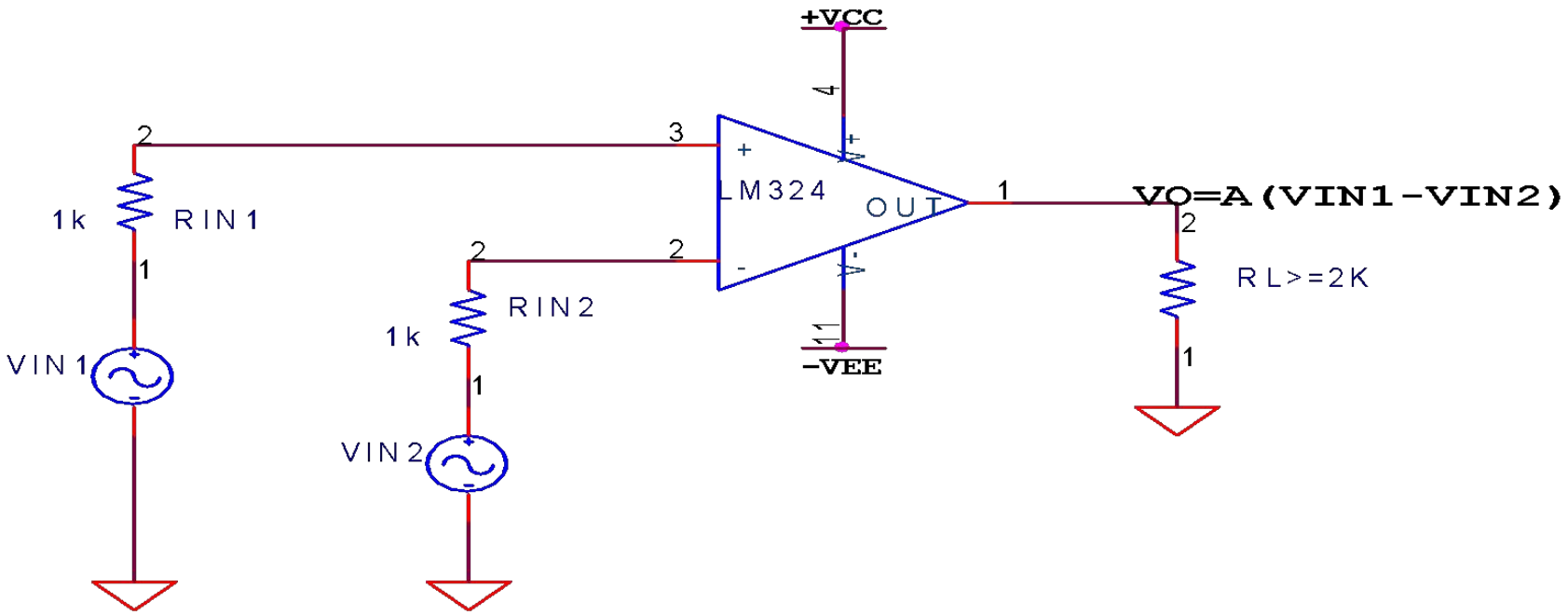
IDEAL VOLTAGE TRANSFER CURVE



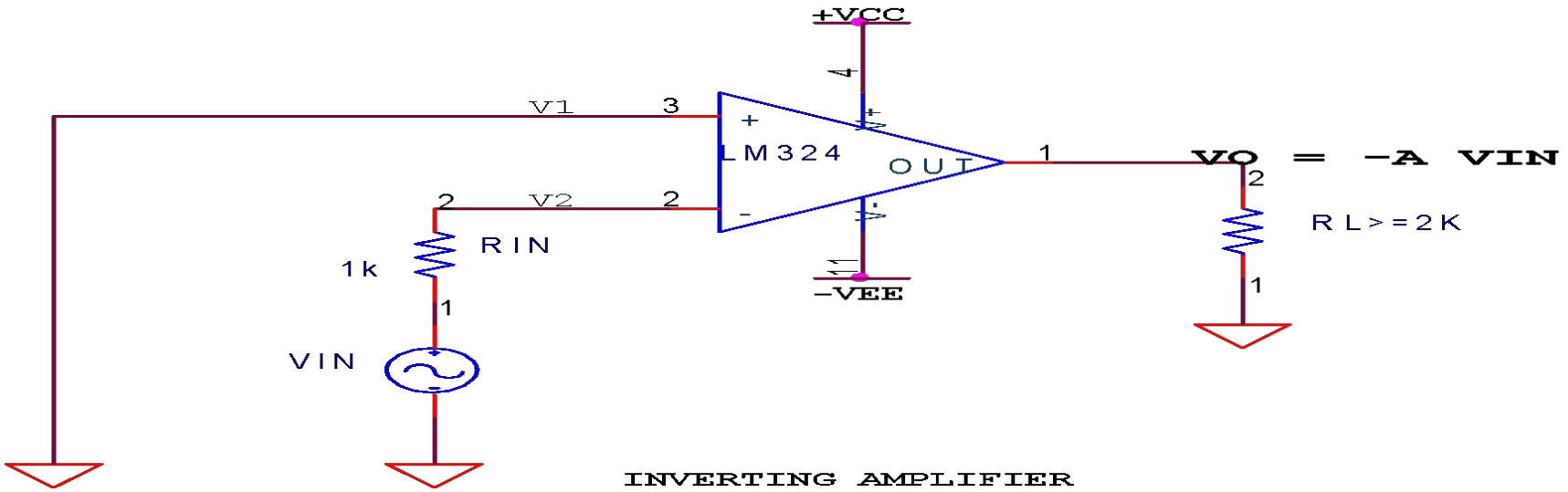
Open –Loop Op-Amp Configuration

1. Differential amplifier
2. Inverting amplifier
3. Non-Inverting amplifier

