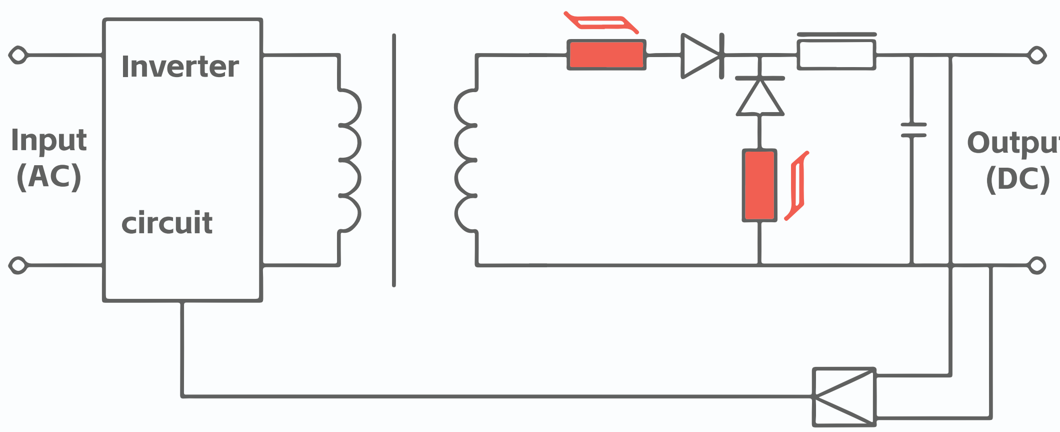
SPIKE SUPPRESSOR

Basic Introduction

Nanocrystalline magnetic cores are widely used in switching power supplies, inverters, and EMC filtering, where they effectively suppress spike noise caused by rapid current changes. A spike suppressor, made by winding one or a few copper wire turns around the core, is simple in structure and installation but highly effective.

High-squareness-ratio nanocrystalline cores feature extremely low core losses and high magnetic permeability.At very low currents, they provide high inductance to block the reverse reset current of diodes.



Application Schematic Diagram

The red part is the spike suppressor

Function and Basic Working Principle of Spike Suppressor

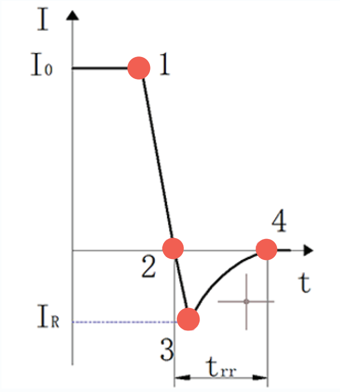


Figure 1
with out surge suppressor

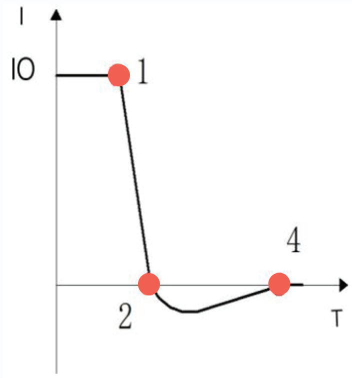


Figure 2
with surge suppressor

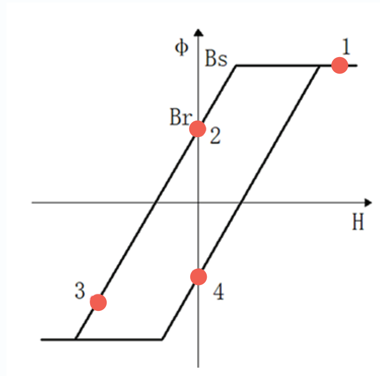
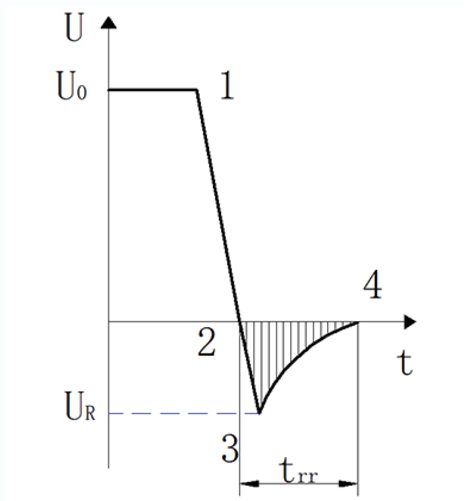


Figure 3

Fig. 3 shows the hysteresis loop of the nanocrystalline core. The spike suppressor works as follows:

- Before point 1 (current conduction), the core is saturated, resulting in very low inductance.
- When current turns off, the operating point moves to remanence
- The diode's reverse recovery effect causes current to decrease negatively.
- The material's ultra-high magnetic permeability increases inductance, effectively suppressing the diode's spike current (see Figure 2).
- IR is the theoretical reverse current spike, corresponding to point 3.The suppressor's high inductance prevents the core from reaching point 3, keeping it at reverse remanence point 4.
- The core is remagnetized to start a new cycle.

