Power Resistors With Low Parasitic Inductance

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Abstract – In this work three types of power non inductive resistors are described. The design and technology for every one is shown. The subject of the experiments are bulk B_4C, thin film and resistors from parallel connected wires. The comparison of main parameters such as resistance (R_n), TCR, accuracy and prices is done.

Key words – **power resistors, non inductive resistors, sintered resistors, low ohm resistors.**

I. INTRODUCTION

The need of high power (high amperage) resistors arrases simultaneously, especially for AC applications. In conjunction with the base resistor parameters $R_{nominal}$, TCR and tolerance $(\varepsilon\%)$, now the parasitic capacitance and inductance are very important. There are a lot of producers in wide range of resistors from parts of ohms to kohms and power up to $1000\,W$ [1÷5].

Almost all technologies and construction are presented such as bulk (sintered), wired, film resistors, grid and ribbon est.

The goal of this work is to describe three possible type of power resistors with low parasitic inductance.

This includes sintered (B_4C) resistors, thin Nichrom and special designed resistors from Cantal or Nichrom wire. The experiments are provided to produce small numbers, accurate and in wide range of parameters resistors. They are used for AC power application in laboratory conditions.

II. DESIGN AND TECHNOLOGY OF EXPERIMENTAL SAMPLES

II.1. Resistor from boron carbide (B_4C).

The boron carbide is well known with its hardness, chemical resistance and electrical parameters: $\rho = 0.1 \div 10\ \Omega cm$ and $TCR \approx -0.5\ \%/^0C$.

The TCR is strongly negative but with addition of Co, Mo, it is closed to $0.01\ \%/^0C$. The preparation of these resistors include the next steps:

- mixing the powder of boron carbide (with $1 \div 5$ % Co or Mo);
- hot pressing (sintering) - $T \approx 2200\ ^0C$;
- ohm contacts made with Ag paste (low $T = 100\ ^0C$) or $AgPd$ ($T=850\ ^0C$).

The shape of thee resistors is as a nozzle (Fig. 1).

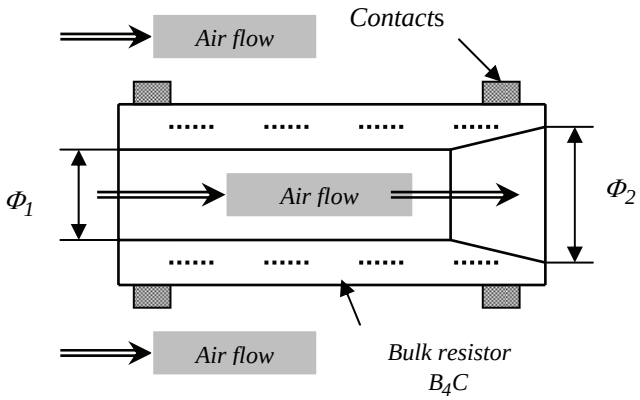

Fig. 1. The shape of the samples.

This design allows well air cooling and measuring the temperature in the centre of the resistors.

The main parameters of boron carbide (B_4C) resistors are:

- nominal value $R_n = 1 \div 10\ \Omega$);
- $TCR = 0.5 \div 10.01\ \%/^0C$;
- production tolerance $\varepsilon = \pm 10\ \%$.

II.2. The film resistors.

Next, very used technology for power low ohm resistors is $NiCr$ thin resistive films on insulating substrate (Fig. 2).

The technology steps are well know as:

- deposition of film combination $NiCr - Ni - Ag$;
- photolithography for pattering resistor $NiCr$ and contacts Au;
- making external connections and attachment to the heat sink;
- trimming and surface protection.

For this type of resistors is important the very accurate resistance could be obtained using electro spark trimming (L - cut) (Fig. 3). With this technique the accuracy of $\pm 0.1\%$ could be done and it depends on method of measurements.