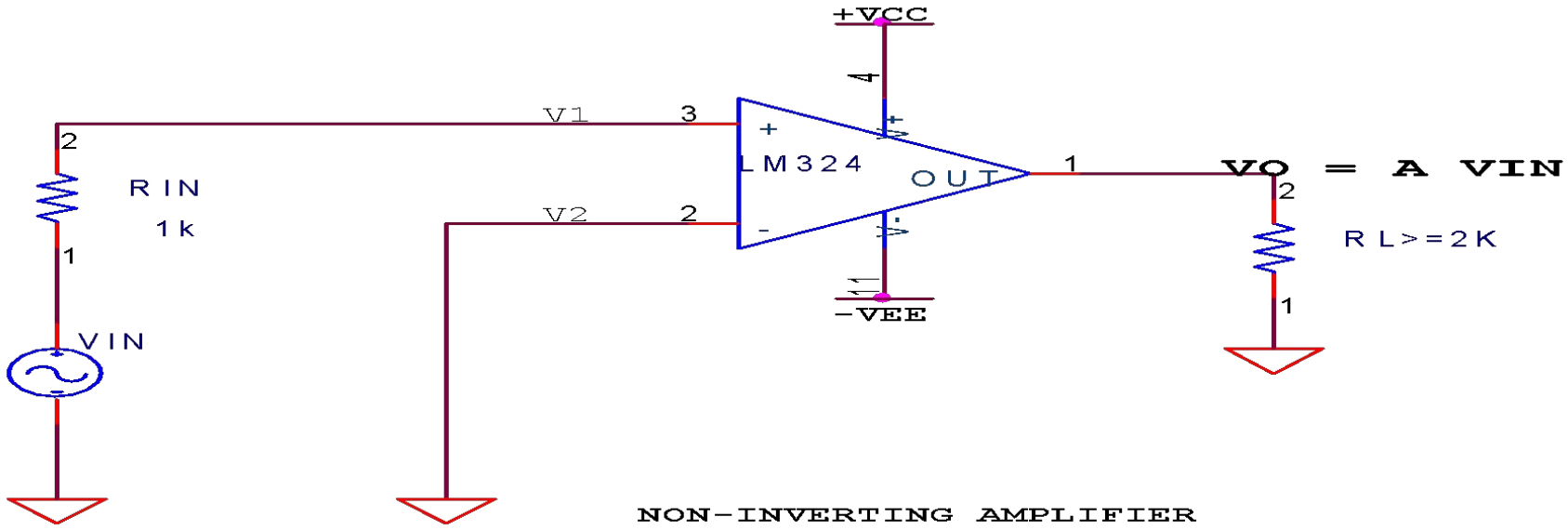
Differential Amplifier



INVERTING AMPLIFIER

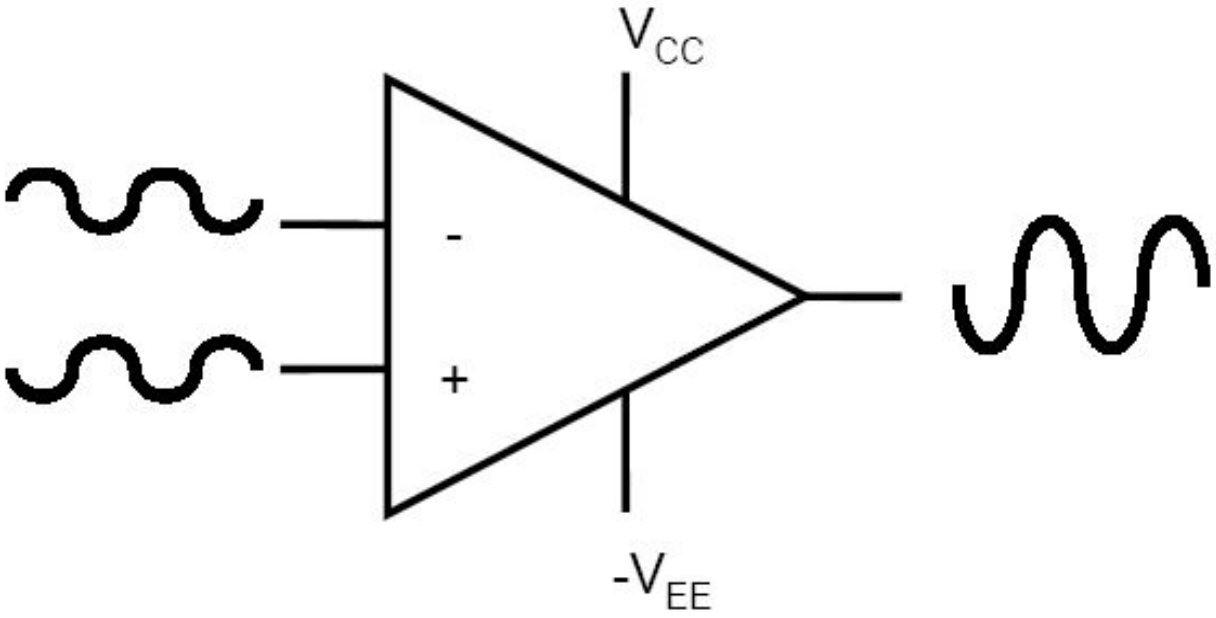


NON-INVERTING AMPLIFIER



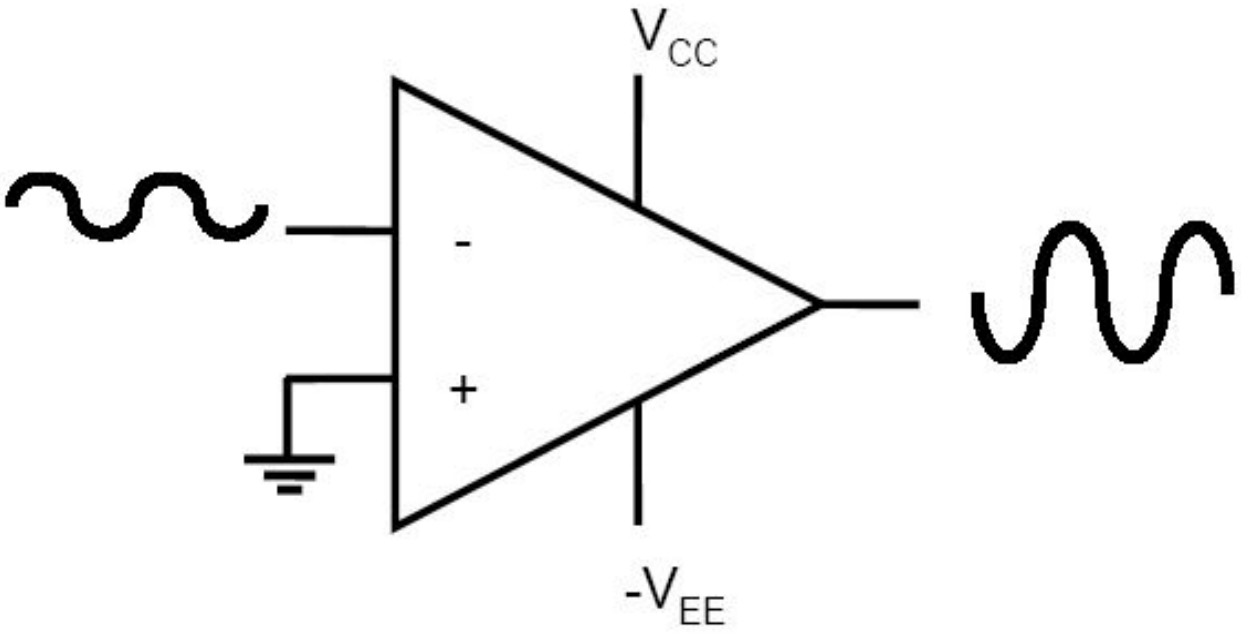
Differential Input Mode

- Both input terminals are used
