

# VITROPERM

## Molded Chokes



### A new approach to cost effective small volume DC/DC-converters for automotive and industrial applications

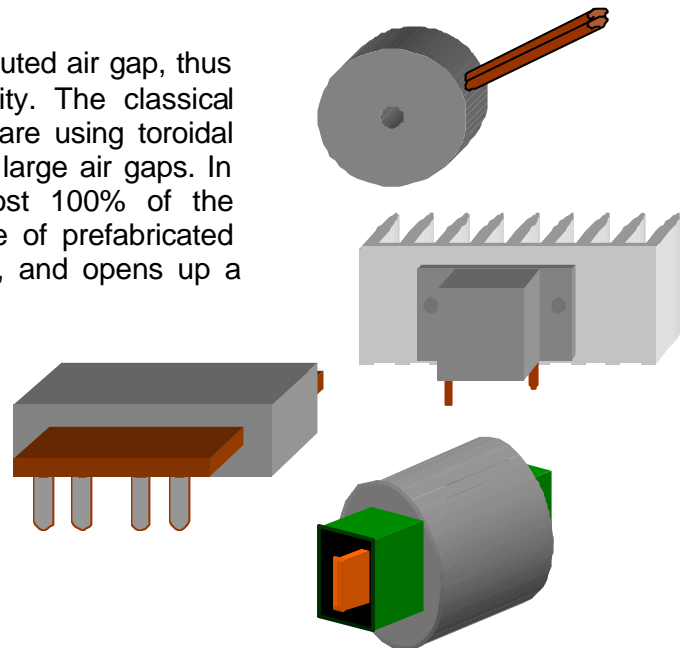
Vacuumschmelze now offers a new type of power component based on VAC nanocrystalline soft magnetic metal VITROPERM.

**VITROPERM-Molded-Chokes** are made from nanocrystalline powder, molded complete with the copper coil and a high temperature plastic resin to the final shape of the component. \*)

The remarkable features of nanocrystalline VITROPERM for use as soft magnetic core material are the high saturation flux density (approx. 1.2 T), the very low coercivity field and the low power losses. These features remain unchanged during milling, so that the powder has the final magnetic properties and needs no sintering or other heat treatment after bringing it to the desired shape. No crystalline material can offer this scale of properties.

**VITROPERM-Molded-Chokes** are chokes with distributed air gap, thus exhibiting high storage energy and DC-bias capability. The classical solutions for the corresponding fields of applications are using toroidal powder cores or laminated metal or ferrite cores with large air gaps. In contrast, this new technology makes use of almost 100% of the component volume for the magnetics, allows the use of prefabricated coils and thus a fully automated production process, and opens up a nearly infinite variety of shapes and designs.

A cylinder shaped pot core-like design, a heat sink mountable choke, an air gap free planar choke with PCB multilayer winding or a filter choke with integrated connectors are only a few examples. A marked reduction in component size and component cost will be the result.



\*) Several patents pending.

## Preferred Fields of Application

The material properties of the VITROPERM powder compound are close to those of well known Sendust or similar toroidal cores. This material is not offered in a molded toroidal shape because classical toroid design limitations and winding techniques still apply to such components. The huge advantages of the VITROPERM Molded Chokes arise from the unique production technology through totally incorporating the copper coil into the magnetic material.

The choke size is dependent on the storage energy and the AC-contribution to the current. The preferred storage energy range is 1mWs up to 100 mWs .

**VITROPERM-Molded-Chokes** are the best solution in cases where the **component volume** and the **flexibility in shape** are determining factors. Considering the possibilities of this technology during the initial stages of system design ensures full utilization of all its advantages. System solutions must not only focus on technical requirements but also consider that the production process needs high quantities to be economical.

