Innovation and Entrepreneurship Based on Differential Amplifier Circuit Teaching

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Abstract. By discussing the practical application of the theory of analog electronic technology in engineering, this paper solves the problem of lack of knowledge of innovation and entrepreneurship in the course of theoretical basis. Firstly, the basic principle of differential amplifier circuit is analyzed. The fully symmetrical circuit structure is used to suppress the common mode signal and amplify the differential mode signal effectively. Secondly, in practical application, the differential signal lines in printed circuit boards are used to effectively suppress electromagnetic interference. Finally, based on this example, this paper innovatively puts forward the integration of simulated electronic technology and innovation entrepreneurship education in basic engineering courses, hoping to give students inspiration about innovation and entrepreneurship in future teaching.

Introduction

Differential amplifier circuit is one of the key chapters of analog electronic technology. Differential signal which is used theory of differential amplifier circuit more and more widely used in high-speed circuit design. Differential structure design is often used for the most critical signal in the circuit [1]. Differential signal pairs which are very close to each other will also be closely coupled with each other, which will reduce EMI (Electro Magnetic Interference) emission, there are conductive interference and radiative interference. Conductive interference refers to the coupling of signals from one network to another through conductive media. Radiation interference refers to the interference source coupling its signal (interference) to another network through space. In high speed PCB and system design, high-frequency signal lines, integrated circuit pins, various connectors and so on may become radiation interference sources with antenna characteristics, which can transmit electromagnetic waves and affect the normal work of other systems or other subsystems in the system.

The Principle of Differential Amplifier Circuit

It is composed of two common emitter amplifier circuits. The output signal is taken from the collector of two tubes. In circuit design, characteristics of the two tubes VT1 and VT2 are identical in fabrication technology, and the resistance and temperature characteristics of the two circuits are identical, that is, the two sides of the circuit are completely symmetrical [2].

In static state, $\Delta U_{I1} = \Delta U_{I2} = 0$, the static potential of the two collectors, $U_{C1} = U_{C2}$, and the output voltage are obtained, $\Delta U_O = 0$. When the temperature changes, the collector potential of the two tubes drifts simultaneously. For example, when the temperature rises, U_{C1} and U_{C2} decreases ΔU_{C1}, ΔU_{C2} at the same time. Because the two sides of the circuit are completely symmetrical, there must be an output voltage, $\Delta U_{C1} = \Delta U_{C2}$, $\Delta U_O = \left(U_{C1} - \Delta U_{C1}\right) - \left(U_{C2} - \Delta U_{C2}\right) = 0$. There is no

temperature drift in the output voltage. The basic differential amplifier circuit uses symmetrical circuit structure to eliminate temperature drift, so the symmetrical degree of the actual circuit will directly affect the output temperature drift.

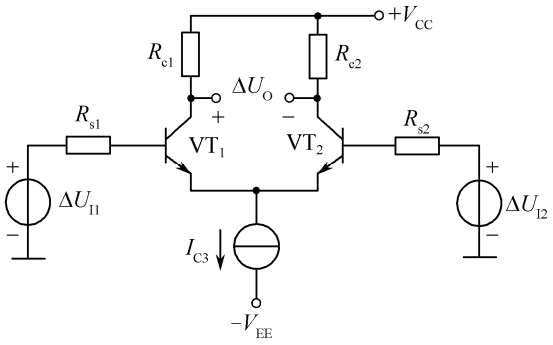

Figure 1. Basic differential amplifier circuit

Common mode signals generally refer to harmful signals caused by temperature drift and electromagnetic interference in the air. When the circuit is ideally symmetrical and output at both ends, the differential amplifier circuit is used, $A_{uc}=0$. The suppression of temperature drift by differential amplifier circuit is the result of its suppression of common mode signal. The factors causing temperature drift can be equivalent to the common mode input signal at the input end. The smaller the A_{uc} of differential circuit is, the better the suppression of temperature drift is.

When the differential amplifier circuit amplifies the signal, the input signal should be added to the two base B1 and B2 input terminals, as shown in Figure 2. If the signal voltage of B1 and B2 end to ground is used ΔU_{I1} and ΔU_{I2} separately, $\Delta U_I=\Delta U_{I1}-\Delta U_{I2}$ is obvious. Under the condition that both sides of the circuit are completely symmetrical, the input signal equals to the input end of the two point circuit. Therefore $\Delta U_{I1}=\Delta U_I/2$, $\Delta U_{I2}=-\Delta U_I/2$, the signal voltage obtained by T1 and T2 is equal, and the polarity is opposite, so the input signal is transformed into differential mode signal. Differential amplifier circuit has no amplification effect on common mode, but only on differential mode signal.

