EE230 - Experiment 6

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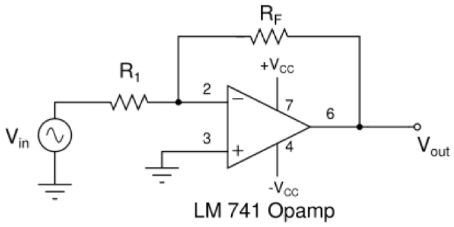
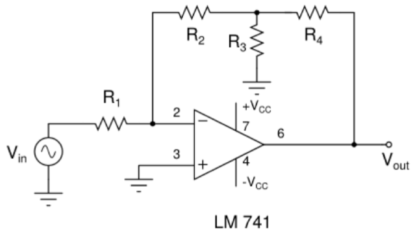
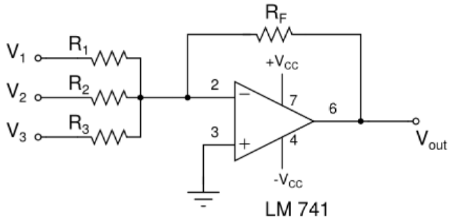
1 Inverting Amplifier



(a) Inverting amplifier



(b) A special type of inverting amplifier



(c) Weighted-summer circuit

1.1 Inverting Amplifier (as a Voltage Amplifier)

1.2 Questions

i) What are the unique features of the inverting amplifier as a voltage amplifier (other than the phase inversion between input and output signals)?
→ Very low output resistance because of negative feedback.
→ Input resistance = R_1 not very high.
→ Phase inversion between input and output signals.
ii) What are the limitations of the inverting amplifier configuration when used as a voltage amplifier?
→ Low input resistance.
→ Low voltage gain if input resistance is made high.
→ Lower bandwidth than non-inverting amplifier
Explanation: A voltage amplifier needs higher input resistance but R_{out} can't be increased more than (say $10M\Omega$) due to op-amp non-ideal currents, So by using higher R_{in} (input resistance), gain is limited.
iii) For what type of applications are the inverting amplifier configuration well suited? Justify your answer.
→ Inverting amplifier is well suited for current amplifier.
Explanation: This is because of low input resistance (= R_1 can be made small)
→ Inverting amplifier is well suited for weighted summing of signals.

1.3 A Special Inverting Amplifier (with Higher Input Resistance and Voltage Gain)

1.4 Questions

i) What are the advantages of the above amplifier circuit (name two major advantages) over the standard inverting amplifier?
→ High input resistance possible so, well suited for voltage amplifier.
→ High voltage gain possible (with suitable resistor ranges)
Explanation: Say $R_1 = R_2 = 1M\Omega$, then $R_3 = 1\Omega, R_4 = 100\Omega$ gives approximately -100 gain while the standard inverting amplifier if $R_1 = 1M\Omega$ then $R_2 = 100M\Omega$ for gain $= -100$

1.5 The Weighted Summer

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

→ Contribution of a signal is independent of other signal to combine.
→ High gain possible
→ Easy to design, simple expression

1.6 Learnings

Understood the inverting amplifier and it's characteristics.

