EE 204 - Analog Circuits
Lecture 13

Harsh S Roniyar

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Contents

1 Operational Amplifier (OpAmp)

In this lecture, we continued our discussion on the Operational Amplifier or the OpAmp, with further emphasis on the integrator and differentiator circuits. We went on to revise some previous configurations of the OpAmp, and we revised the circuit diagrams for the inverting and non – inverting amplifier, along with the unity gain buffer as well. We also revised the pin numbers on an actual OpAmp and what was each pin used for.

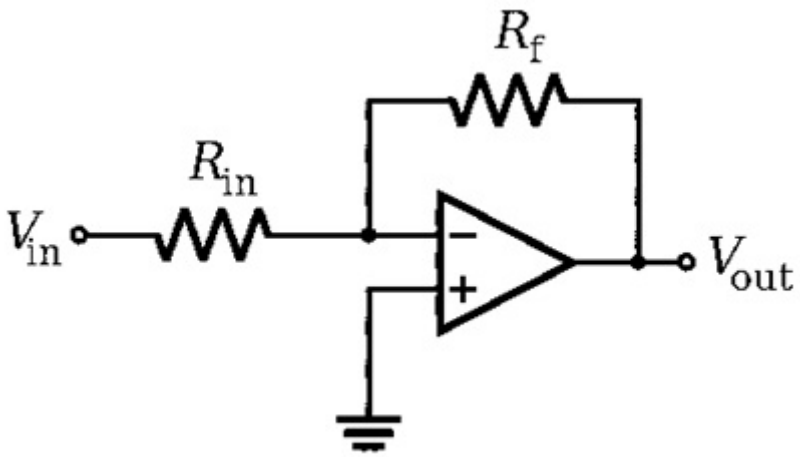


Figure 1: Inverting Amplifier

In this type of amplifier, the output (o/p) is precisely 180° out of phase to the input (i/p). When a positive voltage is applied to the circuit, then the o/p of the circuit will be negative.

If the amplifier is assumed as ideal, then we apply the **Virtual Short** concept at the i/p terminals of the op-amp. So the voltage at the two terminals is equivalent.

Then, by applying KVL/KCL at the terminals, we get open-loop gain

$$A_v = -\frac{R_f}{R_{in}}$$

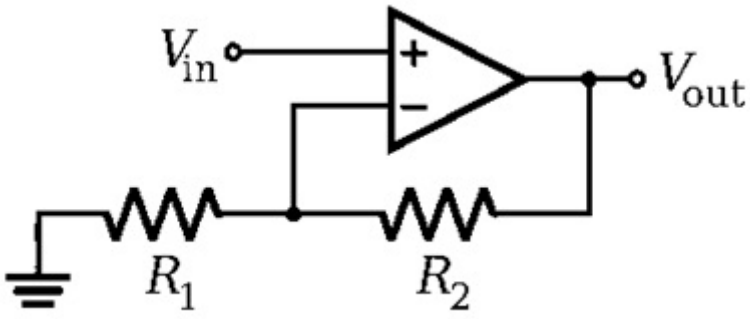


Figure 2: Non-Inverting Amplifier

In a non-inverting amplifier, we connect the voltage source to the non-inverting / positive terminal, leaving the rest of the circuit same as before.

So, in this kind of amplifier, the output is exactly in phase to input. When a positive voltage is applied to the circuit, then the o/p will be positive. The o/p is non-inverted in terms of phase.

Then, by applying KVL/KCL at the terminals, we get open-loop gain

$$A_v = 1 + \frac{R_2}{R_1}$$

2 Three Stage Instrument Amplifier

We continued our discussion and focused on how we could create manifold amplification. This was possible using an OpAmp ladder, which used multiple OpAmps such that the output of the previous OpAmps in the ladder, were fed as inputs to another OpAmp, thus producing much much more amplification as than a single OpAmp. We analysed the circuit for a 3 step ladder.

