Operational Amplifiers

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Introduction and Aim

In this lab, we will use the 741 operational amplifier (op-amp) to demonstrate its versatility in various electronic applications. The 741 op-amp is one of the most widely used op-amps due to its reliability and ease of use in both analog signal processing and control systems. Throughout the experiment, we will explore its fundamental properties and characteristics, such as voltage gain, input impedance, and output voltage swing.

Experimental Method and Result

The 741 Operational Amplifier (opamp) is a high gain voltage amplifier. The inputs to the amplifier consist of $V+$ (non-inverting input) and a $V-$ (inverting input). The main properties of the 741 op amp are:

- High open-loop gain: $A_o \approx 2 \times 105$
- Unity gain bandwidth: $B \approx 2 \times 106Hz$
- High input impedance: $Z_i \approx 106\Omega$
- Low output impedance: $Z_o \approx 100\Omega$

part1: Non-inverting operational amplifier in open loop configuration

In this part, we establish a basic open-loop amplification circuit, using a 12V DC power supply to power the operational amplifier: connect the positive terminal to pin 7 and the negative terminal to pin 4. The operational amplifier is connected in an open-loop configuration, and a DC power supply provides +5V while appropriately grounding the circuit.

Next, we will measure the voltage values of V_cc+ and V_cc-, and record the positive saturation voltage. Then, we will change the input power to -5V and compare the positive voltage values, noting the differences between V_cc+ and V_cc-.

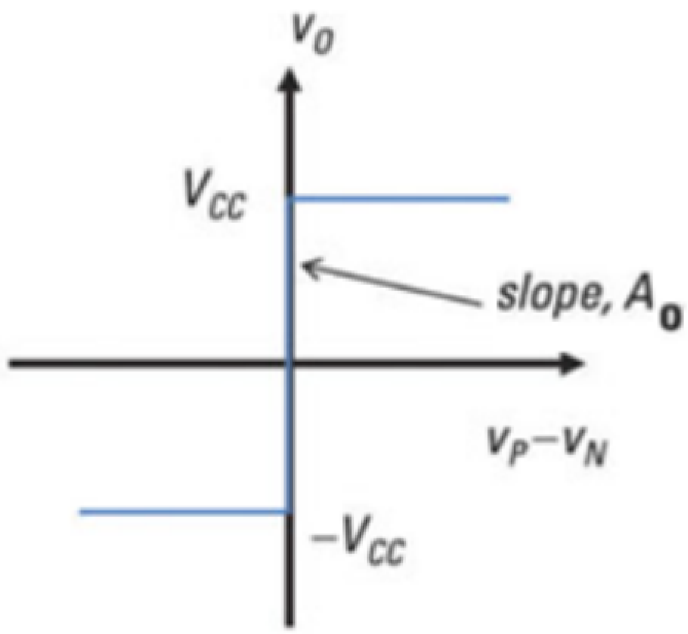
Theory

The output voltage of the op-amp is given by the equation:

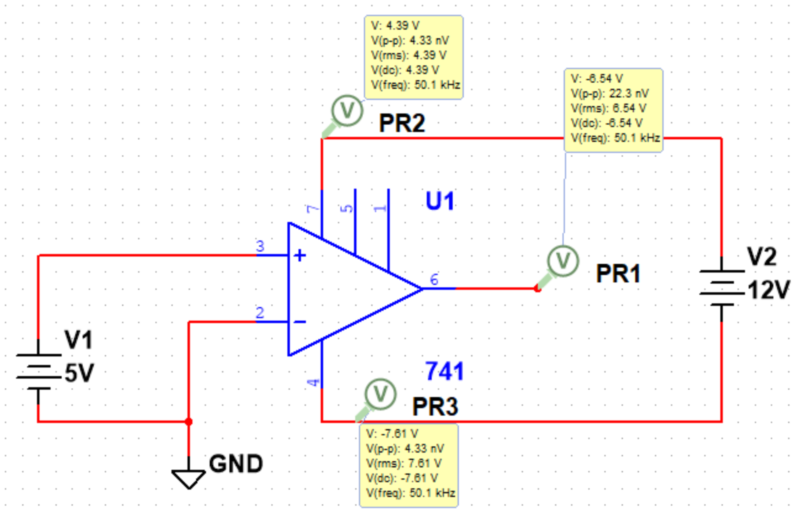
$$V_o = A_v(V_+ - V_-) = A_v \cdot V_d$$

where: V_+ is the voltage at the non-inverting terminal, V_- is the voltage at the inverting terminal A_o is the open-loop gain of the amplifier V_d is the differential input (i.e. $V+ - V-$) $V_cc+$is +12V power input $V_cc-$is -12V power input

