§0．Abstract

With the advancement of technology, the development of the times, and the continuous improvement of people's requirements for miniaturization of electronic products, thick film chip resistors with reliable performance and stable technology are also showing a diversified development trend according to the characteristics of electronic products. Therefore, our factory has developed a chip resistor based on customer and market requirements: high-voltage thick film chip resistors (HV series). This product has a special high-voltage design structure, superior anti-static characteristics, high reliability and high voltage resistance, which can reduce installation area and save costs compared to ordinary products.

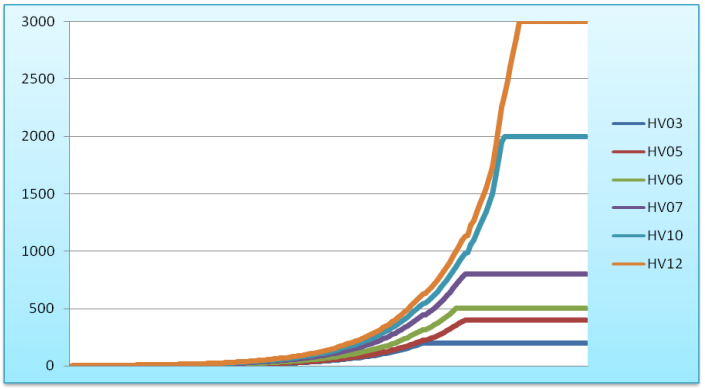
§1．Introduction of HV Series——High-Voltage Thick Film Chip Resistors

The research object of high-voltage products is the voltage above the critical value of ordinary products. It is reported that for printing with the same paste series, the withstanding voltage per unit length of the resistor is the same. The resistance value remains unchanged, but the size of the resistor body itself changes, similar to the voltage sharing principle of a circuit, which will change the voltage limit that the entire resistor body can withstand.

The comparison of voltage performance between high-voltage thick film chip resistors and ordinary thick film chip resistors is as follows:

Comparison		HV Series		Ordinary thick film chip resistors	
Special characteristics	Dimension	Max working voltage	Max overload voltage	Max working voltage	Max overload voltage
	0603	200V	400V	75V	150V
	0805	400V	800V	150V	300V
	1206	500V	1000V	200V	400V
	1210	800V	1500V	200V	500V
	2010	2000V	3000V	200V	500V
	2512	3000V	4000V	200V	500V
	The withstanding voltage of HV series is at least 2 times of that of ordinary products				

Max working voltage curve of HV series is as below：



Explanation: Taking large-sized products as an example, the maximum working voltage of ordinary 2512 products is 200V, and the corresponding critical resistance value is 40K; the maximum working voltage of HV12 (3000V) corresponds to a resistance value of 9M1. At this point, the advantages of high resistance HV products are undoubtedly evident, while relatively low resistance high voltage is meaningless.

§2． HV Series—Introduction of the Structure of High-Voltage Thick Film Chip Resistors

2.1 Design principle:

The research object of high-voltage products is the voltage above the critical value of ordinary products. It is reported that for printing with the same paste series, the withstanding voltage per unit length of the resistor is the same. The resistance value remains unchanged, but the size of the resistor body itself changes, similar to the voltage sharing principle of a circuit, which will change the voltage limit that the entire resistor body can withstand.

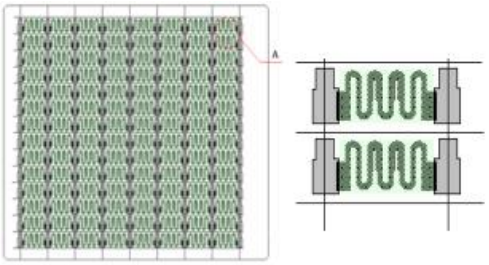
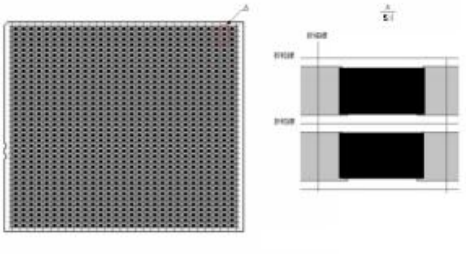
Our company aims to increase the voltage by increasing the length of the resistive conductive tape. Therefore, the R design graphics of HV products are different:

Ω shape　HV03、HV05、HV06

Snake-shape　HV07、HV10、HV12

2.2 Printing (Take HV12 as an example)

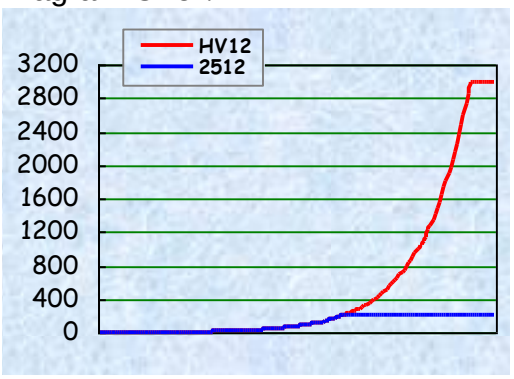
2.2.1 Graphic change

Graphic change	HV Series	Ordinary Thick Film Chip Resistors
C1、R graphics	例如 Example：HV12  C1 printing of high voltage product HV12 is stepped type while R printing is snake-shape. R has a larger size but a smaller cross-sectional area.	例如 Example：2512  C1 and R printing of the ordinary product 2512 are all rectangles. R size is too small.
Summary	Summary: HV product has a larger printing area than that of an ordinary product but a smaller cross-sectional area on the whole.	

2.2.2 Design notes

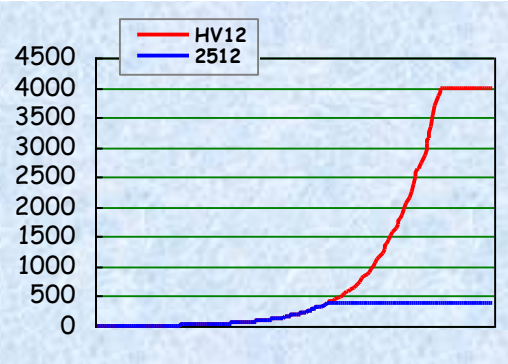
It is obvious that the working voltage and short-term overload voltage of HV12 have the greatest potential for improvement compared to ordinary resistors, with the highest multiple. Please refer to the following diagrams for details:

Diagram One：



工作電壓——高壓產品是普通產品的 15 倍。
Working voltage——HV product’ s working voltage is 15 times of that of ordinary product

Diagram Two：



短時間過負荷電壓——高壓產品是普通產品 10 倍。
Short-time overload voltage——HV product’ s short-time overload voltage is 10 times of that of ordinary product

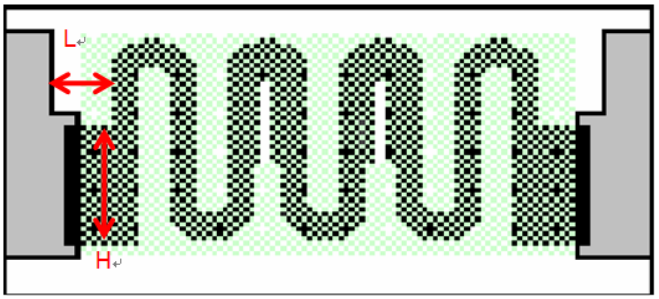
Therefore, when designing, it is necessary to consider the impact of printing technology on high-voltage performance. Mainly refers to the phenomenon of sparking. When the distance between two points is too close, a higher voltage passing through a conductive medium (such as air) may cause the medium between the two points to break down, resulting in sparks. Therefore, it is necessary to achieve the following as much as possible during design:

Increase the distance between the electrode and the resistor body

As R shape changes, it is necessary to modify the shape of C1 to match it. The C1 stepped design allows for an effective distance between the electrode and the resistor body. As shown in Figure L:

Lift the overlap between the electrode and the resistor body

Compared to specifications of other HV products, HV12 has a longer conductive strip with more snake twists. To ensure a certain amount of heat dissipation, the overlap of R and C1 is raised, and the width of the heat dissipation strip is increased. As shown in Figure H:



2.3 Laser (taking HV12 as an example)

According to the formula of resistance : $R = \rho \frac{L}{S}$

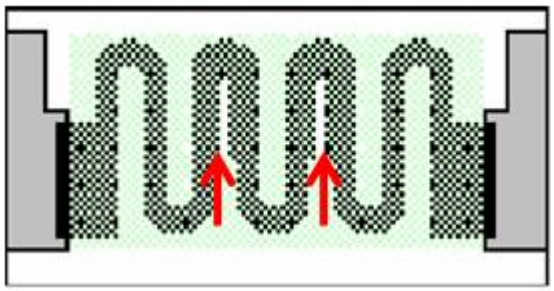
The resistance value is proportional to its length. When the conductive strip of the resistor body is extended, in order to ensure the same resistance value, the paste with the lower resistance value in the R paste series must be selected for on-site printing.

