# EE 230 Experiment - 6

Opamp Amplifiers

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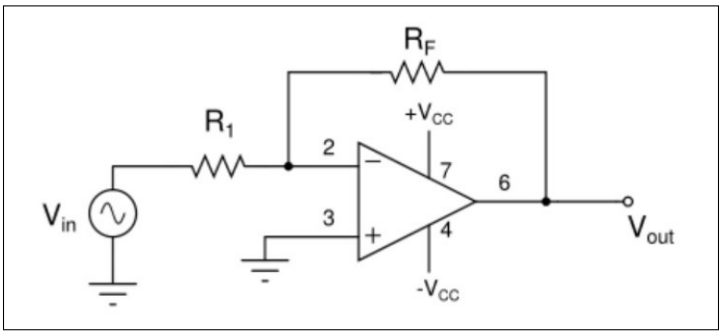
## 2 Inverting Amplifier



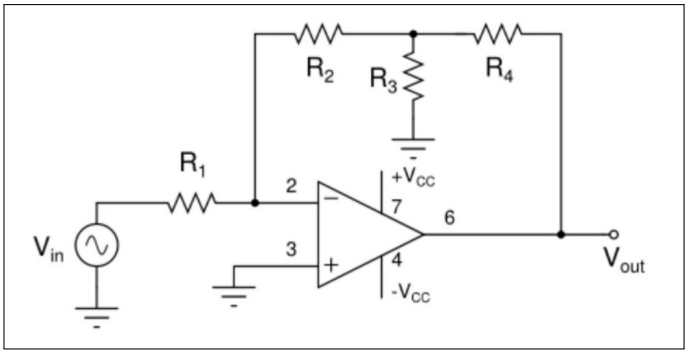

Inverting Amplifier Configuration

$$\frac{V_{out}}{V_{in}} = -\frac{R_F}{R_1}$$

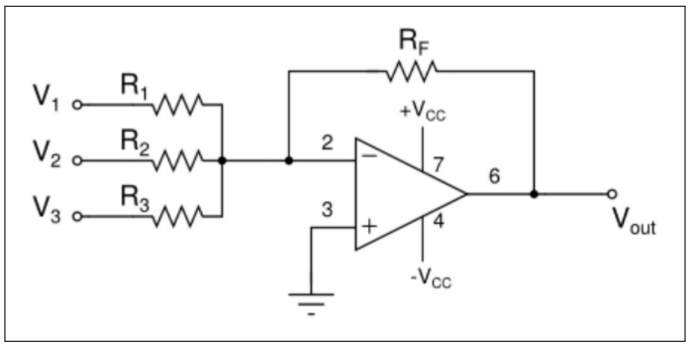
i **What are the unique features of the inverting amplifier as a voltage amplifier (other than the phase inversion between input and output signals)?**
   a No current flows through the input terminal and there is a virtual short between the OpAmp terminals.
   b The closed loop gain depends entirely on external passive components, i.e. the resistors $R_1$ and $R_F$.
   c We get a very stable and predictable system due to negative feedback.

ii **What are the limitations of the inverting amplifier configuration when used as a voltage amplifier?**
Gain-accuracy trade-off: We require a high $R_{in}$ for proper mitigation of signal strength by which gain is limited as $R_{in} = R_1$ gain $= -R_F/R_1$.

iii **For what type of applications are the inverting amplifier configuration well suited? Justify your answer.**
Inverting amplifiers are used in oscillator circuits due to their phase inverting capabilities and in the practical applications of integration.




(a) Special Inverting Amplifier




(b) The Weighted Summer

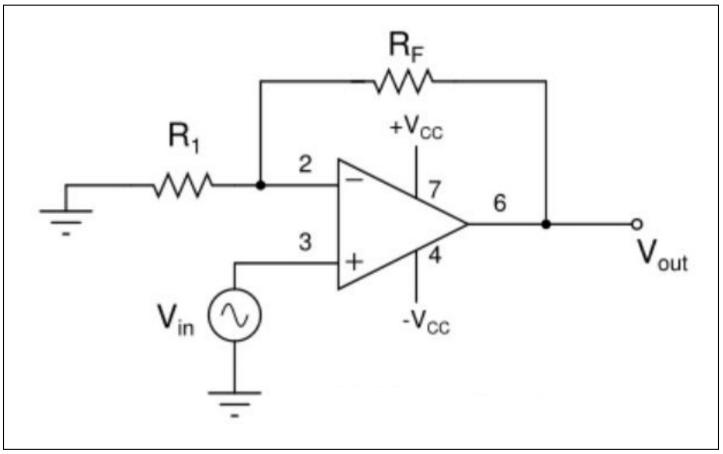
$$\frac{V_{out}}{V_{in}} = -\frac{R_F}{R_1}\left(1 + \frac{R_4}{R_2} + \frac{R_4}{R_3}\right)$$