Basic Design and Calculation Formulas, Required Parameters



Taking the reverse voltage calculationmethod as an example:

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

Integrating both sides of the equation:

$$\int Udt=\int d\varphi$$

$$\varphi = NBS$$

Where N = number of turns, B = magnetic flux density (taking remanence Br), and S = core's effective cross-sectional area. Per the above formula, the area enclosed by points 2-3-4 equals the core flux required for surge suppression, i.e., N×Br×S > … (specific value determined by actual conditions).

Design Notes:

Nanocrystalline core's continuous operating temperature ≤ 150°C. Accurate calculation relies on correct diode reverse recovery time Trr, which is affected by temperature and operating dI/dt. dI/dt is determined by circuit inductance (including the spike suppressor's variable inductance).

Advantages of Nanocrystalline Magnetic Cores in Spike Suppressors

Nanocrystalline magnetic cores excel in spike suppressors:

- High permeability enables efficient suppression of low-current spikes;
- Higher saturation (vs. traditional materials) handles larger current surges stably;
- Low core losses boost energy efficiency, cutting power dissipation in portable electronics/energy-saving supplies.

Expanded Application Scenarios

Nanocrystalline spike suppressors are also used in automotive electronics (to protect ECUs and stabilize vehicle electrical systems) and renewable energy systems (to smooth voltage fluctuations and improve the reliability of solar/wind equipment).

