Experiment Report on Open-Loop Characteristics of 741 Operational Amplifier

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

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1 Introduction and Aim

The experiment aims to investigate the input-output characteristics and saturation voltage conditions of the 741 operational amplifier in an open-loop configuration, thereby deeply understanding its working principle.

2 Theory

The 741 operational amplifier is a high-gain voltage amplifier. The output voltage formula is $V_o = A_o(V_+ - V_-)$, where A_o is the open-loop gain (approximately 2×10^5). In the open-loop state, due to the high gain, the linear region is extremely narrow. A slight change in the input will cause a large change in the output. When saturated positively and negatively, it approaches V_{cc_+} (+12V) and V_{cc_-} (-12V) respectively. These characteristics determine its response characteristics to the input signal and the output range limitation in the open-loop state, providing a theoretical basis for measuring the saturation voltage and analyzing the difference from the power supply voltage in this experiment.

3 Experimental Method and Results

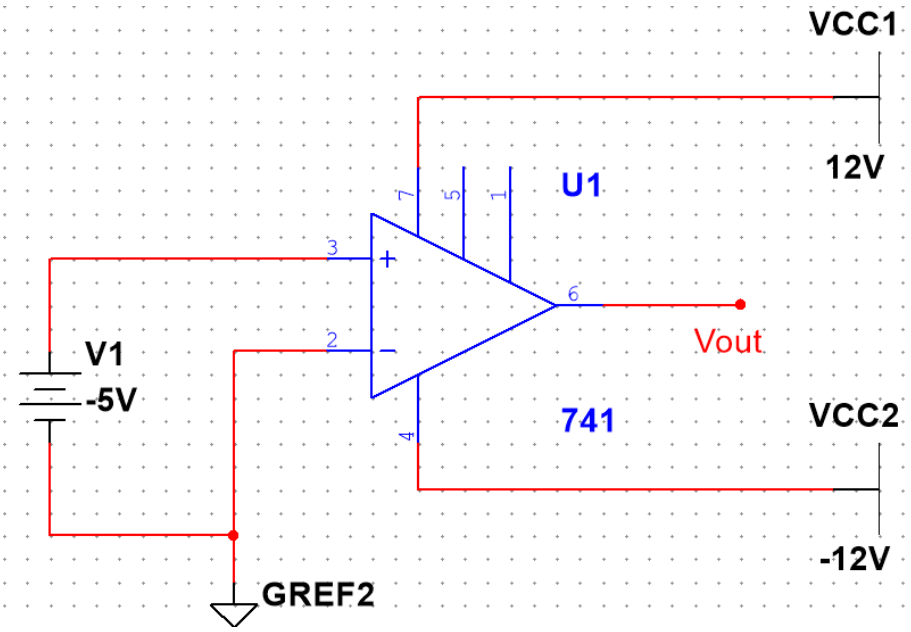
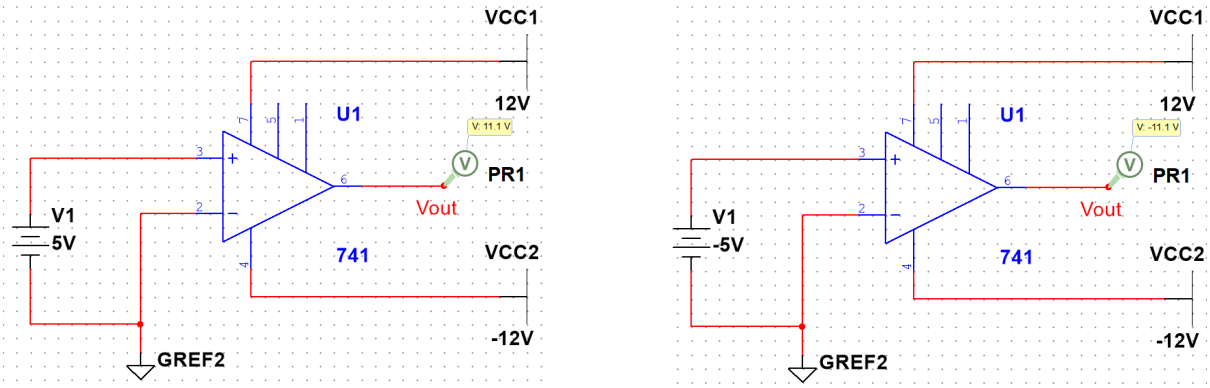


Figure 1: Circuit Diagram

3.1 Circuit Diagram The circuit was constructed according to the manual. A 12V DC power supply was connected to Pin 7 (+) and Pin 4 (-) of the 741 operational amplifier to power the amplifier. When constructing the open-loop circuit, a +5V DC power supply was connected to Pin 3 as the input voltage and properly grounded.

3.2 Experimental Procedure The experiment was carried out precisely. First, a high-precision voltmeter was used to accurately measure and record the input voltages V_{cc+} and V_{cc-}. Then, the input on Pin 3 was adjusted to -5V, and the positive and negative saturation voltage values were carefully measured and recorded. Finally, the saturation values were rigorously compared with V_{cc+} and V_{cc-} and analyzed in depth.

3.3 Results and Discussion The key data obtained from the experiment are as follows: V_{cc+} remained stable at +12V, and V_{cc-} was accurately maintained at -12V. When the input was +5V, the positive saturation voltage reached +11.1V; when the input was -5V, the negative saturation voltage was -11.1V. Compared with the power supply voltages, there was an approximately 0.9V difference between the positive saturation voltage and V_{cc+}, and an approximately 0.9V difference between the negative saturation voltage and V_{cc-}. This deviation is mainly due to the saturation voltage drop of the internal transistors of the operational amplifier, which is affected by the characteristics and working conditions of the transistors. The experiment achieved the purpose of exploration, accurately measuring the saturation voltage and the difference from the power supply voltage, clearly revealing the open-loop characteristics. During the measurement, the accuracy of the voltmeter and the stability of the circuit may introduce small errors. In the future, upgrading the measurement equipment and optimizing the circuit layout can improve the accuracy.



(a) positive saturation voltage (b) negative saturation voltage

Figure 2: Result

4 Conclusion

This experiment was successfully completed, comprehensively and accurately grasping the input-output characteristics and saturation voltage details of the 741 operational amplifier in the open-loop configuration. The principle mechanism that the high gain leads to a narrow linear region and saturation phenomenon, as well as the internal transistor saturation voltage drop causing the difference between the output and the power supply voltage, was clearly defined, laying a solid theoretical and practical foundation for the application of the amplifier in complex circuit design.