

The Basic Structure of Servomotor and The Function of Each Part

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Abstract. This paper mainly introduces the basic structure and the function of each part of servomotor. At first, it talks about what is servomotor and where does it used for. Three parts are introduced in the article, the integration part, the addition part, and the feedback part. In each part, the article talks what the electronic components that are used in each part and how do these electronic components make the arithmetic come true. At last, the paper will discuss the advantage of the feedback part.

Keywords: servomotor, part, components.

1. Introduction

The main machine we decide to talk about is the servomotor. I will introduce its definition. The servomotor is an engine that controls the operation of mechanical components in a servo system is an indirect variable speed device for an auxiliary motor. The servomotor can control the speed and the direction is very accurate, because it has a very nice feedback system. Also, it can let the electric signal be converted into the angular displacement or angular velocity output on the motor shaft, so it has a quick reaction speed. In conclusion, there are six advantages that the servomotors have. First, precision, it can control the position, speed, and torque. Second, it has very high-speed performance. It also has good adaptability, stability, and it has low heat and noise. And the last one is the timeliness, it has a fast acceleration and deceleration, so it can quickly follow our order.

The servomotor can be used in a closed ring. That is, it sends signals to the system at any time, and uses the signals given by the system to correct its own operation. What is more, servomotor can also be controlled by single chip microcomputer.

2. Background

After introducing the servomotor, I list some components which will be used in the following parts. Some very basic components, like resistances and capacitances. And the special one we used this time is the Operational Amplifier. It is widely used in the circuit to realize some of the operation. In practical circuits, the feedback network is usually combined to form some functional modules. It is an amplifier with a special coupling circuit and feedback. The output signal can be the result of addition, subtraction, differentiation, integration, and other mathematical operations of the input signal. And

nowadays, the Operational Amplifiers are often put into chips and used in the circuit. In this article, we will use the Operational Amplifier named LM741.

LM741 is a general-purpose operational amplifier which is widely used. Due to the use of active load, high voltage gains and wide common-mode and differential mode input voltage range can be achieved with only two stages of amplification. The circuit uses internal compensation, the circuit is relatively simple and not easy to self-excitation, stable working point, easy to use, and the design of a perfect protection circuit, not easy to damage. LM741 can be used in a variety of digital instruments and industrial automatic control equipment. (Chip37, 2019, [1]). Which means when the positive input voltage is higher than the inverting input voltage, the comparator output is high level. If the inverting input voltage is higher than the inverting input voltage, the output is low. The output of an operational amplifier is the product of gain and input voltage. In the following picture, I give the simplest formular of the LM741 about the relationship between its input and output.

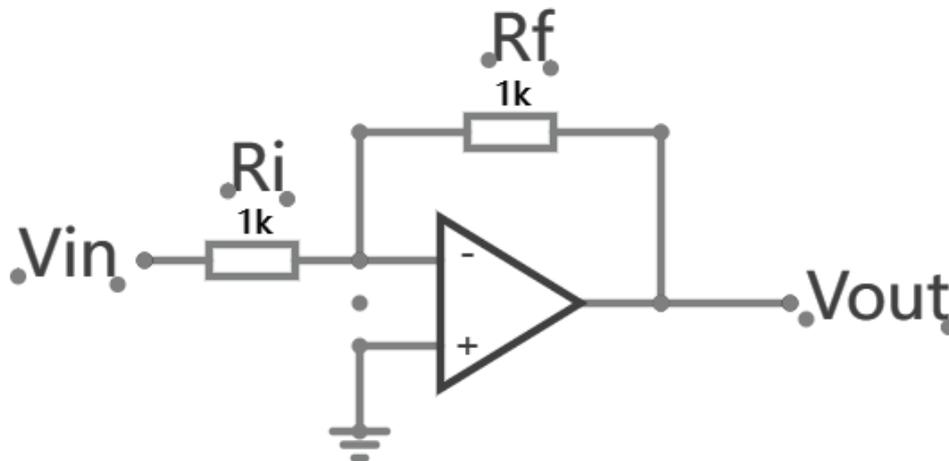


Figure 1. LM741.

Source: author's own photograph

$$V_{out} = -\frac{R_f}{R_i} * V_{in}$$

These are the things we will use in the following article.

3. Integration part

The first part is the integration part, we will use the resistances and capacitances and the LM741. This is a very important part, only you we can get the integration, the feedback part can be good to work.