$$V_{out} = -R_F\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$$

i **What are the advantages of the special inverting amplifier (name two major advantages) over the standard inverting amplifier?**
   a The circuit utilizes lesser resistances than those of a normal inverting amp due to which the use of a high inverting resistance is avoided.
   b The circuit can be used as a current amplifier.

**Learnings:** Learnt the structure, uses, advantages, disadvantages and characteristics of a Inverting Amplifier.

# 3 Non-inverting Amplifier




Non-inverting Amplifier Configuration

$$\frac{V_{out}}{V_{in}} = 1 + \frac{R_F}{R_1}$$

For the same values of $R_F$ and $R_1$, the gain of a non-inverting amp is marginally higher than that of an inverting amp. There is also no phase inversion.

i **What are the unique features of the non-inverting amplifier (other than input and output waveforms having the same phase)?**
   a The voltage gain is always greater than or equal to 1 and positive.
   b The closed loop voltage gain depends entirely on external passive components, i.e. the resistors $R_1$ and $R_F$.
   c $R_{in} = \infty$ and $R_{out} = 0$.

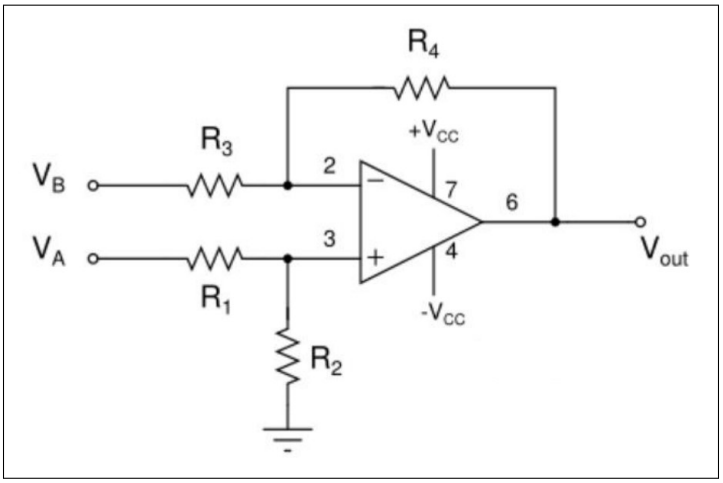
ii **For what application is the non-inverting amplifier configuration best suited? Justify your answer.**
It is used in Voltage Follower, Power Amplifier, Impedance Transformer etc. because of its precise output characteristics.

iii **What are the limitations of the non-inverting amplifier configuration?**
   a The input signal range is limited by the OpAmp's common-mode input voltage range.
   b The amplifying circuit has no virtual ground and therefore has a large common mode voltage, and the anti-interference ability is relatively poor. So, the Opamp requires a higher common mode rejection ratio.
   c The amplifier can only amplify signals upto the range of +Vcc to -Vcc. Beyond this range, we may lose information.

## Learnings:

Learnt the structure, uses, advantages, disadvantages and characteristics of a Non-inverting Amplifier.

# 4 Difference Amplifier




Difference Amplifier Configuration

In order for the circuit to work with a differential gain, $A_d = R_4/R_3$, the following condition has to be satisfied:

