2011 International Conference on Computer Science and Information Technology (ICCSIT 2011)
IPCSIT vol. 51 (2012) © (2012) IACSIT Press, Singapore
DOI: 10.7763/IPCSIT.2012.V51.134

The Theory and Implementation of Gain Test for Operational Amplifiers

Peng Xiao-hong, Li Xiao-qing+, Dong Li-min, Geng Shu-qin, Wu Wu-chen

VLSI & System Laboratory, Beijing University of Technology, Beijing, China

Abstract. In many OPAMP parameters under test, the output voltage equals zero is required. If open loop mode is used to test, due to the voltage offset or biasing current, zero modulation should be done continuously. But there may be more difficulties when the gain is very high. Therefore, closed loop mode should be used; especially an aided OPAMP should be used as well. The methods adopted in this work are based on the aided OPAMP and resistors to build a test circuit. The Altium Designer tool is used to draw the schematics and PCB boards of the test circuits. Finally the gain tests are accomplished satisfactorily with the designed test circuits.

Keywords: operational amplifier; open-loop; closed-loop; gain test; frequency response

1. Introduction

Integrated operational amplifier is a high magnification of the multi-level direct-coupled amplifier. In the development of the earliest, most widely used kind of analog integrated circuits, from the outside can see the equivalent dual-ended input, single-ended output differential amplifier circuit, usually by differential input stage, intermediate gain stage, push-pull output stage, and at all levels Bias circuit. In recent years, integrated operational amplifier has been widely used in many areas, the use of integrated operational amplifier for signal processing and computing, the occurrence of the waveform and signal conversion, power amplification and signal measurement functions.

The purpose of this paper is to study and design an integrated operational amplifier test circuit, aims at test the parameters of the OPAMP, get rid of drift and other factors, to achieve the gain in the transformation between 1 and 10 tested two amplifier gain, the use of aid amplifiers, Feedback input signal to achieve amplification, calculation of the gain amplifier, optimized test circuit, a final design to meet the requirements of the PCB version.

The board performance:

Testing circuit has 1 and 10 times magnification, the conversion circuit using jumpers and pin in the form;

On the amplifier to zero, change the OPAMP parameters, the measured amplifier and aid amplifier to separate the power supply, can be commonly ground;

Circuit can measure a variety of models to achieve the double-line gain of the OPAMP;

Note that the reliability of the design problem, in order to avoid the small-signal fed back by the other circuit components, and by the interference of its package to shield the time, which can be extended if the design, measurement of multiple parameters of the test.

2. Gain test theory

2.1. Analysis

+ Li Xiao-qing
e-mail: maillxq@163.com

The output from the signal source Vin, after a test after the OPAMP voltage Vout, in an ideal OPAMP, the calculation of the gain when the Gain = Vout / Vin. but we usually use a linear drift of the OPAMP, the larger internal resistance and other reasons, through the feedback signal back to the OPAMP input voltage is not the time to Vout (typically microvolt), so the gain is calculated using the above often lead to large errors, so if you can enlarge Back to the small signal feedback, denoted Vin1, the ratio calculated using Vout/Vin1 gain relatively more accurate.

After the above analysis, we can determine the need for an aid amplifier to achieve the small signal amplification, to ensure that by stable OPAMP output signal distortion, we need a voltage follower. To improve the accuracy of the computation, we also need to be zeroing OPAMP. This test circuit consists of four basic components, namely, the measured amplifier, voltage follower, aid amplifier, zero circuit.

Let the input signal Vin, the measured gain of the OPAMP Av. After a test after the OPAMP output voltage Vout, the measured resistance and the amplifier with a negative feedback circuit structures, so that magnification is 10, so there:

$$Vout = 10Vin \tag{1}$$

Vout through the voltage follower output voltage after V1, voltage follower input equals output:

$$V_1 = Vout = 10Vin \tag{2}$$

Since the voltage follower as a buffer stage, input resistance, output resistance is small; the measured voltage follower OPAMP with negative feedback loop to form a stable system, the measured input voltage of the OPAMP is Vin1

$$V_{in1} = \frac{Vout}{Av} = \frac{V_1}{Av} \tag{3}$$

Vin1 OPAMP's output through the secondary value of V2, in accordance with the auxiliary amplifier connected in negative feedback to achieve a 30 times magnification

$$V_2 = 30V_{in1} \tag{4}$$

In the calculation of the measured amplifier gain, according to the formula:

$$Gain = 20\log\left(\frac{V_1}{V_2}\right) \tag{5}$$

From (2) (3) (4) can be got:

$$\frac{V_1}{V_2} = \frac{10V_{in}}{30V_{in1}} = \frac{10V_{in}}{30(V_1/A_V)} \tag{6}$$

