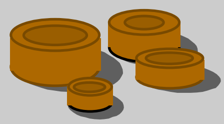
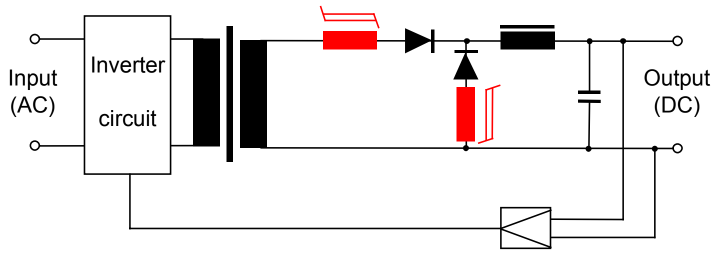
# amorphous VITROVAC 6025Z
# Tape-wound cores for Spike Blocker



Our amorphous VITROVAC 6025 Z tape-wound cores are well established in Switched-Mode Power Supplies (SMPS), Frequency Inverters, UPS and other applications for effective noise suppression caused by rapid changes in current. The Spike Blocker is often used as single-turn choke or with very few turns of copper wire only. It is an easy to install and effective solution to act against the source of spike noise.




VITROVAC 6025 Z amorphous cores feature lowest core losses and a very high squareness of the hysteresis loop resulting in a high inductance when the current crosses zero. This high inductance effectively blocks reverse recovery currents created by diodes. The material saturates at relative small currents. Thus, spike blocking is not possible at DC currents.

### Basic Principle of Operation

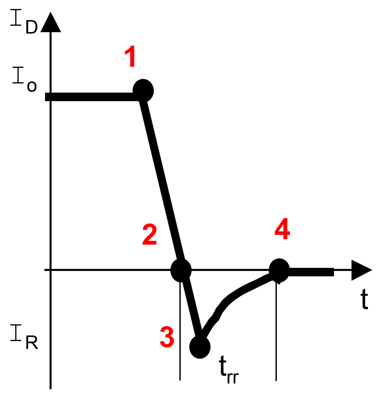



Fig. 1: Current in diode **without** Spike Blocker

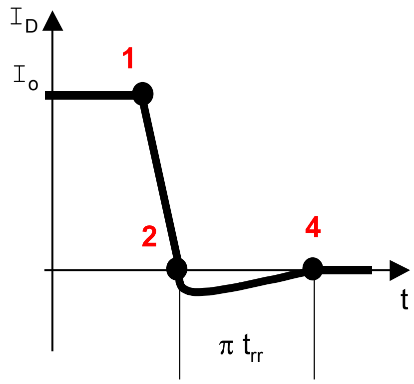



Fig. 2: Current in diode **with** Spike Blocker

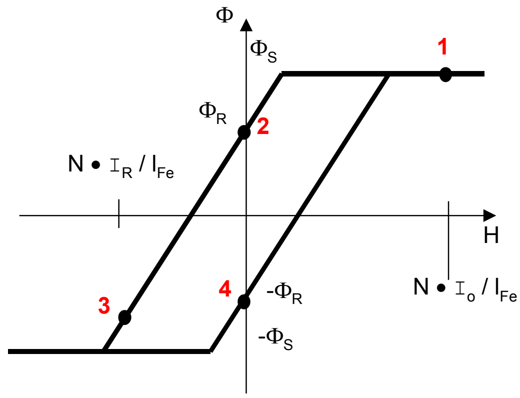



Fig. 3: Schematic hysteresis loop of Spike Blocker

Figure 1 and 2 show the current through the diode ($I_D$) with and without Spike Blocker, figure 3 the corresponding hysteresis loop of the core material. The Spike Blocker is saturated (= very low inductance) before and at operating point 1 and shifts to its remanence point (2) when the current is switched off. The reverse recovery effect of the diode continues to decrease the current below zero. Now, the high permeability of the amorphous material respectively high inductance of the Spike Blocker suppresses effectively current spikes with high $dI/dt$ and enabling a so-called „soft-recovery“ of the diode (see figure 2) with decreased $dI/dt$. $I_R$ is the max. reverse current of the diode corresponding to operating point 3 of the hysteresis loop. But the high inductance prevents the Spike Blocker to reach the theoretical operating point 3. The material remains in the opposite remanence (operating point 4) to get again magnetized during the next switching cycle.