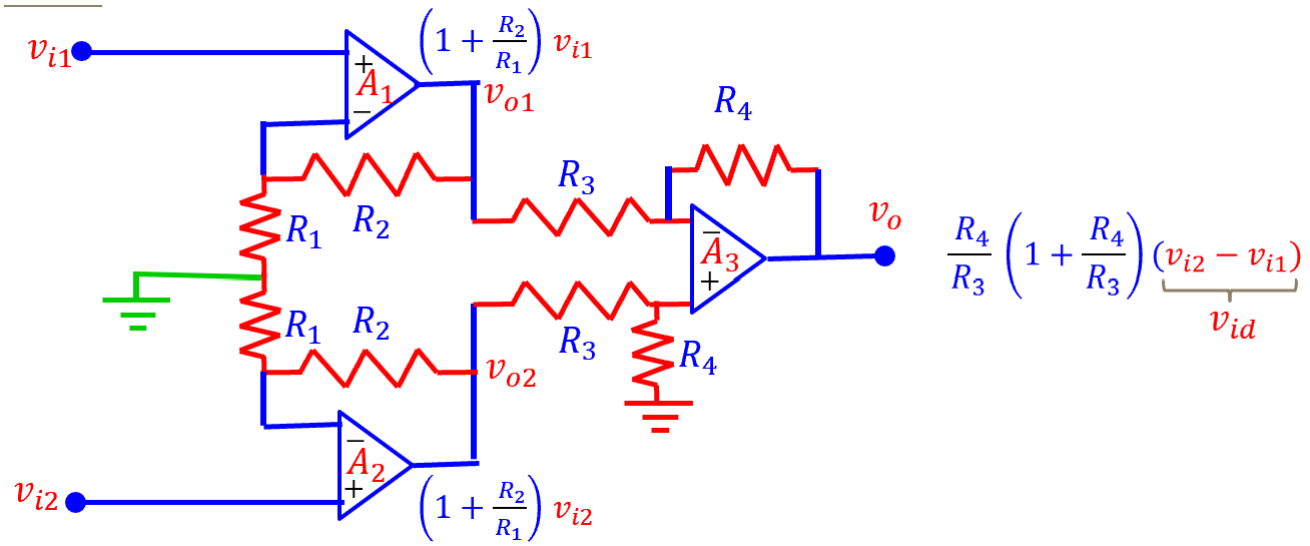


Figure 3: Three Stage Instrument Amplifier

This is used for exponential amplification, as we observe that the final amplification consists of the multiple of the gains of both the OpAmps, the ones on the previous step of the ladder and the final OpAmp.

2.1 Properties and Uses of Three Stage Instrument Amplifier

- R_{in} is infinite
- Cascaded Amplifier hence large gain
- Very large common mode gain
- Opamps A_1 and A_2 can be saturated
- A_3 has to handle large i/p
- Eliminate green ground connection
- Eliminate common mode at A_1 and A_2
- Commonly used as instrumentation amplifier single chip for matching of components

3 Integrator

We moved on to the integrator circuit, where we attached a capacitor between the output and the inverting input, hence creating an integrator.