At the beginning, I give the formular of the integration part, we can see that if we change the R and C, we can get the correctly integration. However, it is the inverting integration, but there is no problem because we can change the position of it so that to realize the function.

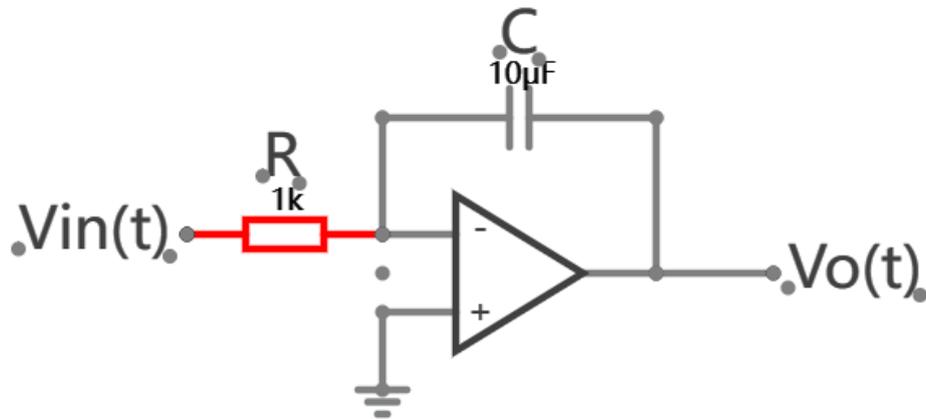


Figure 2. Integration Formular.

Source: author's own photograph

$$V_o(t) = -\frac{1}{R * C} * \int V_i(t)dt$$

Because the formular is hard to type in the word, so I still give the picture of the operation process. After writing it, we can see that it is not too difficult, in each step, we only use very simple thing, and finally we have such a result.

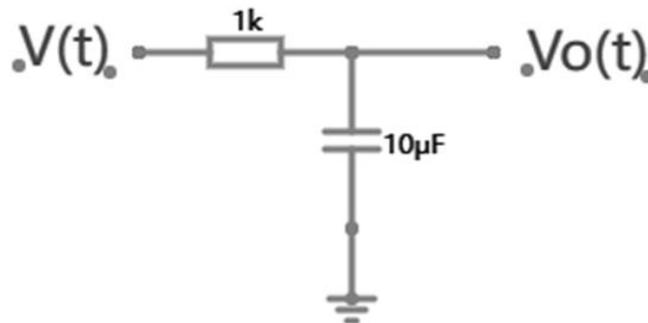


Figure 3. Operation Process.

Source: author's own photograph

$$\begin{aligned}
 V(t) &= Q' * R + \frac{Q}{C} \\
 V_o(t) &= \frac{Q}{C} \\
 V(t) &= e^{st} \quad s = j\omega \\
 &= e^{j\omega t} \\
 &= \cos(\omega t) + j\sin(\omega t) \\
 e^{st} &= Q_o S R e^{st} + \frac{Q_o e^{st}}{C} \\
 V_o &= \frac{Q_o e^{st}}{C} \\
 \frac{V_{out}}{V_{in}} &= \frac{\frac{Q_o e^{st}}{C}}{e^{st}} = \frac{Q_o}{C}
 \end{aligned}$$

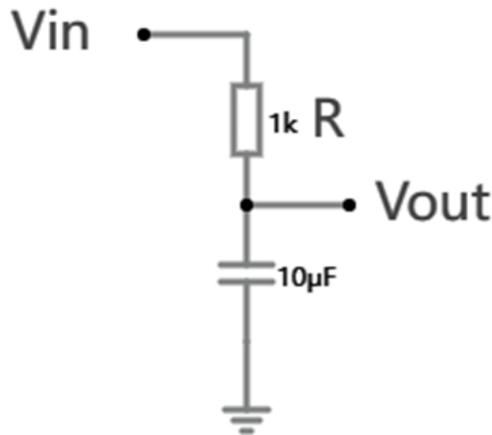


Figure 3. Operation Process.

Source: author's own photograph

$$Q_o \left(SR e^{st} + \frac{1}{C} * e^{st} \right) = e^{st}$$

$$Q_o = \frac{1}{SR + \frac{1}{C}} = \frac{C}{SRC + 1}$$

$$\frac{V_{out}}{V_{in}} = \frac{1}{SRC + 1}$$

This part is quick simple, and we do not use any complex components in this part. In the feedback part, we will use the derivative, second derivative, maybe even the third derivative, which is very useful in the error feedback, so if we want to use this, the integration part is very significant in the system. In other word, this part can make the servomotor more accurate and rapidly. Because this derivative can correct the error better.