So:

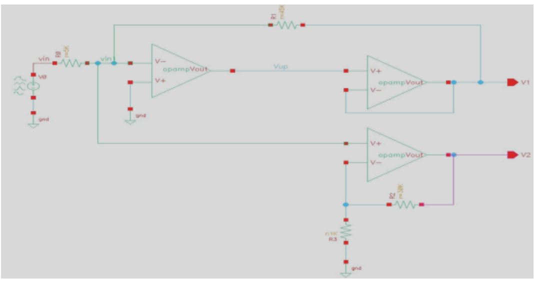
$$A_V = 20\log\left(\frac{3V_1^{\,2}}{V_{in} \cdot V_2}\right) \tag{7}$$

V1 and V2 in the formula by the oscilloscope or network analyzer test data; Vin is the input signal source.

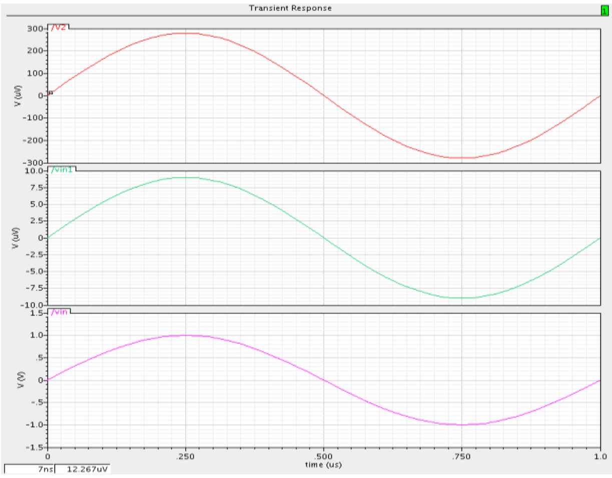
Determine the circuit model, then we should enter the circuit simulation, simulation by the circuit after the concrete structures, concrete problems to be solved in connection with the circuit, OPAMP is zero, the device selection. Parameter determination of the power supply module design, grounding design, the protection of small-signal circuit reliability problems such as crosstalk and circuit operability and scalability, then layout and verification.

2.2. Simulation results

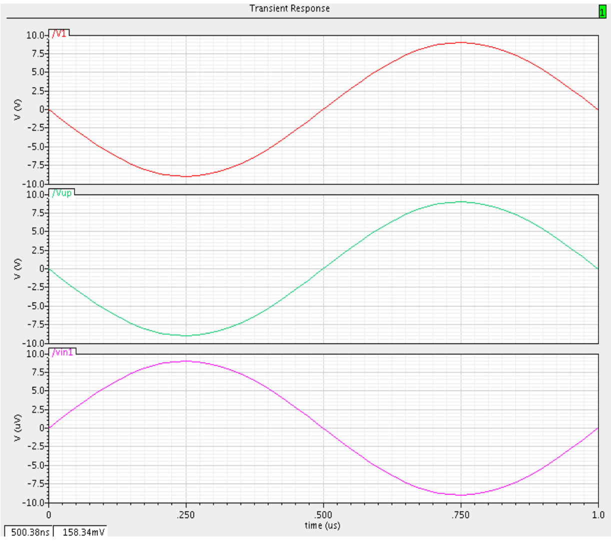
This circuit is simulated by Cadence simulation tools, in accordance with design requirements, building the test circuit model, in which R1 = 45K, R0 = 5K; R2 = 30K, R3 = 1K. Signals measured from the signal source output to the input OPAMP side of the voltage Vin, amplified by the OPAMP voltage Vup, through the voltage follower to return after the test through the feedback resistor when the OPAMP input signal V1, in an ideal OPAMP, the Gain = Vout / Vin = V1/Vin. but we usually use a linear drift of the OPAMP input offset voltage and current and other reasons, the signal to return to the OPAMP input voltage is not the time for the V1 but Vin1, Vin1 often μV level, so the gain is calculated using the above often lead to large errors, so if you can use the auxiliary amplifier small signal fed back, that is amplified V1, get the voltage V2, calculated using the ratio of V1/V2 to gain relatively accurate. Simulation results are shown in Fig.1. (a).



(a)



(b)



(c)

Fig.1. Test circuit and simulation result (a)test simulation circuit (b) V1 out waveform (c) V2 out waveform

Requirements expected results: the measured input signal through the amplifier 10 times magnification, the small signal feed back through the auxiliary amplifier 30 times magnification.

