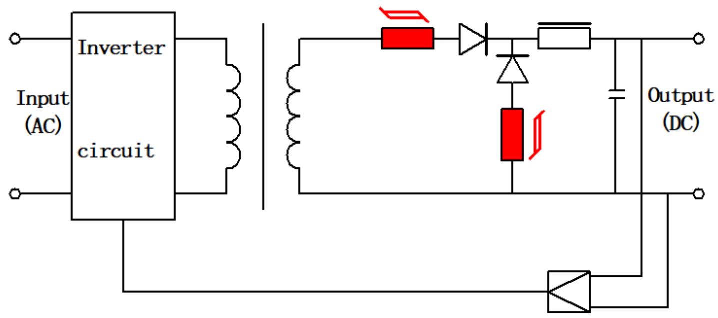
Spike Suppressor

1. Basic Introduction

Nanocrystalline magnetic cores are widely used in fields such as switching power supplies, inverters, and EMC filtering. They can effectively suppress spike noise generated by rapid current changes. A spike suppressor is usually made by winding one or a few turns of copper wire around a magnetic core. Its structure and installation are very simple, yet it is highly effective in suppressing spike noise.

Nanocrystalline magnetic cores with a high rectangular ratio have extremely low core losses and extremely high magnetic permeability. When the current is very small, they have a very large inductance value. This large inductance value effectively blocks the reverse reset current generated by the diode. This material can quickly reach saturation even with a very small current.

Application Schematic Diagram: (The red part is the spike suppressor)



2. Function and Basic Working Principle of Spike Suppressor

Figure 1

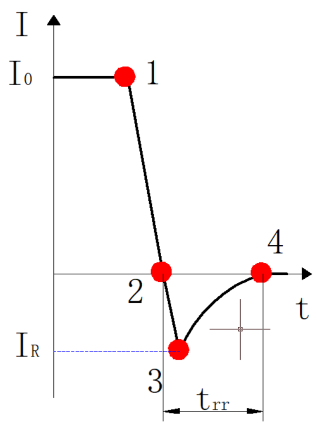


Figure 2

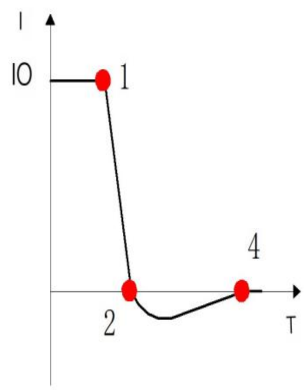


Figure 3: Hysteresis loop schematic diagram of the spike suppressor (working principle)

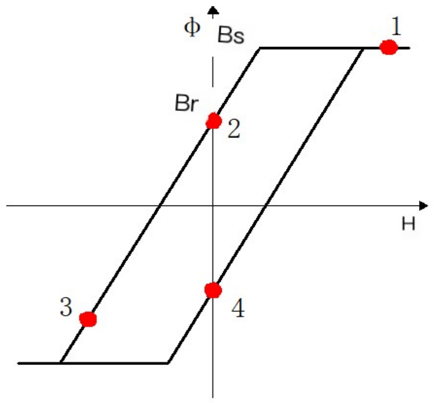


Figure 3 shows the hysteresis loop of the nanocrystalline magnetic core material. The working process of the spike suppressor is as follows: Before reaching point 1 (when the current is conducting), the magnetic core is in a saturated state and has a very low inductance value. When the current is turned off, the operating point reaches the remanence point 2. The reverse recovery effect of the diode causes the current to continue to decrease in the negative direction. At this time, due to the extremely high magnetic permeability of this amorphous material, its inductance value is very large. Therefore, it can effectively suppress the spike current of the diode (Figure 2 shows the suppressed current). IR is the theoretical reverse current spike, corresponding to the theoretical operating point 3. However, due to the high inductance value of the spike suppressor, it prevents the magnetic core from reaching the theoretical operating point 3 and remains at the reverse remanence point 4. Then it is magnetized again to start another cycle.

3. Basic Design and Calculation Formulas, Required Parameters

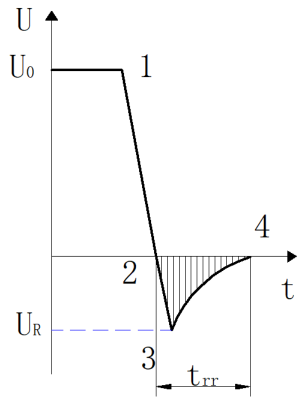
Taking the reverse voltage calculation method as an example:

$U=\frac{d\varphi}{dt}$

Integrating both sides of the equation:

$\int Udt=\int d\varphi$

$\varphi = NBS$



where N is the number of turns, B is the magnetic flux density, taking Br (remanence), and S is the effective cross - sectional area of the iron core.

According to the above formula, the area enclosed by points 2 - 3 - 4 is equal to the magnetic flux of the iron core required to suppress the surge. That is, $N\times Br\times S>\cdots$ (the specific value needs to be determined according to the actual situation)

Points to Note in Design:

1. The continuous operating temperature of the nanocrystalline magnetic core should not exceed 150°C.

2. Accurate calculation mainly depends on the correct value of the diode reverse recovery time T_{rr}. It is affected by temperature and the dI/dt during operation. And the dI/dt value is determined by the inductance value of the circuit (including the variable inductance of the spike suppressor).

4. Advantages of Nanocrystalline Magnetic Cores in Spike Suppressors

Nanocrystalline magnetic cores offer several distinct advantages in spike suppressor applications. Their high magnetic permeability allows for more efficient suppression of spike currents, even at low current levels. Compared to traditional magnetic materials, nanocrystalline cores can achieve a higher degree of saturation, enabling them to handle larger current surges without significant performance degradation.

Moreover, their low core losses contribute to energy efficiency. In applications where power consumption is a concern, such as in portable electronics or energy - saving power supplies, the use of nanocrystalline magnetic cores in spike suppressors can help reduce overall power dissipation.

5. Expanded Application Scenarios

In addition to the commonly mentioned switching power supplies and inverters, spike suppressors with nanocrystalline magnetic cores are also finding applications in automotive electronics. In modern vehicles, with the increasing use of electronic control units (ECUs) and high - power electrical components, the electrical system is prone to voltage spikes. Spike suppressors can protect these sensitive electronic components from damage caused by voltage surges, ensuring the stable operation of the vehicle's electrical system.

Another emerging application area is in renewable energy systems, such as solar power inverters and wind turbine generators. These systems often generate electrical signals with complex waveforms and are susceptible to spikes during start - up, shutdown, or when there are sudden changes in load. Spike suppressors with nanocrystalline magnetic cores can help smooth out these voltage fluctuations and improve the reliability of renewable energy systems.