4. Addition part

This part is also simple, it uses the LM741 to add to circuit together. But it is also important in the circuit. When we deal with the part of the feedback, we do not only have one feedback, but we will also add several data together, like the derivative, second derivative and so on. Therefore, it is also the essential part in the servomotor. As for how to realize the function, just put the two in parallel so we can do it.

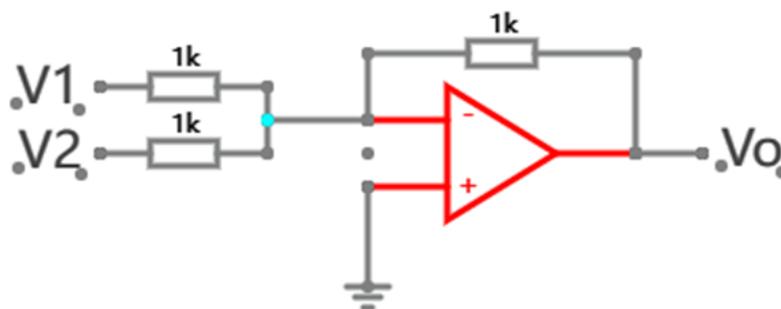


Figure 4. Addition Formular.

Source: author's own photograph

$$V_o = -(V_1 + V_2)$$

I give the one situation of the addition part, we can change the coefficient of the V_1 , V_2 and V_0 through changing the numerical value of the resistances and capacitances. It is basic but useful.

5. Feedback part

This part does not like the previous two part, I cannot say what part is the feedback part. When the data is put into the system, it will be calculated and output now one, but this system need the feedback to adjust the output to make it better. So that it can realize the function that accelerate and stop in a high speed, which is timeliness. The main calculation in the feedback part is the addition. We need to add the derivative, second derivative so that it can have the more accurate result.

Then, after the feedback are dealt with, the system can change the speed of the motor through two components, NPN and PNP.

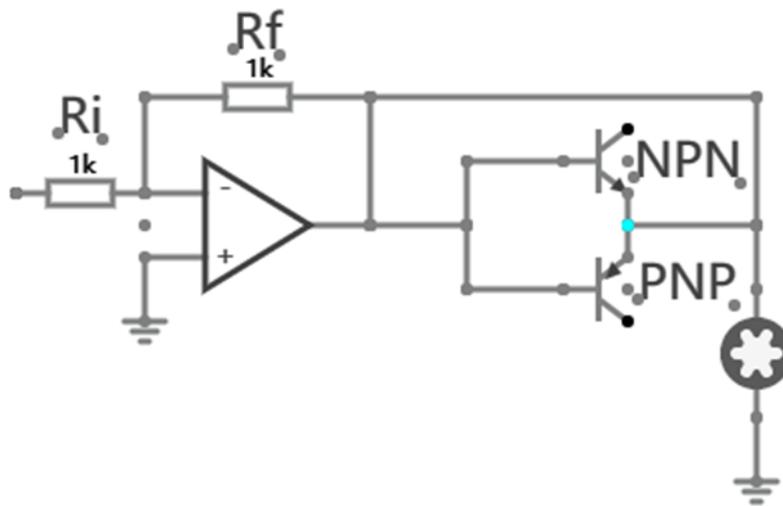


Figure 5. NPN and PNP.

Source: author's own photograph

This is the picture and it shows how these two are used.

6. Conclusion and Discussion

This article introduces some basic structures of the servomotor, how the electronic components are used in the circuit, how these parts connect to each other and play the role in the servomotor, and how the servomotor works. The addition part and the integration part can be combined in each situation to get the result we want. It is very simple but useful in the circuit, so it is good to master it. And we need to learn more about these parts that could do the special operation and know more electronic components that are also useful.

I have known some basic knowledge of the servomotor, but it is a very simple one, so I still have many things to learn. In this research, I learn something new and review some I have learnt. We use these electronic components to realize arithmetic, it is amazing that these components can do beyond 0 and 1. I do not learn something more this time, but I can imagine that in the future I can use more electronic components to realize more complex arithmetic and use it to do more things. It is a pity that because of the COVID-19, I cannot go to the lab and do it physically. In the future, once I have the chance, I will try it in the lab.

References

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