2 Non-inverting Voltage Amplifier

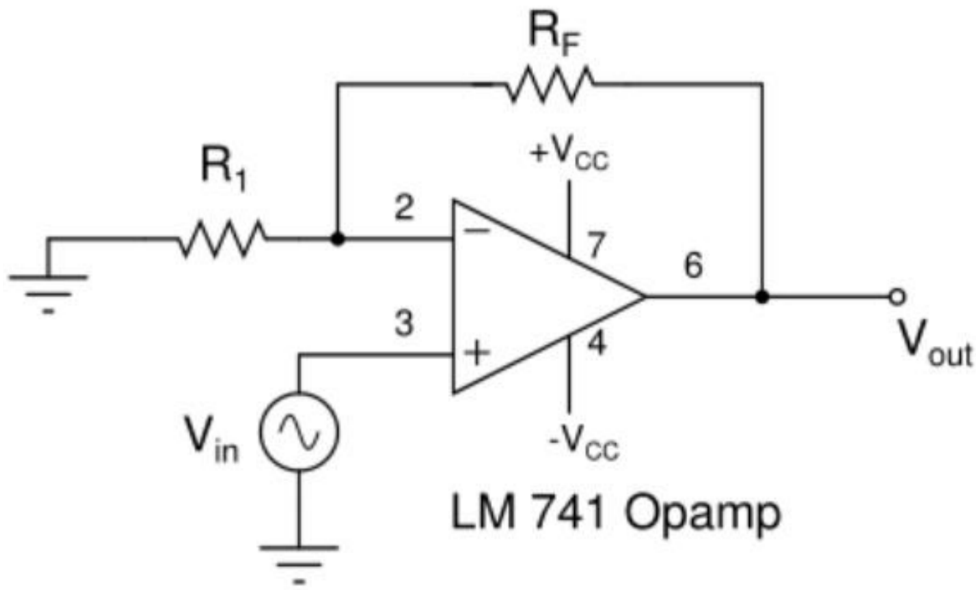


Figure 2.1: Non-Inverting Voltage Amplifier

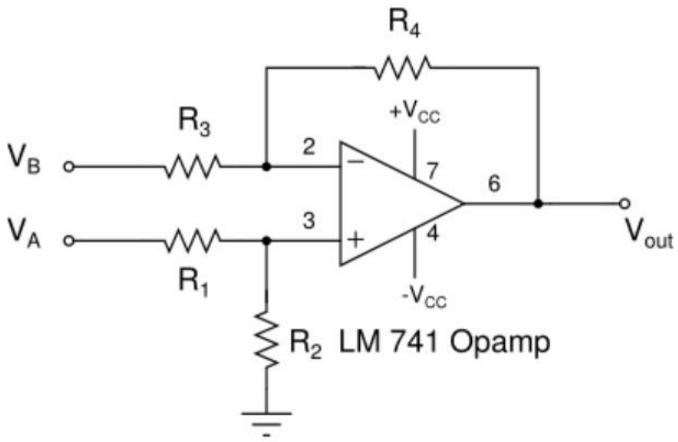
2.1 Questions

i) What are the unique features of the non-inverting amplifier
(other than input and output waveforms having the same phase)?
→ Gain is always greater than 1.
→ Very low output resistance because of negative feedback.
→ Very high input resistance because of feedback.
→ Higher bandwidth than inverting amplifier
ii) For what application is the non-inverting amplifier configuration best suited? Justify your answer.
→ Suited for voltage amplification.
→ Suited for voltage divider.
→ Suited for voltage follower.
Explanation: High input resistance already, So gain is just $1 + \frac{R_F}{R_1}$
iii) What are the limitations of the non-inverting amplifier configuration?
→ Clipping of output voltage can occur due to High Gain
→ Less stability than inverting amplifier, higher noise gain
→ CMRR limitations due to common-mode signal (absent in inverting amplifier)
→ No Phase inversion between input and output signals.

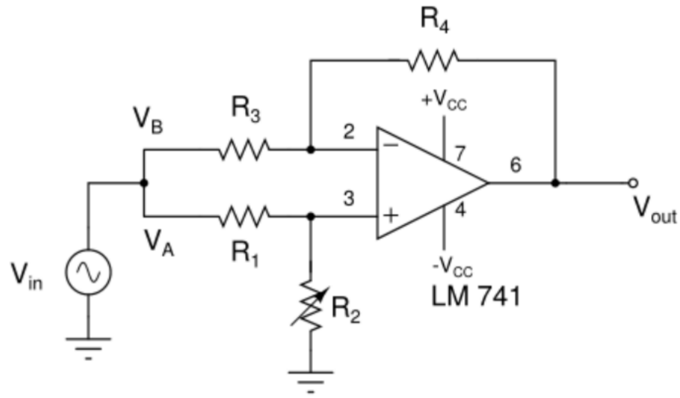
2.2 Learnings

Understood the non-inverting amplifier and it's characteristics.

3 Difference Amplifier



(a) Single-opamp difference amplifier



(b) Setup for measuring A_{cm} of the difference amplifier

3.1 Difference Amplifier

For this circuit to work as Difference Amplifier, $\frac{R_4}{R_3} = \frac{R_2}{R_1}$. the differential gain will be $A_d = \frac{R_4}{R_3}$

3.2 Questions

i) What are the unique features of the difference amplifier which are useful in field applications? → High differential gain and Low common mode gain (ideally 0). So, it is used for common mode rejection (High CMRR)
→ Noise Suppresion has applications in media. Example: volume control, amplitude modulation
→ Very low output resistance.
→ High bandwidth.
ii) What are the limitations of the single-opamp difference amplifier? Name two such limitations.
→ For very high differential gain $\left(\frac{R_4}{R_3}\right)$, the input resistance R_3 will be low.
→ Difficult to change differential gain.