When the op-amp is on open-loop configuration, due to the very high open loop gain of the amplifier there is a very limited linear region. The higher the gain of the amplifier, the larger the slope of the linear region and the closer the line becomes to a vertical as shown below.



circiut Diagram



At positive saturation the output voltage produce approaches the maximum positive supply voltage V_cc+. At negative saturation the output voltage produce is close to the maximum negative voltage V_cc-.

data table

input value	V_cc+	V_cc-	positive saturation voltage	negative saturation voltage
5	4.39	-7.61	11.4	None
-5	-0.61	-12.6	None	-11.5

We can observe that both the positive saturation voltage and the negative saturation voltage are close to the supply voltage value of 12V.

part2: Negative feedback non-inverting voltage amplifier

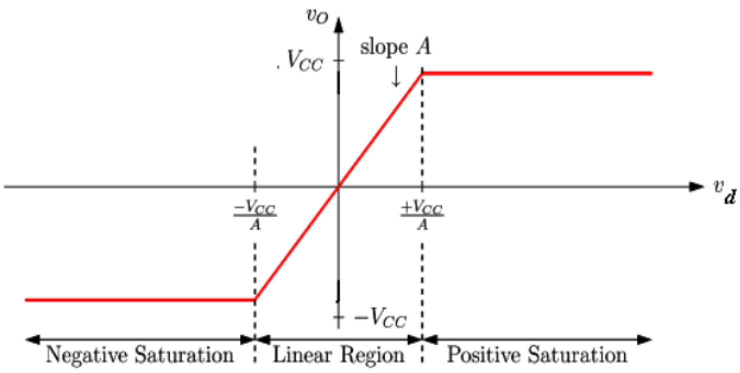
In this section, we construct a non-inverting feedback operational amplifier circuit. This type of circuit is designed with a feedback loop that connects the output to the inverting input, which stabilizes and controls the gain of the amplifier.

The focus of this setup is to study the voltage transfer characteristics of the circuit, particularly how the feedback mechanism affects the relationship between the input voltage and the output voltage. By introducing feedback, the circuit achieves a more controlled and predictable operation within the linear region. This is because the gain of the amplifier is significantly reduced compared to an open-loop configuration, making the circuit less sensitive to small variations in the input voltage.

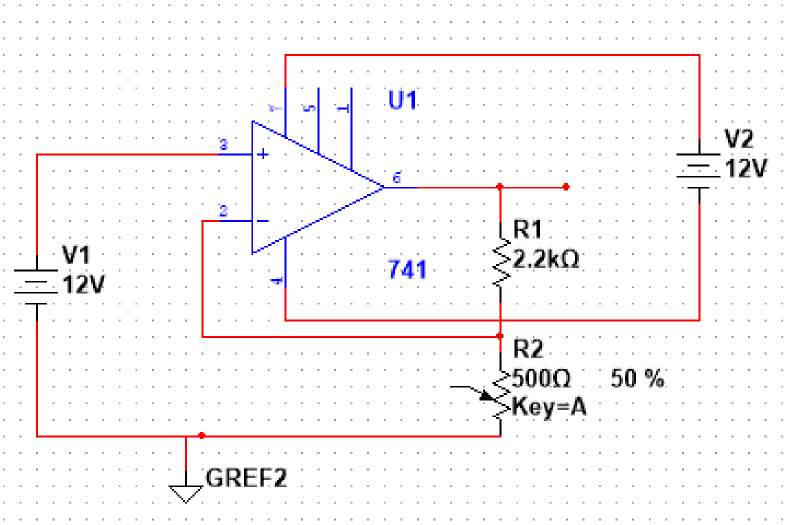
Theory

Negative feedback is a fundamental concept in operational amplifier (op amp) circuits that enhances stability, precision, and bandwidth. In a non□inverting voltage amplifier, negative feedback ensures that the output voltage closely tracks the input signal while maintaining high gain and minimal distortion. This configuration amplifies the input without inverting its phase and provides advantages such as reduced sensitivity to component variations, improved linearity, and controlled gain. By applying feedback, the amplifier becomes more stable, with predictable behaviour, and operates effectively across a wide range of frequencies, making it ideal for signal amplification in precision applications.

The voltage transfer characteristic (V_o versus V_i) for a negative feedback non-inverting op amp is shown below in Figure 2. It shows an increased linear region due to the reduction in gain. The feedback section consists of R_f a fixed resistor in series with avariable resistor R_g. The addition of the variable resistor in series with the fixed resistor allows the feedback section to be varied between and thus allow control over the gain of the amplifier.