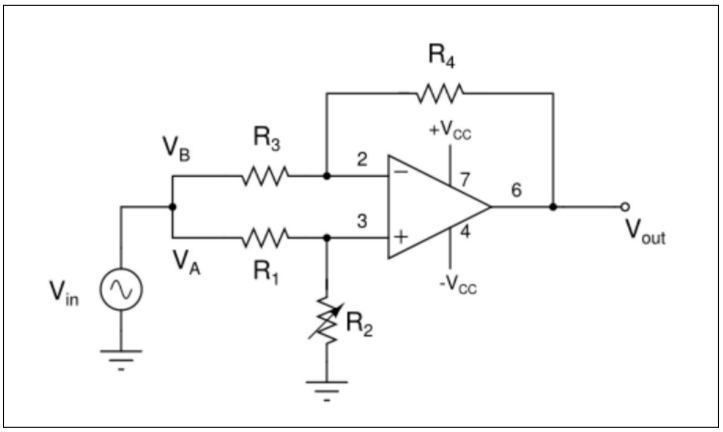
$$\frac{R_4}{R_3} = \frac{R_2}{R_1}$$

Then, we get the output voltage as:

$$V_{out} = (V_A - V_B)\frac{R_4}{R_3}$$

Difference amplifier is used to amplify small differences between the input signals.

## 4.1 Measurement of Common-mode Gain, $A_{cm}$

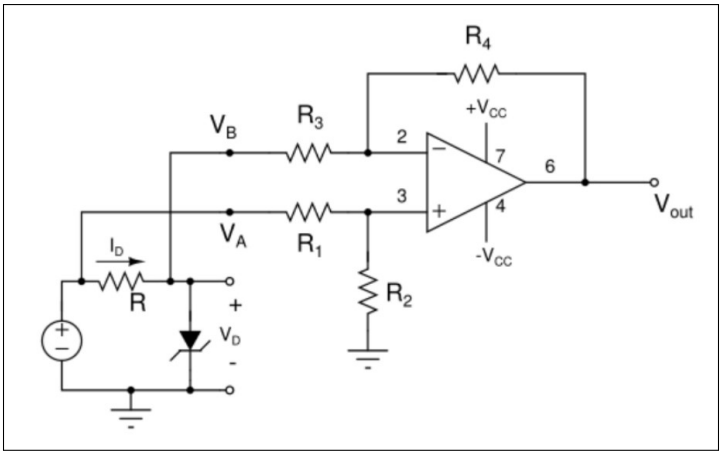



Measurement of Common-mode Gain, $A_{cm}$

i **What are the unique features of the difference amplifier which are useful in field applications?**
   a The gain can become unity if all the resistors become equal ($R_1 = R_2 = R_3 = R_4$). $V_{out}$ then becomes $V_2 - V_1$.
   b Single OpAmp Difference Amplifiers are used to design the more accurate Instrumentation Amplifier, which is used to amplify very small differential signals from strain gauges, thermocouples or current sensing devices in motor control systems.

ii **What are the limitations of the single-opamp difference amplifier? Name two such limitations.**
   a The input impedances are lower compared to other OpAmp configurations.
   b Each input voltage source has to drive current through an input resistance, which has less overall impedance than that of the op-amps input alone. This may be good for a low impedance source such as a bridge circuit, but not so good for a high impedance source.

## 4.2 I-V Characteristics of a Zener Diode




I-V Characteristics of a Zener Diode

With the given circuit values, the difference amplifier output:

$$V_{out} = (V_A - V_B) = I_D R$$

Since $R = 1\ k\Omega$, the magnitude of $V_{out}$ in *volts* will be same as that of $I_D$ in $mA$.

i **Explain why a triangular (ramp) signal is used in the diode circuit. What would happen, if instead of the triangular signal a sinusoidal waveform or a square waveform (with the same peak amplitude) is used?**
The triangular ramp is used because of its linear nature. It becomes very easy to plot $V_{out}\ vs\ V_{in}$.
If we used non-linear Sine or a Square Wave, the output would be less comprehensible.
The Square Wave would also give a delayed output because of the OpAmp's slew rate as the wave consists of frequencies from 0 to $\infty$.

ii **Why is the frequency of the triangular wave kept between 100 Hz to 1 kHz? What would happen if the frequency is made 10 kHz or 20 kHz?**
If we increase the frequency, the capacitor impedance in the Zener diode becomes significant.

iii **Why are the cut-in voltages of the LEDs very different from that of a Si/Ge diodes, and also different for each different LED?**
Cut-in voltages are different for LEDs and Si-Ge diode as they are made of different materials and hence have different doping densities.

## Learnings:

Learnt the structure, uses, advantages, disadvantages and characteristics of a Difference Amplifier.

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