### Basic Design and Calculation Equations:

Required data:
- voltage over diode in blocking direction $U_R$ [V]
- reverse recovery time of diode $t_{rr}$ [s]
- current over diode $I_o$ [A]
( - switching frequency f [Hz] )

The following basic condition must be fulfilled for the Spike Blocker:

$$\Phi \bullet W_a \geq \pi \bullet t_{rr} \bullet U_R \bullet I_o / S / f_{Cu}\ [\mathrm{Vs\ mm^2}] \qquad (1)$$

with:

| | | | |
|---|---|---|---|
| with: | $\Phi$ | = | magnetic core flux in Vs |
| | $W_a$ | = | max. geometric winding area of the core in mm$^2$ |
| | S | = | current density of the copper wire in A/mm² |
| | $f_{Cu}$ | = | copper filling factor, $f_{Cu}$ = 0.3 to 0.4 for wound chokes, $f_{Cu}$ = 1 for $d_{Cu} \approx$ core I.D. |

Assuming a wound choke with a medium wire current density, equation 1 can be reduced as follows:

$$\Phi \bullet W_a \geq 1.5 \bullet t_{rr} \bullet U_R \bullet I_o\ [\mathrm{Vs\ mm^2}] \qquad (1a)$$

The wire diameter $d_{Cu}$ can be calculated according:

$$d_{Cu} = (4 / \pi \bullet I_o / S)^{1/2}\ [\mathrm{mm}] \qquad (2)$$

The required min. no. of turns can be calculated for a given core size:

$$N \geq \pi \bullet t_{rr} \bullet U_R / \Phi \qquad (3)$$

**VACUUMSCHMELZE GMBH & Co. KG**, P.O. Box 2253, D-63412 Hanau, Germany Tel: +49 6181 38-0 FAX: +49 6181 382075

**Core selection:**

- Calculate right side of equation 1 (or 1a) and select the smallest sized core from the standard core table that fulfills equation 1 (or 1a).
- Determine wire diameter according equation 2.
- Calculate and determine no. of turns according equation 3.
- Experimental testing.

**Design considerations:**

The operating temperature of amorphous VITROVAC 6025 Z cores should not exceed 90°C for continuous operation with hot spot temperatures of 120°C for short time.

The accuracy of all calculations are mainly determined by the correct value of the reverse recovery $t_{rr}$ time of the diode. It is influenced by temperature and by dI/dt during operation. The value of dI/dt is determined by the inductances of the circuit including the changing inductance of the Spike Blocker.

## Core informations:

Our amorphous VITROVAC 6025 Z cores are preferably supplied in plastic protective cases, adding silicone rubber (Fix 022). This finish is suitable for direct winding and offers optimum mechanical protection for the core, and thus the best magnetic properties.
The resins used for the plastic cases are according to UL94V-0 or UL94V-1. Epoxy coated (Fix 350) core designs aswell as many other core sizes are available on request.

## Material data of VITROVAC 6025Z:

| | typical values |
|---|---|
| Saturation flux density (25 °C), $B_s$ | **0.58 T** |
| Bipolar flux density swing (25 °C) | **1.15 T** |
| Bipolar flux density swing ( 90 °C) | **1.0 T** |
| Squareness, $B_r$ / $B_s$ | **> 95 %** |
| Saturation magnetostriction (25 °C) | **< 0.2 × 10$^{-6}$** |
| Curie temperature, $T_c$ | **240 °C** |
| Continuous upper operation temperature | **90 °C** |