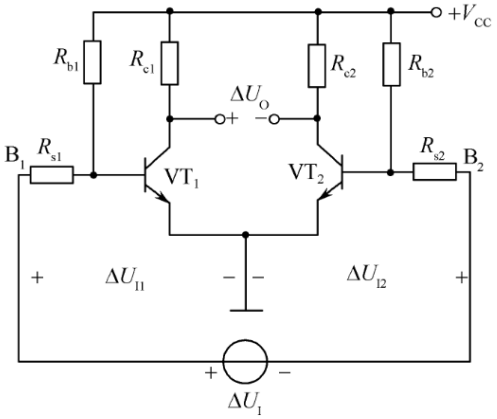

Figure 2. The input of differential mode signal in differential amplifier circuit

Practical Application

Differential mode signals shown in Figure 3 are transmitted through a pair of signal lines. One signal line transmits what we usually understand; the other transmits an equivalent signal in the opposite direction. Then the receiver judges whether the logical state is 0 or 1 by comparing the difference between the two voltages. Differential and single ended modes do not differ much when they first appear, because all signals have loops.

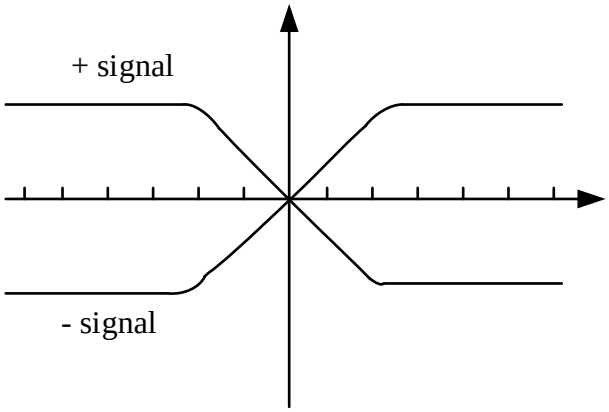

Figure 3. Differential signal logic state change

Signals in single ended mode are usually returned via a zero-voltage circuit (or ground). Each signal in the differential signal must be returned through the ground circuit. Since each signal pair is actually equivalent and reversed, the return circuit simply cancels each other, so there will be no differential signal return component in the zero voltage or ground circuit. Common mode means that the signal appears on two signal lines of a signal line pair, or both on a single-ended signal line and on the ground. Common mode signals are mostly noise signals generated in circuits or coupled by adjacent or external sources according to hypothetical conditions. Common mode signals are almost always harmful, and many design rules are designed to prevent common-mode signals from appearing.

For PCB engineers, the most important concern is how to ensure that these advantages of differential routing can be fully utilized in actual routing [3]. In the process of layout and routing of differential pairs, we hope that the two PCB lines in the differential pairs are identical, so as to ensure that the two differential signals keep opposite polarity at all times and reduce common mode component and reflection. This means that in practical applications, every effort should be made to ensure that the PCB lines in the differential alignment have exactly the same impedance and the wiring length is exactly the same. Differential PCB lines are usually routed in pairs, as shown in Figure 4, and the distance between them remains constant at any position along the direction of the pairs. Generally, the layout and routing of differential pairs are always as close as possible.

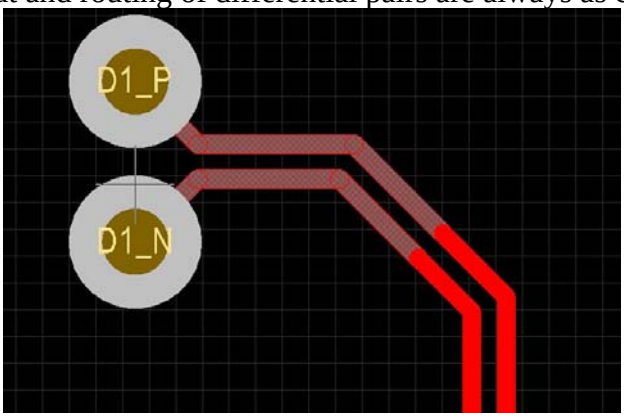

Figure 4. Example of differential wiring

The external impedance of the signal line will be affected by the coupling between the differential signal lines, so the terminal matching strategy must be adopted. However, it should be noted that the coupling between differential lines will directly affect the calculation of differential impedance. Coupling between differential lines must be ensured to maintain a constant along the whole differential line or to ensure the continuity of impedance. This is also the reason why the design rules of constant spacing must be maintained between differential lines.

Summary

Based on the principle of differential amplifier circuit and the concepts of common-mode and differential mode signal [4], this paper gets different inspiration from the application of differential amplifier circuit in practical circuit design and PCB wiring. In the teaching of basic analog electronic technology, not only the theoretical knowledge of electronic technology and the application skills of hardware composition, analysis and design in practical circuits, but also the innovation and entrepreneurship ideas need to be integrated into it, so as to get various inspirations from specific engineering cases. In the follow-up teaching, through further teaching reform, I hope that innovation and entrepreneurship is no longer a pure theoretical knowledge, nor a book like Jobs Biography, but a practical case close to learning and life of students, through sharing and discussion, to cultivate innovative ability of students.

References

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