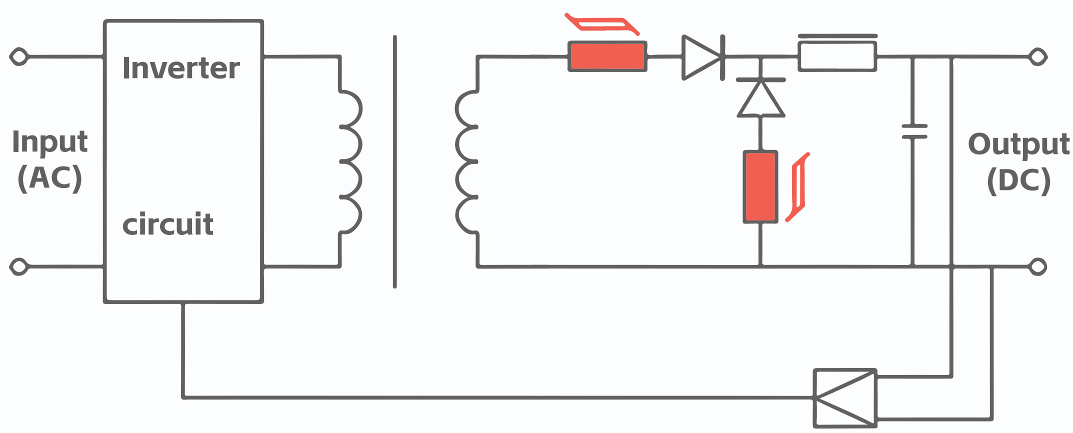
SPIKE SUPPRESSOR

认识纳米晶尖峰抑制器

纳米晶磁芯广泛应用于开关电源、变频器等领域，可抑制电流尖峰噪声；尖峰抑制器结构简单（磁芯绕少量铜线），安装便捷且抑制效果显著。

纳米晶高矩形比磁芯具备两大关键特性

- 极低磁芯损耗与极高磁导率，电流较小时能产生超大电感量，可阻挡二极管反向复位电流。
- 易饱和，小电流下快速饱和

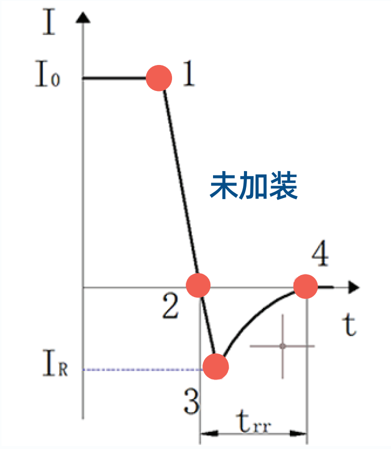


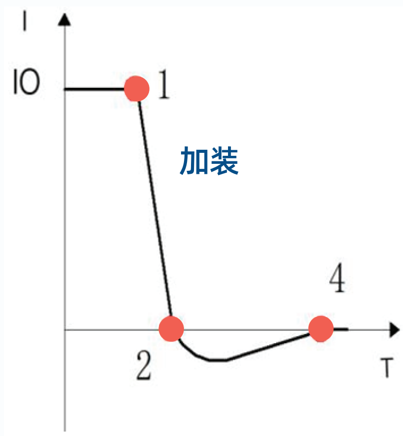
-尖峰抑制器应用简图-

红色标注为尖峰抑制器

尖峰抑制器工作原理与作

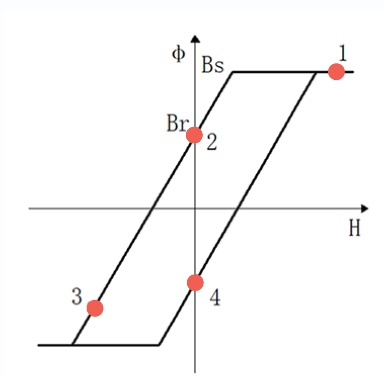
电流抑制效果对比





对比项	未加装尖峰抑制器	加装尖峰抑制器
电流波形特征	二极管反向尖峰电流(IR)干扰电路	大幅抑制尖峰电流，曲线平滑
核心差异	难挡二极管反向恢复尖峰	高电感阻反向电流，软恢复实现

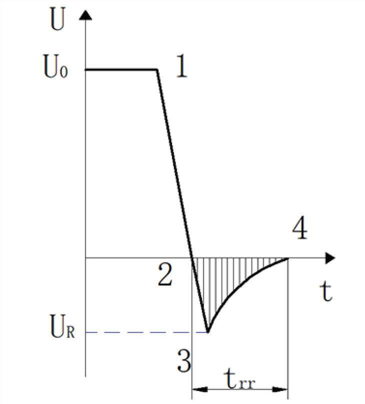
磁滞回线工作原理



- **电流导通阶段(工作点1之前)**
  磁芯饱和、电感量低，不影响正常电流传输。
- **电流关断阶段(工作点 2)**
  电流关断后，工作点至剩磁点，二极管反向恢复使电流向。
- **尖峰抑制阶段(避开工作点 3)**
  纳米晶材料磁导率骤升、电感量增大，阻止磁芯达反向尖峰工作。
- **循环阶段(工作点 4)**
  磁芯停留在反向剩磁点 4，随后重新磁化，进入下一个工作循环。

基本设计和计算公式

核心计算公式(以反向电压计算为例)



公式类	公式内容	参数说明
反向电压基础公式	$U = \frac{d\phi}{dt}$	反向电压、磁通、时间
积分推导公式	$\int U dt = \int d\phi$	通过积分计算磁通变化量
磁通计算式	$\phi = NBS$	匝数、磁通密度(取剩磁 Br) 铁芯有效截面积
抑制条件公式	$N \times Br \times S > \int U dt$	2-3-4 点包围面积需小于NxBrxS, 保障浪涌有效抑制

设计关键注意事项

温度耐受上限

纳米晶磁芯连续工作温度≤150°C，需兼顾散热设计 。

关键参数精度控制

二极管反向恢复时间 Trr 为关键参数，受温度、线路dl/dt(电流变化率)影响，dl/dt由线路电感(含尖峰抑制器变化电感)决定，需精准测算。

纳米晶磁芯在尖峰抑制器中的优势

纳米晶磁芯在尖峰抑制器中表现卓越

- 高磁导率可高效抑制小电流尖峰;
- 相比传统材料具有更高的饱和特性，能稳定应对更大的电流浪涌;
- 低磁芯损耗可提升能源效率，降低便携式电子设备与节能电源的功耗。

拓展应用场景

纳米晶尖峰抑制器还可应用于汽车电子领域(用于保护车载控制器ECU，稳定车辆电气系统)，以及可再生能源系统(用于平滑电压波动，提升光伏/电设备的运行可靠性)。