The simulation results show in Fig.1.(b) and (c).It can be seen from the simulation waveforms when the input voltage Vin is 1V, the output voltage of the OPAMP under test Vup is 10V, the voltage follower after the voltage V1 , the feedback received as measured by the OPAMP input voltage Vin1 Is 10μV, the signal fed back through the auxiliary Vin1 amplified by OPAMP output voltage V2 is 300μV, It can be concluded that the basic form of this circuit can be connected to achieve the desired magnification.

3. Test circuit design

3.1. The PCB design

We use AD8001 for the aid amplifier. AD8001 is a low power, high-speed amplifier design for ±5V power supply, AD8001 has a unique linear circuit, it has excellent differential gain to drive the load, relative performance of only 50mW power. AD8001 is a current feedback amplifier, and there is a differential gain and phase of 0.01% and 0.025 °, 0.1 dB gain flatness to 100MHZ, which makes him a professional video electronics such as cameras and video switch ideal for original.Fig.2 shows the Test circuit PCB schematic.

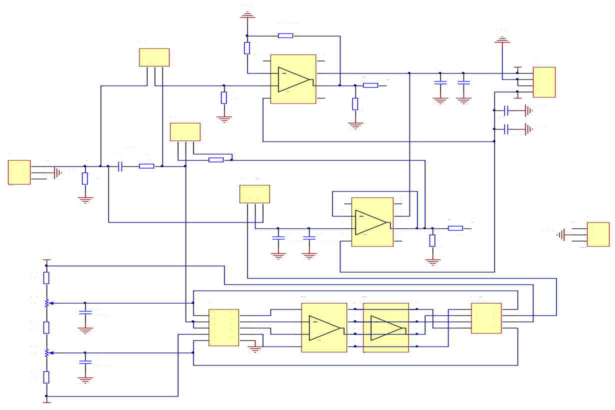


Fig.2. Test circuit PCB schematic

3.2. Aid test amplifier design

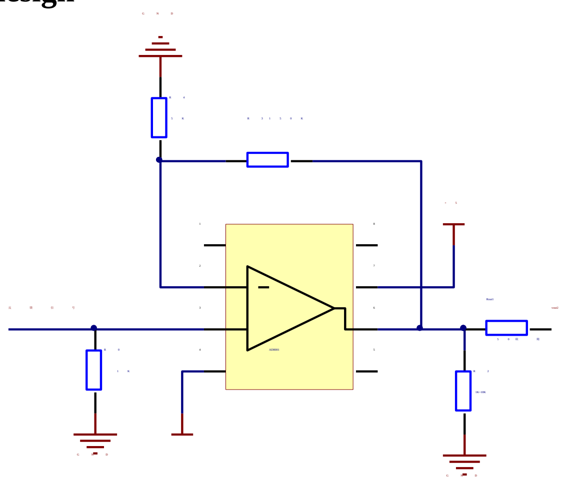


Fig.3. Aid amplifer design

The feedback signal is the signal source to the point of the input signal is amplified through the amplifier under test, through the voltage follower OPAMP under test to return to the small signal input

The resistance R0 is the resistance to ground, the main role played by sub-voltage protection of the OPAMP input. Resistor network R2 and Rout1 composition, played partial pressure, easy to measure the output voltage by R3 and R4 constitute a negative feedback circuit, the OPAMP is 30 times magnification

C. NC pin adjust circuit:

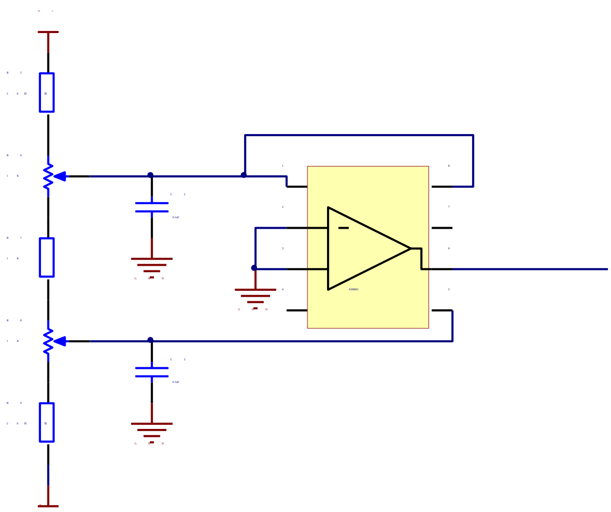


Fig.4. NC pin adjust circuit design

Adjustable resistor network is made up of three resistors and two sliding rheostat, and two filter capacitor, which connects NC pin OPAMP under test for zero OPAMP under test, and change the gain of the OPAMP input offset voltage And the current, common mode rejection ratio, etc.

