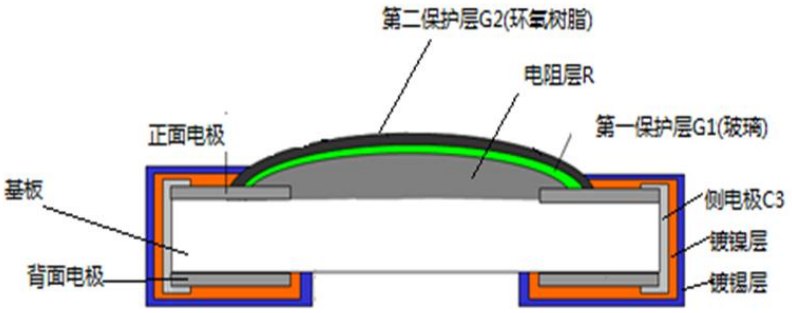
Application Analysis of High Resistance Chip Resistors

§0．Abstract

When using high resistance SMD resistors, due to the soldering process and the adsorption of moisture and dust on the surface during the application process, parallel effects can occur and the resistance value decreases. In order to avoid the impact of parallel resistance values as much as possible during application, measures such as selecting type and increasing protection during application to reduce the impact of parallel resistors.

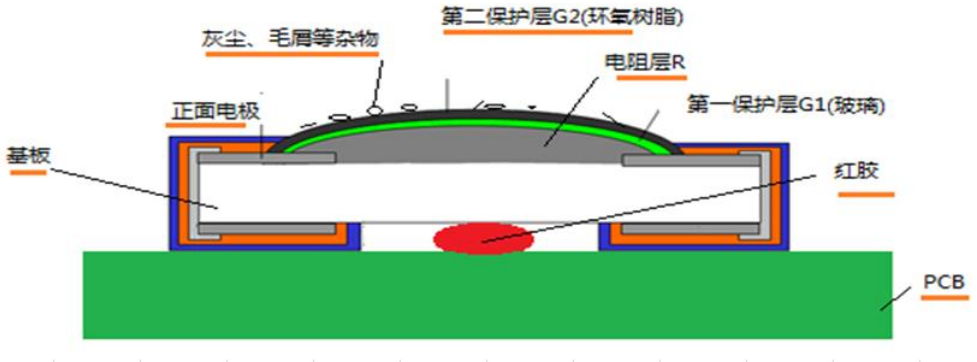
§1．Structural Characteristics of Chip Resistors

The main structure of SMD resistors is composed of four parts: substrate, resistance element layer, electrode, and protective layer. The electrode part is further divided into inner electrode (silver-palladium), barrier (nickel), and outer electrode (mainly tin). As shown in Figure 1:



§2．Analysis of Parallel Effect in the Application of Resistors:

The resistance value is the value measured at both ends of the electrode. The measured value is determined by multiple factors, such as the electrode, resistance layer, protective layer, etc. of the internal resistance itself. During application process, it can also have an impact on the resistor and form a final resistor in parallel, such as the red glue at the soldering point between tin and PCB board in external soldering, dust and debris generated in the application environment, and moisture on the surface protective layer of the resistor. As shown in Figure 2:



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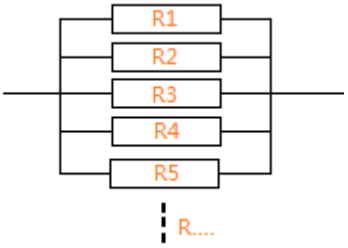
Taking into account the resistance values generated by various factors above, the final parallel connection forms a resistor as shown in the following figure:
R=(R1+R2+R3+R4...)/Rn



Analyze and exclude the above factors：

a. The internal resistance layer and electrode layer of the resistor are both sintered at high temperature, which has little effect on the resistance value and can be ruled out;

b. During resistor soldering, the substrate, PCB and red glue are on the back of the resistor, which has little effect on the resistance value, so it can be ruled out;

c. If the resistor is used in a damp and poor environment for a long time, there may be adsorption of dust, shavings, etc.; then the protective layer will generate a certain resistance value. This impact is significant.

§3．Analysis of the impact of moisture absorption on the surface of resistors:

G1 and G2 are both protective layers. G1 is glass protective layer, with a sintering temperature of 600 ℃. G2 is a resin layer, with a curing temperature of around 200 ℃. Together, the two layers act as insulation layers to protect the resistor R layer and prevent harmful substances from directly immersing on and harming the R surface. When the protective layer is affected by moisture, it will have a certain resistance value of about 50M Ω, which is connected in parallel on both sides of R and will have a certain impact on the R value. Assuming the resistance value is Ro and the resistance of the protective layer is RG, then the resistance value after parallel connection is RZ.