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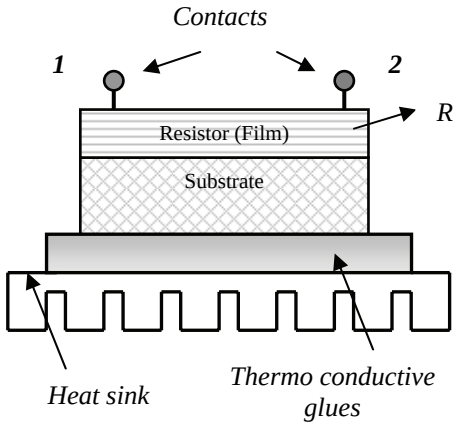


Fig. 2. Thin film $(NiCr)$ resistor.

These thin film power resistors have $R_{nominal}$ from 10 to $100\ ohms$. The disadvantage is very high parasitic capacitance $(10 \div 20\ pF/cm^2)$ depending to the dielectric substrates (Sital, Al_2O_3) and surface.

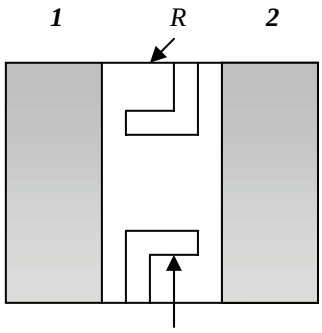


Fig.3. Trimming with L - cut.

II.3. Resistors based on resistive wires.

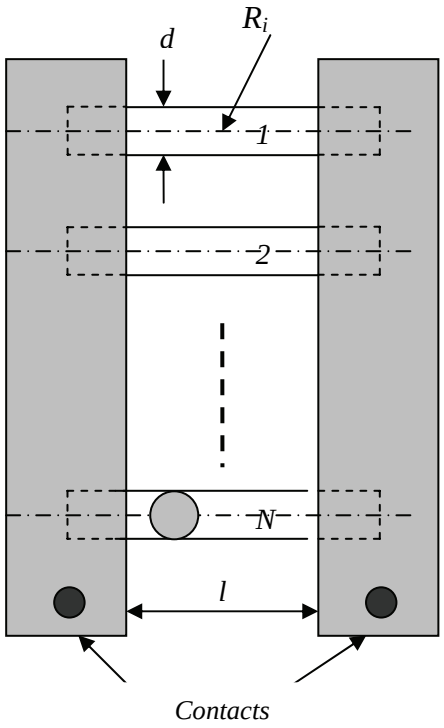
The construction of these resistors is shown on Fig. 4.

If consist a number of resistive wires connected in parallel between $Cu\,(Cu + Ag)$ external contacts. As a resistive material the wires from Nichrom or Cantal is used with different diameters. From the Fig. 4 it could be seen that they are several possibility for reaching dose tolerance:

- resistivity of ρ_W;
- length material of wires L;
- diameter of wires d;
- number of wire N.

For example, of the need is power shunt resistor $R = 0.006\ \Omega$, the design could be calculated as fallows:

- $\rho_{WIRE} = 20 \div 30 Mohm/cm^2$;
- $L = 1\ cm$;
- $R_{nominal} = 0.006\ \Omega$;
- $R_n = \rho_W / N$;
- $N = (20 \div 30)/0.006 \approx 4 \div 5$.



N – number of wires

Fig. 4. Low ohm, low inductive resistors.

These type of resistors are really low ohm with low parasitic capacitance and inductance, low TCR, high accuracy and without special protection.

CONCLUSION

The described three type of power resistors have advantage and disadvantages on the base of construction, technology and materials. The best parameters are:

- boron carbide (B_4C). – high stability (temperature and chemical);
- thin film $(NiCr)$ - best accuracy (tolerance $\pm 0.1\%$);
- Cantal and Nichrom parallel wires – easiest technology and low price.

For laboratory use (small numbers - $1 \div 10\ psc$) the last type of resistors is a good solution.

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