Circuit Diagram



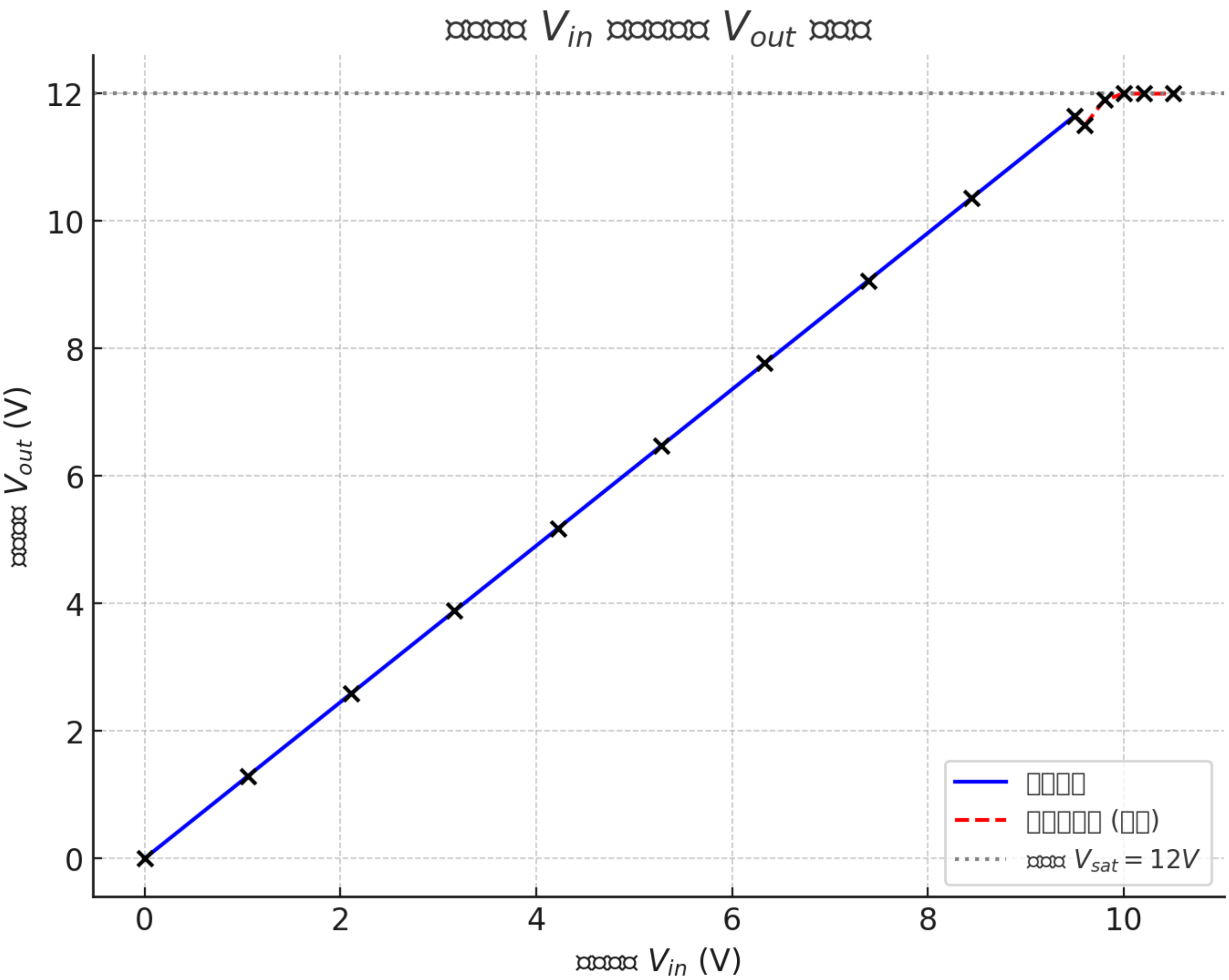
Data table

When the circuit work in the linear area:

&R_g	V_o	V_-
500	0.665	0.5
460	0.665	0.55
340	0.809	0.7
260	0.894	0.8
180	0.974	0.9
140	1.011	0.95

When the circuit works in the non-linear area:

V_in	**$V_out**
9.6v	11.5
9.8v	11.9
10.0v	11.9
10.2v	11.95


V_{in}
V_{out}
V_{out} (V)
V_{in} (V)
0
2
4
6
8
10
12
0
2
4
6
8
10
$V_{sat} = 12V$