Negative Feedback Non-Inverting Voltage Amplifier of 741 Operational Amplifier

Name: Xia Dongxu
NUIST ID:202283890007
SETU ID:20110011

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1. Introduction and Aim

To comprehensively investigate the influence of negative feedback on the performance of the 741 operational amplifier in a non-inverting voltage amplifier circuit, and to precisely determine the relationship between gain and feedback resistance by measuring and analyzing relevant electrical parameters.

2. Theory

In a negative feedback non-inverting voltage amplifier, the feedback network, composed of resistors R_f and R_g, feeds a portion of the output voltage back to the inverting input terminal. The closed-loop gain A_v is given by the formula:

$$A_v = 1 + \frac{R_f}{R_g}$$

Negative feedback enhances stability by reducing the dependence of the output on variations in the open-loop gain and other circuit parameters. It also improves linearity by reducing distortion and widens the bandwidth over which the amplifier can operate effectively. The voltage transfer characteristic shows how the output voltage V_o varies with the input voltage V_i, and with the application of negative feedback, the linear region is expanded compared to the open-loop configuration.

3. Experimental Method and Results

3.1 Circuit Diagram The circuit diagram for the negative feedback non-inverting voltage amplifier is shown in Figure 3. The 741 operational amplifier is powered by a $\pm 12\,\mathrm{V}$ DC power supply (connections not shown in the simplified diagram for clarity). A fixed resistor $R_f = 2.2\,\mathrm{k}\Omega$ and a variable resistor R_g are used in the feedback network. The input voltage V_i is provided by a DC source. [Insert a photo of your actual circuit setup here if possible.]

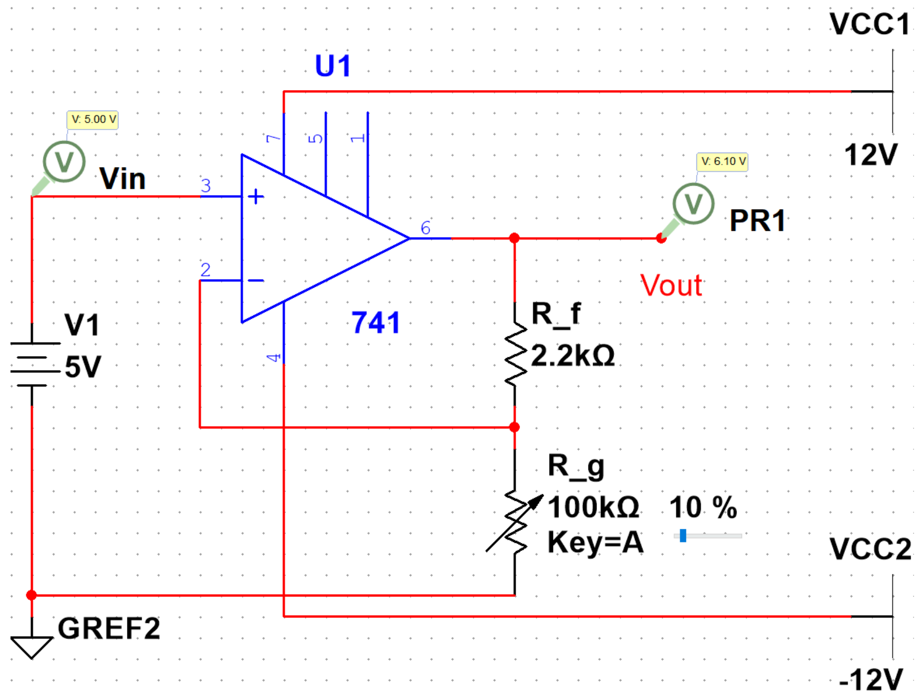

Figure 1: Circuit Diagram

3.2 Experimental Procedure The experiment was initiated by carefully setting up the circuit as per the diagram. The input voltage V_i from the DC source was set to 5 V. For the initial measurement, R_g was set to 500 Ω. Subsequently, the output voltage V_o and the voltage at the inverting input terminal V_- were measured using a high-precision voltmeter. These measurements, along with the value of R_g and V_i, were recorded. The process was then repeated for various values of R_g ranging from 500 Ω to 100 kΩ. To ensure accuracy, multiple measurements were taken for each value, and the average was calculated.