- Input signals are 180° out of phase
- Output is in phase with non-inverting input



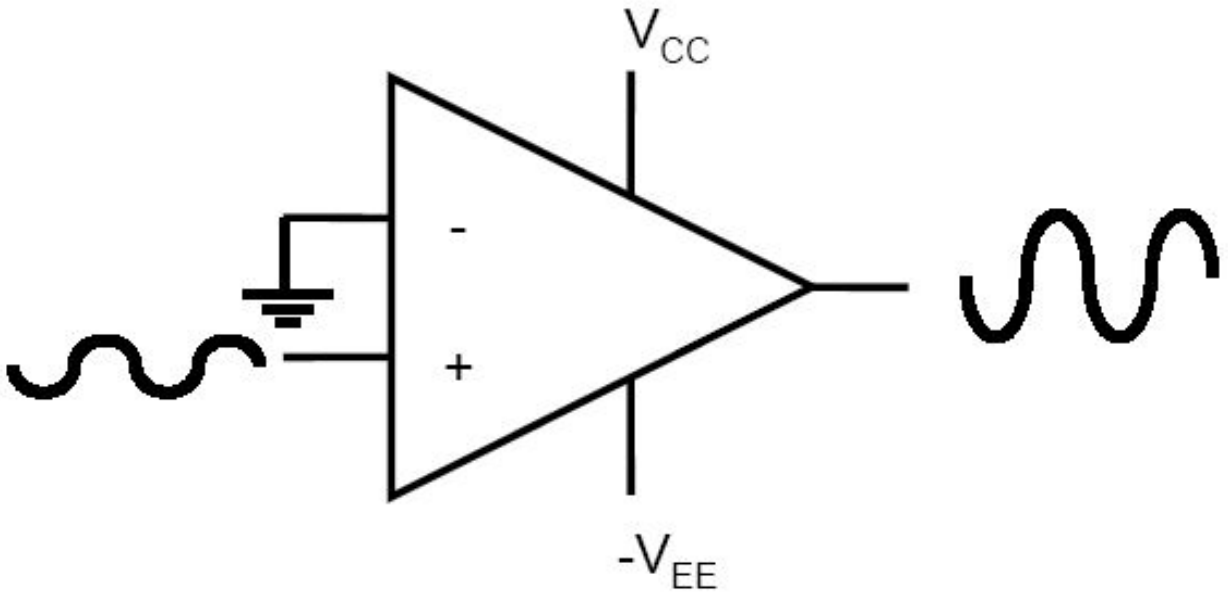
Inverting Mode

- Non-Inverting input is grounded (Connected to mid-supply)
- Signal is applied to the inverting input
- Output is 180° out of phase with input



Non-Inverting Mode

- Inverting Input is grounded
- Signal is applied to the non-inverting input
- Output is in phase with the input



IC 741 OP AMP Pin Diagram