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$$\frac{1}{R_Z} = \frac{1}{R_0} + \frac{1}{R_G}$$

$$R_Z = \frac{R_0 * R_G}{R_0 + R_G}$$

If its impact is ：

$$\triangle R = R_Z - R_0$$

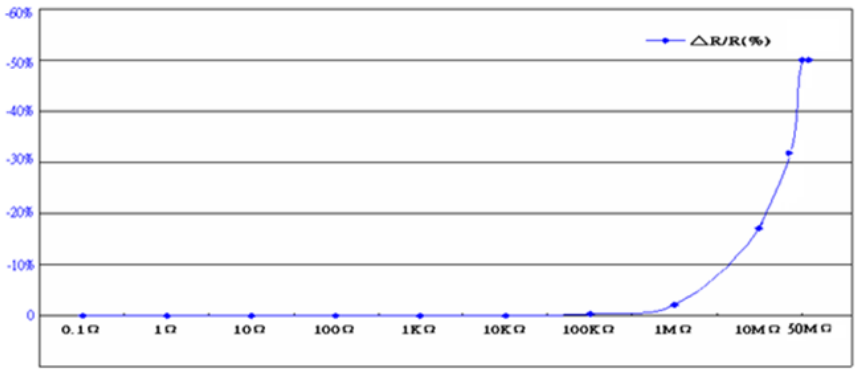
$$= \frac{R_0 * R_G}{R_0 + R_G} - R_0 = \frac{R_0 * R_G}{R_0 + R_G} - \frac{R_0 R_0 + R_0 R_G}{R_0 + R_G}$$

$$= \frac{R_0 * R_G - R_0 R_0 - R_0 R_G}{R_0 + R_G}$$

$$= \frac{-R_0 R_0}{R_0 + R_G}$$

Then：

$$\frac{\Delta R}{R_0} = \frac{-R_0 R_0}{R_0 (R_0 + R_G)} = \frac{-R_0}{R_0 + R_G}$$ Set R_G equal to 50MΩ



R_0	0.1Ω	1Ω	10Ω	100Ω	1KΩ	10KΩ	100KΩ	1MΩ	10MΩ	25MΩ	50MΩ
△R/R(%)	0	0	0	0	0	0	-0.20%	-2.00%	-17%	-33%	-50%

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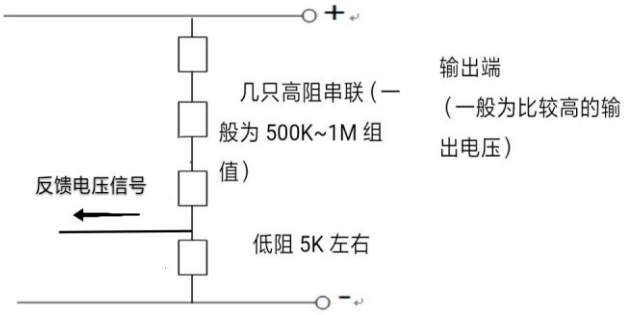
§4．Series voltage sharing feedback circuit and its characteristics

The complete machine cannot be free from AC power. Generally, to stabilize the output voltage, a voltage sharing feedback circuit is designed at the output end. The purpose is to ensure that the actual voltage can be divided onto resistors according to the resistance values. When the output voltage fluctuates, the voltage sharing on the resistors will also change. This change will be reflected in former section and adjusted by the circuit to ensure stable output voltage. However, if the series resistance value used changes, error signals will feedback, causing the entire machine to shut down. The series voltage sharing feedback circuit is shown in Figure 3：



a. Resistor operates under DC voltage；
b. The load rate of the resistor is relatively high；
c. The product has some problems after being used by the customer for a period of time
d. This circuit is sensitive to resistance values, and changes in resistance values can change the magnitude of the voltage sharing.

§5．Summary

Based on above analysis, it is recommended to pay attention to the following points when selecting high resistance chip resistors:

5.1 Try to choose products with larger dimensions in length and width for use. According to the resistance formula R= ρ L/S, when resistor L increases, the impact on resistance value is small;

5.2 Avoid using products with too high resistance values (such as resistance values above 10M), series connection can be designed to reduce the resistance values of the resistors;

5.3 Avoid being used in series voltage sharing feedback (sensitive) circuits;

5.4 When using high resistance chip resistors, it is recommended to provide surface protection and add moisture-proof measures