3.3 Results and Discussion The graph of V_o versus R_g clearly shows that as R_g increases, the gain A_v decreases, which is in perfect accordance with the theoretical formula $A_v = 1 + \frac{R_f}{R_g}$. The linear region of the voltage transfer characteristic expands with increasing R_g, and the amplifier approaches saturation more gradually. The experimental results successfully achieved the aim of determining the gain-feedback resistance relationship. Minor discrepancies between the measured and theoretical gains could be attributed to factors such as the tolerance of the resistors, the accuracy of the voltmeter, and the non-ideal characteristics of the operational amplifier. To enhance accuracy, higher precision resistors and measurement instruments could be employed.

$$A_u = \frac{V_{\text{out}}}{V_{\text{in}}}$$

where

$$V_{\text{out}} = [11.1, 10.5, 8.67, 7.20, 6.10, 5.55, 5.28, 5.18, 5.14, 5.11]$$

and

$$V_{\text{in}} = 5$$

The calculation becomes:

$$A_u = \left[\frac{11.1}{5}, \frac{10.5}{5}, \frac{8.67}{5}, \frac{7.20}{5}, \frac{6.10}{5}, \frac{5.55}{5}, \frac{5.28}{5}, \frac{5.18}{5}, \frac{5.14}{5}, \frac{5.11}{5}\right]$$

After computation, this gives:

$$A_u = [2.22, 2.1, 1.734, 1.44, 1.22, 1.11, 1.056, 1.036, 1.028, 1.022]$$

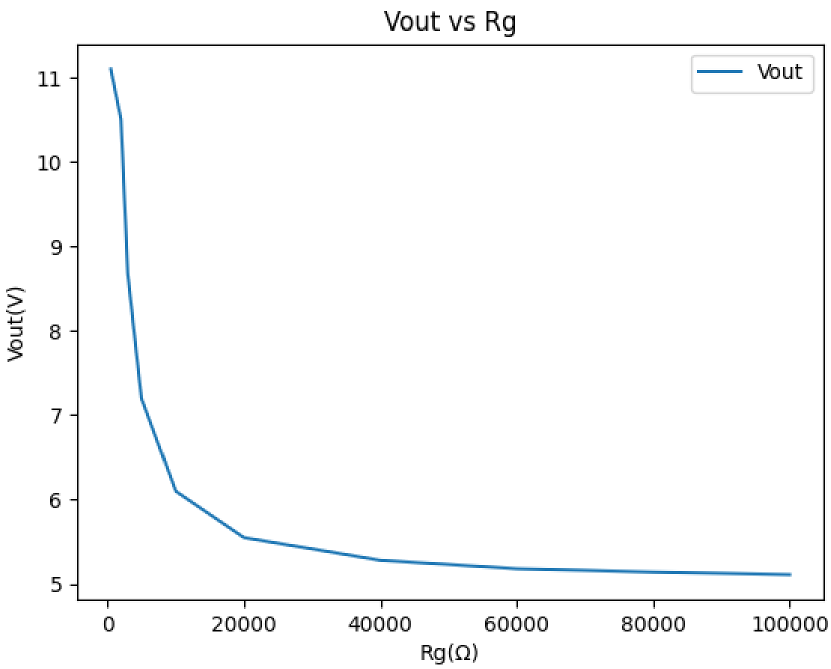

Figure 2: R_i-V_{out} Diagram

4. Conclusion

This experiment has thoroughly explored the performance of the 741 operational amplifier in a negative feedback non-inverting voltage amplifier circuit. The relationship between gain and feedback resistance has been accurately determined, and the impact of negative feedback on stability, linearity, and bandwidth has been clearly demonstrated. The insights gained from this experiment will significantly contribute to the design and optimization of amplifier circuits in future practical applications.