3.3 Learnings

Understood the differential amplifier and it's characteristics.
Understood, the measurement of A_{cm}.

4 Difference Amplifier - Applications

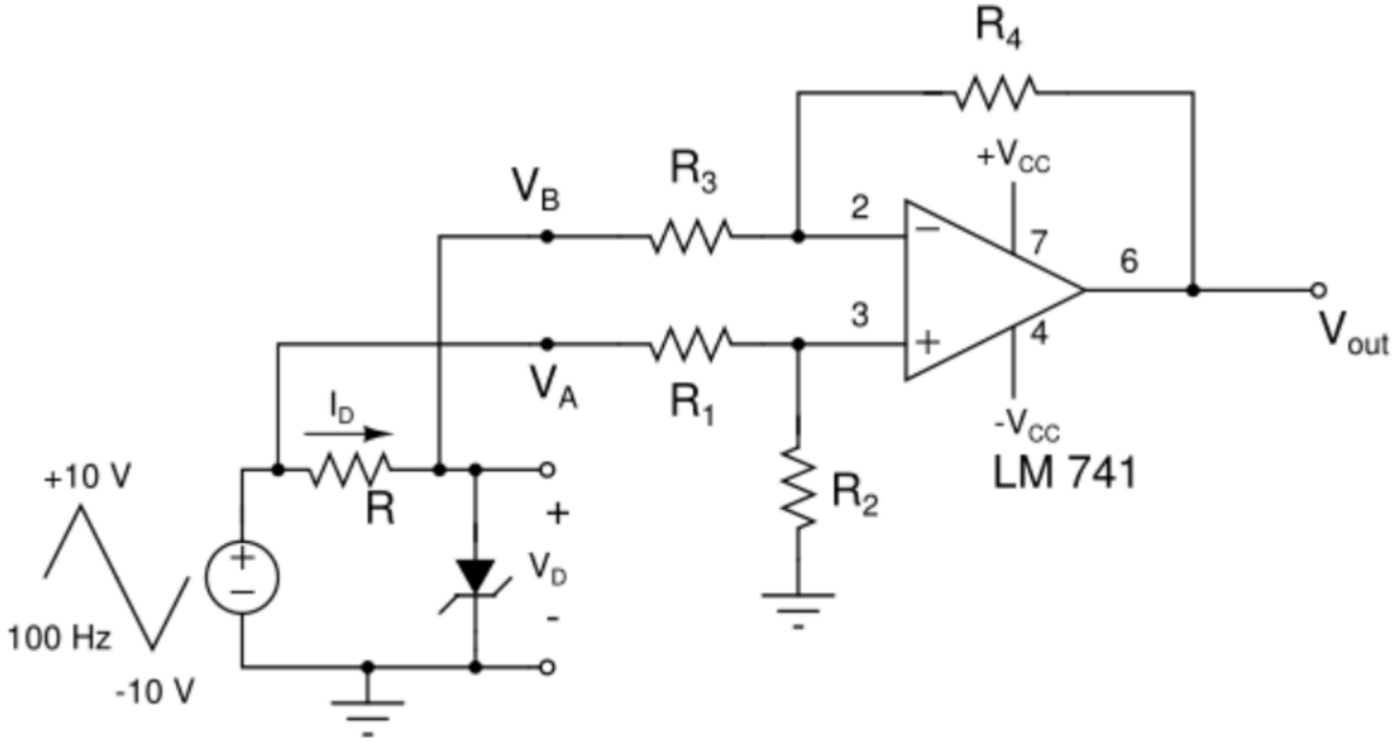


Figure 4.1: Setup for measuring the I-V characteristic of the Zener diode

4.1 Questions

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?
→ We need linear x-y axis to get correct characteristic plot (like a graphsheet).
Here are x-axis is voltage, So the input voltage should be linear like a ramp signal.
If we instead use a square waveform then we will only have current values for peak magnitude voltages for other voltages, the variation in current would be imperfect due to high slope (sudden change in voltage).
For a sinusoidal waveform as voltage isn't linear the values of current will be some complication function of voltage and difficult to grasp.
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?
→ At higher frequencies, internal capacitances of diodes come into the picture. These capacitors can't change voltage around them fast enough. This phenomenon is captured in **slew rate**. So, the frequency must be less than slew rate of differential amplifier.
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?
→ The difference in cut-in voltages arises from difference in built-in voltages of LEDs and from difference in band gap of Si/Ge diodes.

4.2 Learnings

Learnt the applications of differential amplifiers and devices concepts.