To improve the computing precision, before use in the operation, should first be transferred to the DC output potential of zero, that is to ensure that input is zero, the output is also zero. Adjusted to zero, the input is grounded, the zero-side access potentiometer R6 and R8, with a DC voltage meter to measure the output voltage U0, carefully adjust the R6 and R8, so that U0 is zero (ie, offset voltage is zero.)

3.3. Buffer circuit design:

When the input signal through the amplifier under test after V1, go through the C4, C5 two filter capacitors, and the output signal after the AD8055 for V1.

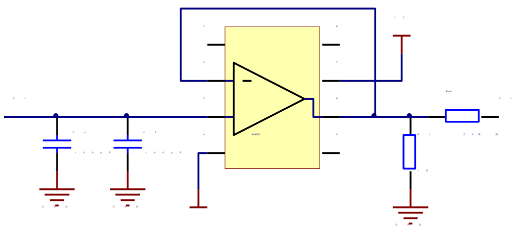


Fig.5. Buffer circuit design

3.4. The PCB layout:

Fig.6 shows the total PCB layout. Taking this board, we test a multistage amplifier with the Network analysis as shown in Fig.7.the test results as shown in Net work analysis. From the test results, as we can see, the test board was working properly.

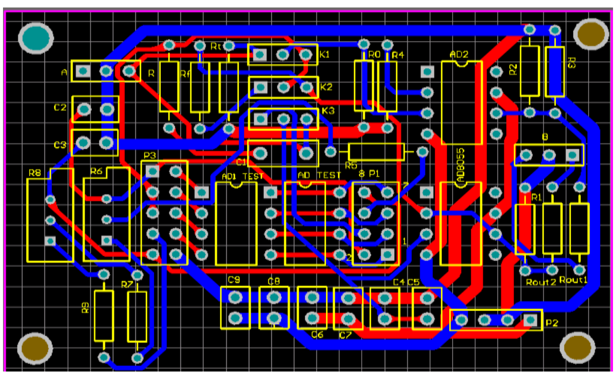


Fig.6. testing circuit Pcb design

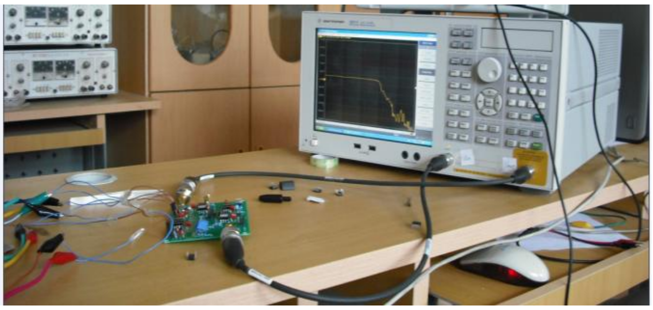


Fig.7. the demo testing IC use network analysis

4. Conclusion

The design of the test circuit to meet design requirements, to achieve both 1 and 10 times magnification, the OPAMP can be measured for more accurate test, use this test circuit testing integrated operational amplified large and reduce the time, cost savings. Parameters for further study of automatic test provide a research model. Because this circuit is compact and durable, the future integrated operational amplifier in the laboratory parameters measured, and can be applied in the classroom teaching of this circuit.

5. Acknowledgment

This work was supported by the National Natural Science Foundation of China (60976028) and the Startup Foundation for Doctors of BJUT (X0002014201101, X0002012200802, and X0002013201103).

6. References

[1] XU Ya, “Judgment method of feedback configuration”, Journal of Anhui Technical College of Water Resources and Hydroelectric Power, Vol.3 2004, Page:2

[2] CHENG Dongbo, SUN Lingling, HONG Hui, HAN Jian, “Design and Implementation of a Fully Differential Operational Amplifier with Gain-Boosting Technique”, Chinese Journal of Electron Devices, Vol.6 2010,Page: 3

[3] Behzad Razavi, Design of Analog CMOS Integreated Circuits, 2001

[4] Gong Shiyao, “Application of Single Chip Microprocessor in Operational Amplf ier Measuring System” , Journal of Nanjing Institute of Posts and Telecommunications, Vol.1 1991,Page: 3

[5] Tian liang, Zhan hongying, “Integrated Operational Amplifier Testing Problems”, Electronic Measurement Technology, Vol.02 1981, Page:1

[6] Zhong ping, “Main Parameters of Auxiliary Amplifier for Testing Integrated Calcalating Amplifier”, Journal of Gannan Teachers College, Vol.6 DEC.1999, Page:1

[7] Zheng xiaoling, Zheng erxin, Peng chenlin, “A Method of Detecting L ow-Level Physiological Signals by the Use of Operational Amplifier”, Journal of Biomedical Engineering, Vol.4 1987, Page:248-250