## amorphous VITROVAC 6025 Z cores for Spike Blocker, standard sizes:

| **core dimensions** | **finished dimensions (limiting values)** O.D. mm | I.D. mm | H mm | **core cross-section** $A_{Fe}$ cm² | **mean core path length** $l_{Fe}$ cm | **core mass** $m_{Fe}$ g | **total flux** [1] **(25°C)** $\phi$ µVs | **total flux** [1] **(90°C)** $\phi$ µVs | $W_a \cdot \phi$ Vs mm$^2$ | **single turn choke** $R_{th}$ K/W | **wound choke** $R_{th}$ K/W | **part number, order code** T6000... |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10×8×4 | 11.6 | 6.5 | 5.1 | 0.032 | 2.83 | 0.7 | 3.7 | 3.2 | 106 * 10$^{-6}$ | 99 | 56 | 6-E4010-**W534** |
| 10.1×6.9×4.5 | 11.6 | 5.5 | 6.0 | 0.058 | 2.67 | 1.2 | 6.7 | 5.8 | 138 * 10$^{-6}$ | 95 | 57 | 6-E4010-**W663** |
| 12.8×9.5×3.2 | 14.7 | 7.9 | 4.8 | 0.042 | 3.50 | 1.1 | 4.8 | 4.2 | 206 * 10$^{-6}$ | 79 | 44 | 6-E4012-**W464** |
| 12×8×4.5 | 14.0 | 6.6 | 6.2 | 0.07 | 3.14 | 1.7 | 8.1 | 7.0 | 246 * 10$^{-6}$ | 78 | 47 | 6-E4012-**W547** |
| 12.5×10×5 | 14.0 | 8.5 | 6.8 | 0.050 | 3.53 | 1.4 | 5.8 | 5.0 | 284 * 10$^{-6}$ | 76 | 42 | 6-E4012-**W535** |
| 14×8×4.5 | 15.5 | 6.5 | 5.7 | 0.108 | 3.46 | 2.9 | 12.4 | 10.8 | 358 * 10$^{-6}$ | 72 | 44 | 6-E4014-**W481** |
| 16×10×6 | 17.9 | 8.2 | 8.2 | 0.144 | 4.08 | 4.5 | 16.6 | 14.4 | 760 * 10$^{-6}$ | 57 | 34 | 6-E4016-**W536** |
| 17.5×12.5×6 | 19.1 | 10.9 | 8.1 | 0.120 | 4.71 | 4.4 | 13.8 | 12.0 | 1120 * 10$^{-6}$ | 54 | 30 | 6-E4017-**W537** |
| 19×15×5 | 21.2 | 13.0 | 7.3 | 0.080 | 5.34 | 3.3 | 9.2 | 8.0 | 1062 * 10$^{-6}$ | 49 | 27 | 6-E4019-**W539** |
| 19×15×10 | 21.2 | 13.0 | 12.3 | 0.160 | 5.34 | 6.6 | 18.4 | 16.0 | 2124 * 10$^{-6}$ | 43 | 24 | 6-E4019-**W540** |
| 20×12.5×8 | 22.6 | 10.3 | 10.2 | 0.240 | 5.10 | 9.4 | 27.6 | 24.0 | 2000 * 10$^{-6}$ | 43 | 26 | 6-E4020-**W538** |
| 25×16×10 | 27.9 | 13.6 | 12.5 | 0.360 | 6.44 | 17.9 | 41.4 | 36.0 | 5230 * 10$^{-6}$ | 33 | 19 | 6-E4025-**W541** |
| 25×20×10 | 27.7 | 17.1 | 12.9 | 0.200 | 7.10 | 10.9 | 23.0 | 20.0 | 4593 * 10$^{-6}$ | 33 | 18 | 6-E4020-**W542** |
| 30×20×10 | 32.8 | 17.6 | 12.5 | 0.400 | 7.85 | 24.2 | 46.0 | 40.0 | 9731 * 10$^{-6}$ | 28 | 16 | 6-E4030-**W543** |
| 40×25×15 | 43.1 | 22.4 | 18.5 | 0.900 | 10.2 | 70.8 | 103.5 | 90.0 | 35467 * 10$^{-6}$ | 19 | 11 | 6-E4040-**W544** |
| 40×32×15 | 43.3 | 28.8 | 18.3 | 0.480 | 11.3 | 41.8 | 55.2 | 48.0 | 31269 * 10$^{-6}$ | 19 | 11 | 6-E4040-**W545** |

[1] $\Phi = 2 \times B_s \times A_{Fe}$