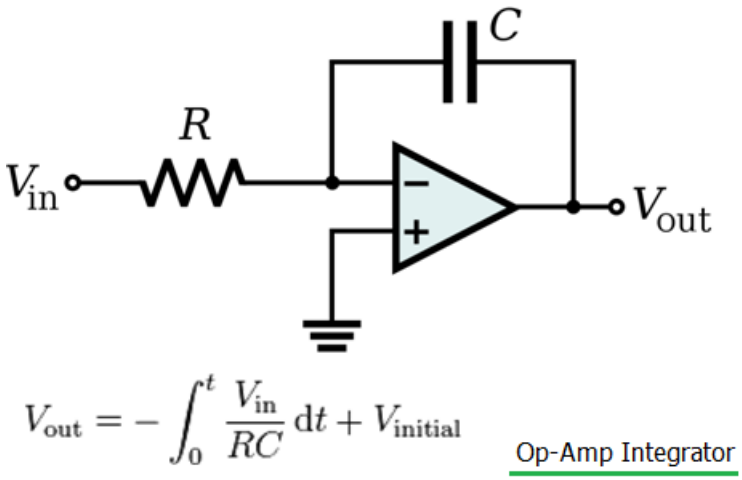
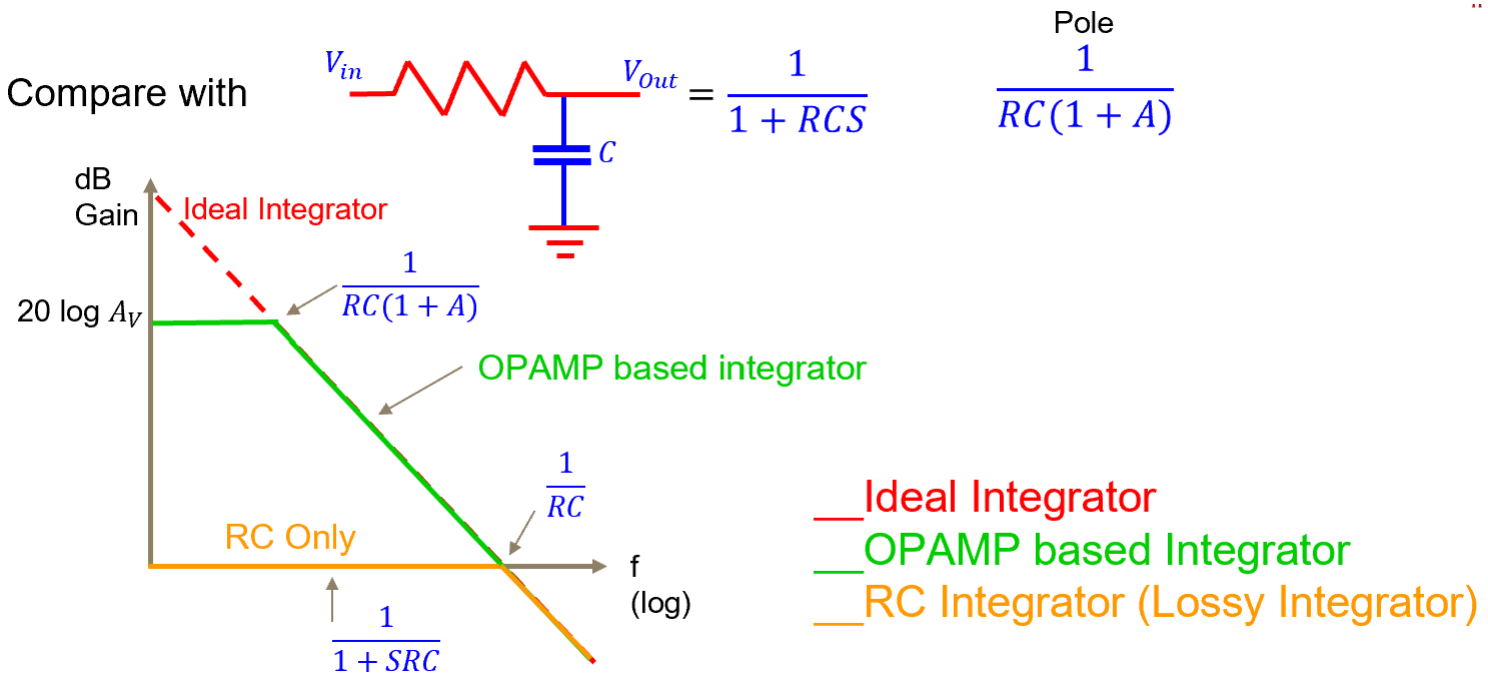


Figure 4: Integrator

We also studied about the different graphs between the gain of the integrator and the frequency, for different devices like the ideal integrator, the OpAmp based integrator and the RC integrator. We compared between these devices using the following graphs.



4 Differentiator

We moved on to the differentiator circuit, where just interchanging the locations of the capacitor and the resistor R changes the circuit from integrator to differentiator.

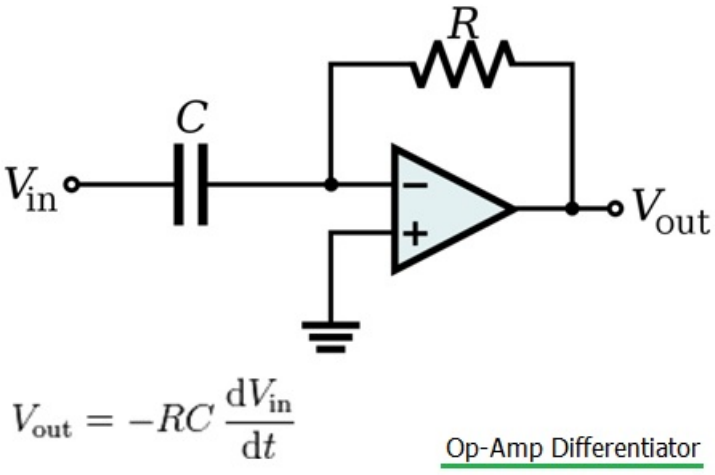


Figure 5: Differentiator

Even for the differentiator we studied various graphs between the gain and the frequency so as to study the frequency response on the gain. We again performed the same comparative study between an ideal differentiator, the OpAmp differentiator and the RC differentiator.