- **VITROPERM-Molded-Chokes are a basis of advanced system solutions rather than a replacement of classic components in existing solutions!**

**VITROPERM-Molded-Chokes** exhibit **low power losses** in the magnetic material. The level of typical loss density is between those of Sendust and MPP cores. This, in combination with the higher flexibility in the coil design, makes the new technology superior to the more classic solutions in applications with a large high frequency AC-contribution to the current as in:

- **Buck- and Boost-converters (DC/DC-converters),**
- **power factor correction circuits and in-line noise filters,**
- **resonant mode or quasi-resonant mode push-pull-converters.**

**VITROPERM-Molded-Chokes** are excellent for use in **heat sink applications**. The high thermal conductivity of the Vitroperm powder compound ensures good coupling between the magnetic material, copper windings and heat sink. When compared to classic solutions, temperature rise can be reduced **or** the design can result in smaller component volume.

## Availability

Samples of **VITROPERM-Molded-Chokes** with simple rectangular shapes (no complicated tools required) are available in about one month. This normally includes the design by VAC, according to customer's requirements. Sample quantities are limited by economical reasons only.

The production process is not a fundamentally new technology but it is still being developed, investment has to be done and the production line has to be installed. Price estimations and budgetary quotes will be made according to the current state of the process development.

## Comparison with Conventional Chokes

The volume  $V$  of a component can be described by the following relation

$$V \propto b_{-}^2 * \sqrt{P_1 * R_{th}} * \frac{V_{comp}}{V_{mag}}$$

For **VITROPERM-Molded-Chokes** the DC-bias capability  $b_{-}$  and power losses  $P_1$  are comparable to solutions with conventional high grade powder cores. But the design factor  $V_{comp}/V_{mag}$  makes the large difference! The total component volume  $V_{comp}$  is only slightly larger than the volume of the magnetic core material  $V_{mag}$ . That means, the design allows ideal utilization of the available volume. Another important difference arises from the high thermal conductivity of the VITROPERM powder compound and is utilized when the component is mounted on a heat sink.

Comparison of design factors:  $\frac{V_{comp}}{V_{mag}} \approx 1.2$  for **VITROPERM Molded Chokes**

and for conventional toroidal core designs:   
 2.5 wound core only, no casing;   
 4.0 potted component, rectangular casing

Comparison of heat dissipation, when the choke is mounted on a heat sink:

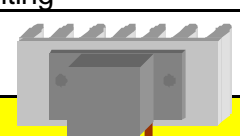
$$R_{th} \approx \frac{250}{\text{surface}} \frac{\text{cm}^2\text{K}}{\text{W}} \text{ for VITROPERM Molded Chokes}$$

$R_{th} \gg (500 / \text{surface}) \text{ cm}^2\text{K}/\text{W}$  for conventional toroidal core designs.

**Example 1: Choke in a DC/DC-converter for the 14V/42V vehicle electric system.**

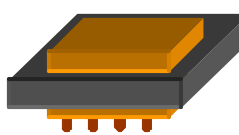
Data:  $L = 4.5 \mu\text{H}$ ;  $I = 50 \text{ A}$ ;  $\Delta I = 20 \text{ A}$ ;  $f = 100 \text{ kHz}$ ;  $T_{amb.} = 105 \text{ }^\circ\text{C}$ .



	Natural cooling	Heat sink mounting
conventional solution with High Flux toroidal core (potted)	$V \gg 65 \text{ cm}^3$	$V \gg 50 \text{ cm}^3$
<b>VITROPERM-Molded-Choke</b>	$V \gg 40 \text{ cm}^3$ .	<b><math>V \gg 28 \text{ cm}^3</math></b>



**Example 2: 200 W-SMPS with PFC circuitry. Choke for the boost converter.**

Data:  $L = 500 \mu\text{H}$ ;  $I = 2 \text{ A}$ ;  $\Delta I = .6 \text{ A}$ ;  $f = 100 \text{ kHz}$ ;  $T_{amb.} = 60 \text{ }^\circ\text{C}$ , natural cooling.