The laser of HV products, like ordinary products, is processed through laser trimming technology to adjust the resistance value. The process parameters for laser trimming of two products have to be A cutting energy of 0.5-5W and B trimming line is clean without residues. Besides, there are slight differences in other control standards. Details are as follows:

	HV12	Ordinary 2512	Remarks
Trimming initial value	0~-18%	0~-25%	
Length of trimming line	Within 70%	Within 50%	Ratio of trimming line to resistor width
Trimming method	Single trimming	L-shape trimming	
Trimming position	1/2 place	2/5 place	The start position of trimming line is at the width of conductive strip

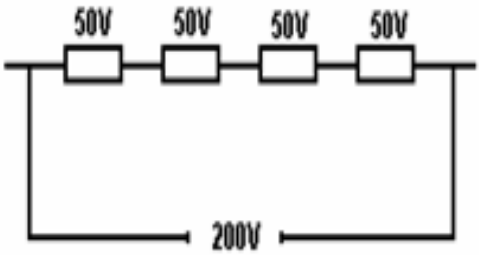
Note: Trimming line of HV12 is no longer than 2.1mm and the length of "A" value of the snake-shape corner trimming is no less than 0.3mm

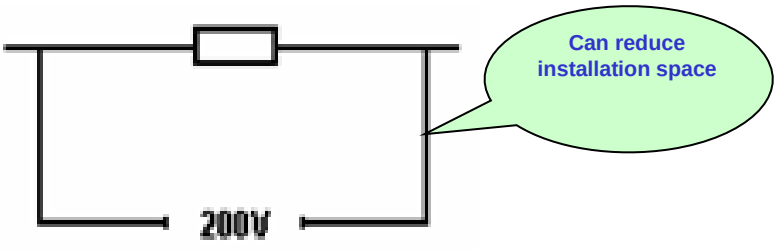
Comparison of trimming patterns between HV12 and ordinary products:



§3．HV series—application of high-voltage thick film chip resistors

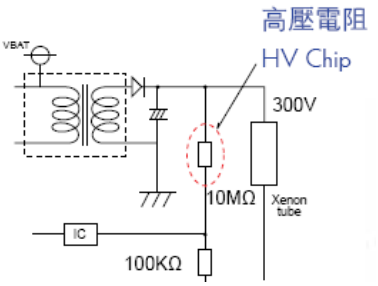
- ➤ High voltage power supply and high voltage sampling circuit
- ➤ Electrostatic leakage return circuit
- ➤LCD backlight circuit
- ➤ The Flash Circuit of Cameras
- ➤LED light control circuit



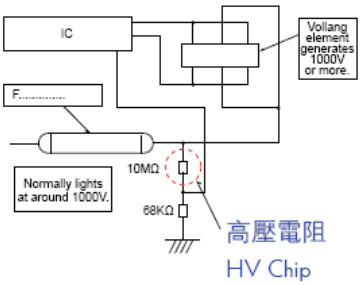


Application examples：

a. In camera flash circuit



b. Conversion circuit for display backlight



§4. Summary

The biggest feature of the HV high-voltage series products compared to ordinary products is that they can withstand larger working voltages and short-term overload voltages. Due to time constraints, the general test verification starts with a short-time overload voltage.

Our company enhances the withstanding voltage performance by changing the size pattern and laser cutting method, and adding conductive strips of the resistor.

The change in R printing patterns requires a corresponding C1 size change. To solve the problems of high voltage heat dissipation and stability, HV12 product needs to undergo two C1 printing operations and increase the width of the heat dissipation strip. To ensure better insulation of high-voltage products, G1 layer has to complete cover of the R layer (ordinary product G1 only covers the effective area of R). In addition, HV products are targeted at high resistance sections, and low resistance high voltage is meaningless.