Conventional solution: Ferrite EF 25 (or Sendust toroidal core with  $V \approx 8.5 \text{ cm}^3$ )   $V \gg 10 \text{ cm}^3$

**VITROPERM-Molded-Choke**    $V = 5 \text{ cm}^3$ .

## Prototypes of VITROPERM-Molded-Chokes

$L = 3 \times 11 \mu\text{H}$

$I = 3 \times 25 \text{ A}$

$\Delta I = 8 \text{ A}$

$f = 100 \text{ kHz}$

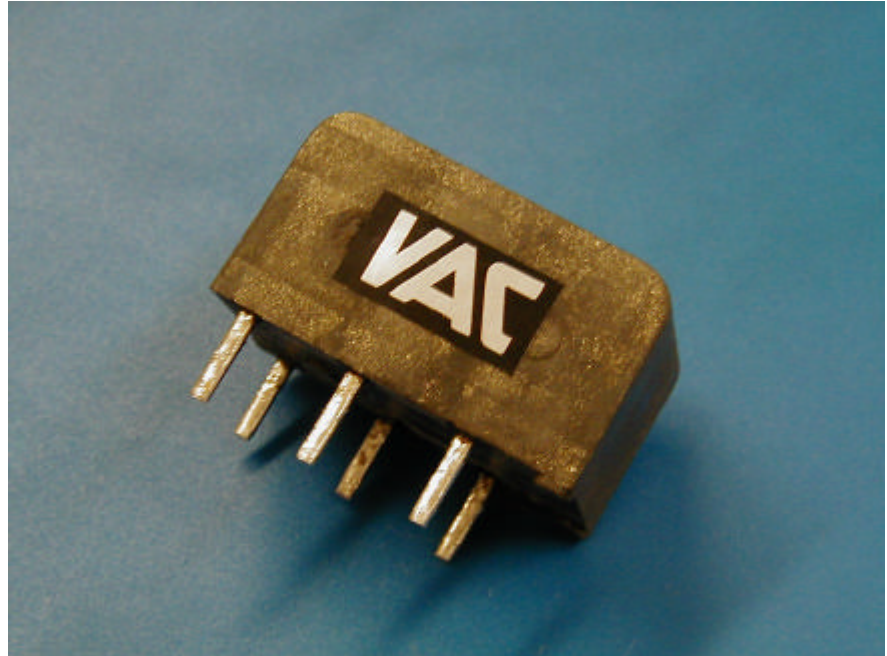
$P_L = 6.3 \text{ W}$

Heat sink mounting

$T_{\text{heat sink}} = 85 \text{ }^\circ\text{C}$

Dimension:

$1.1 \times 1.14 \times 1.97 \text{ in}^3$



Triple-Choke for a 3-phase-converter in the 14V/42V vehicle electric system

$L = 13 \mu\text{H}$

$I = 30 \text{ A}$

$\Delta I = 10 \text{ A}$

$f = 100 \text{ kHz}$

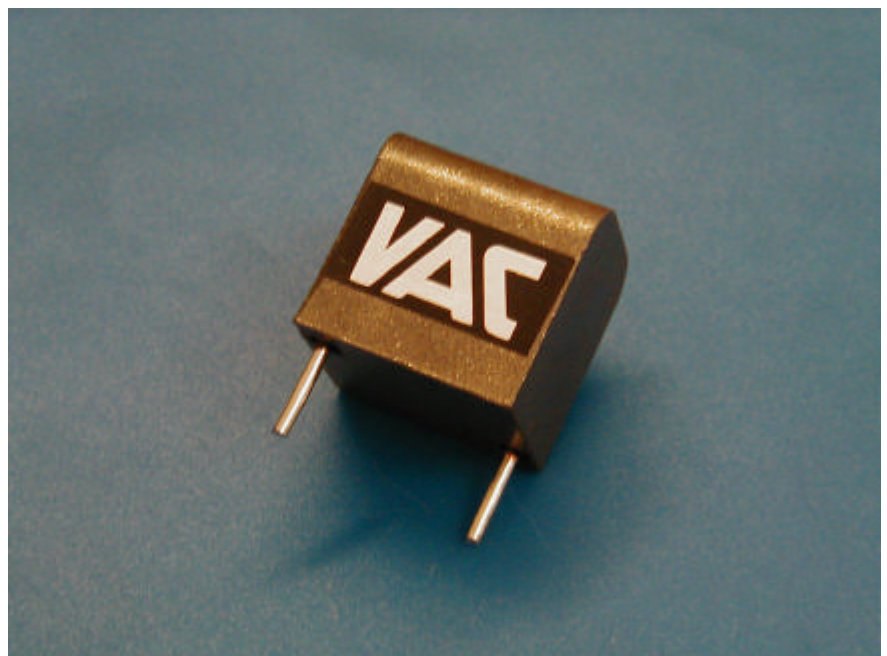
$P_L = 4.9 \text{ W}$

Heat sink mounting

$T_{\text{heat sink}} = 85 \text{ }^\circ\text{C}$

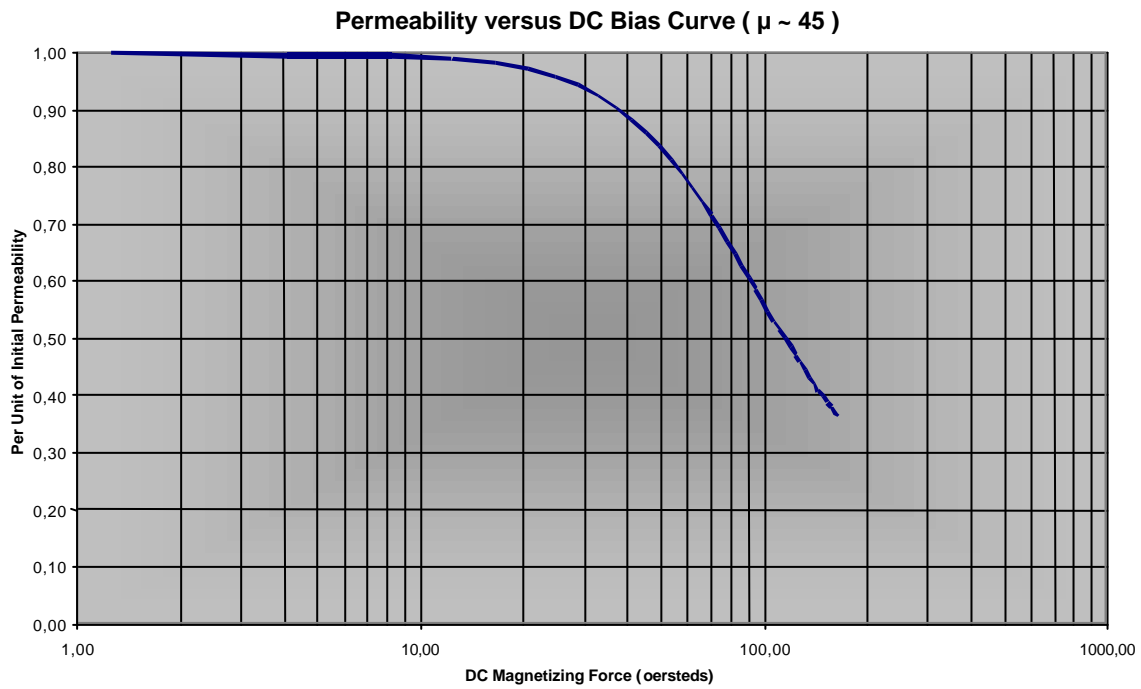
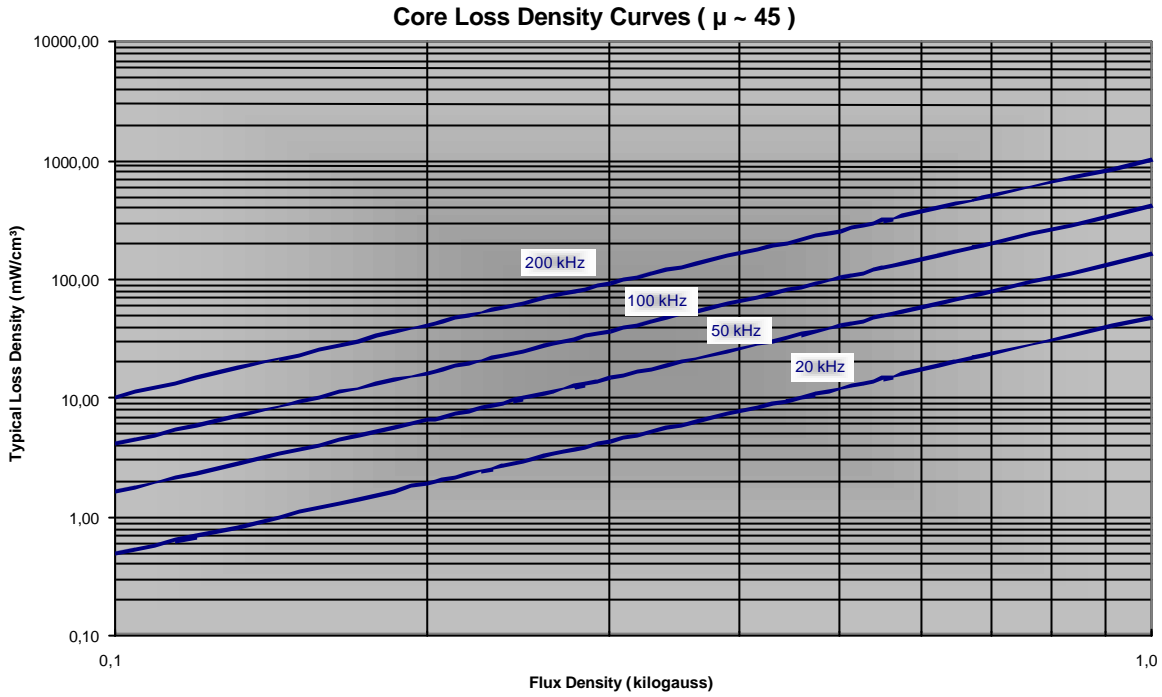
Dimension:

$1.0 \times 1.06 \times 1.06 \text{ in}^3$

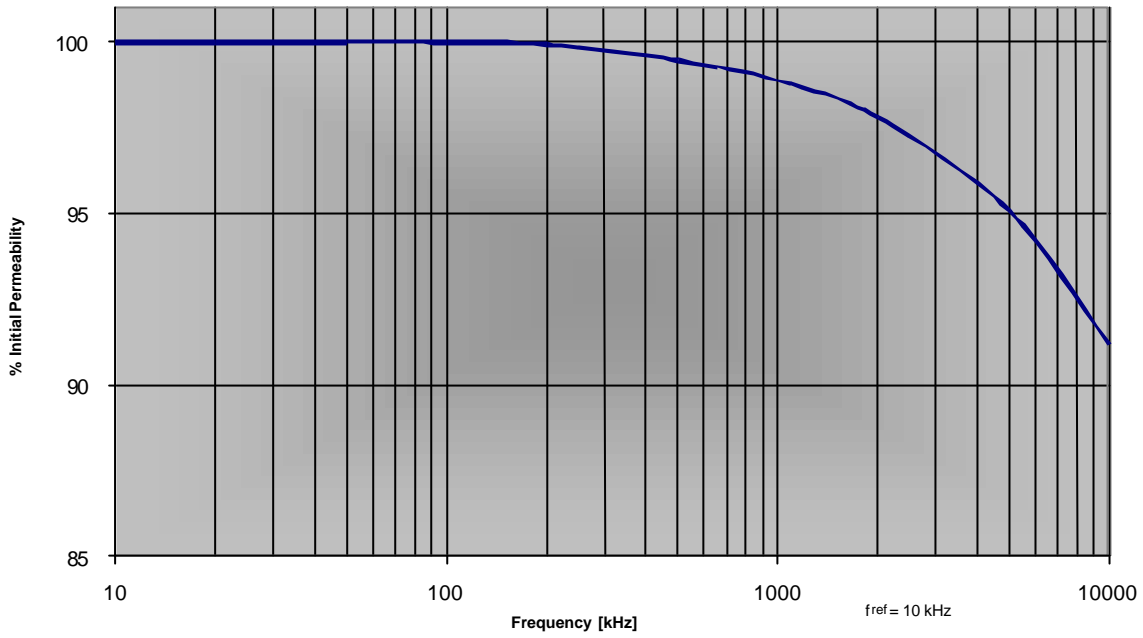


Single-phase Choke for a DC/DC-Converter

**VITROPERM Molded Chokes : Material Data\***



Permeability versus Frequency Curve,  $\mu \sim 45$



\* preliminary data