Cores for Common Mode Noise Suppression for Automotive Applications

- Developed for noise suppression of the high-voltage DC battery or at the DC output of the drive inverter as well as at the AC output of the drive inverter in hybrid and electric vehicles.
- Automotive qualified according to AEC-Q200
- Ambient temperature: $T_a = -40^\circ C \ldots +105^\circ C$
- Max. continuous operating temperatures depending on type $T_{op} = +130^\circ C$ or $T_{op} = +150^\circ C$
- Production in IATF 16949 certified VAC production facilities
- Design with plastic housing taking into account “Technical cleanliness” according to VDA 19 Part 2 and ZVEI guideline “Technical Cleanliness in Electrical Engineering”

General advantages and benefits of nanocrystalline cores

- Small size
  - High $\mu$, high $B_s$
- Suitable for high currents and/or high voltages
  - High $\mu$, high $B_s$, optimized core designs
- Compact filter concepts possible
  - Extremely broadband attenuation behaviour, high permeability, low capacitance designs, slow $\mu$-decrease towards high frequencies, low Q-factor in the range of 150 kHz
- High efficiency, low power losses
  - Low number of turns required for high $L$, ideally no turn required, filter stage reduction
- Suitable for high and low ambient temperatures and high working temperatures
  - High Curie temperature, material properties ($\mu$, $B_s$, $\lambda_s$) almost temperature-independent
- “Easy filter design”
  - Material properties ($\mu$, $B_s$, $\lambda_s$) almost temperature-independent, constant impedance over a wide common mode current range due to linear magnetization curve
- Optimal adapted solutions available for various applications
  - Different $\mu$ levels, different VITROPERM alloys
VITROPERM: Making the most of iron

The nanocrystalline VITROPERM® alloys are materials based on iron, silicon and boron with additions of niobium and copper. By using rapid solidification technology, which VAC is one of only very few companies in the world to have mastered, they are produced as thin strips in a single step in their final thickness of approximately 18 μm. High-purity raw materials are melted at 1300 °C and cast onto a cooled, spinning copper wheel. A cooling rate of 1 million degrees Kelvin per second results in an amorphous ribbon, which undergoes a heat treatment at 500 °C to 600 °C to form the nanocrystalline microstructure. On special winding machines, the strips are further processed into toroidal tape-wound cores with outside diameters of 2 mm to 600 mm.

The two-phase structure with fine crystalline grains (mean diameter 10 - 40 nm) resulting from the heat treatment is embedded in an amorphous residual phase. This structural feature is the prerequisite for achieving the highest permeability and the lowest coercivity values. In addition, the low ribbon thickness and the relatively high electrical resistance of 1.1 - 1.2 μΩm ensure the lowest eddy current losses and an excellent frequency response of the permeability. The combination of these properties together with a saturation flux density of 1.2 T and excellent thermal properties, make the nanocrystalline soft magnetic state-of-the-art VITROPERM material the universal solution for EMC problems, superior in many ways to conventional ferrites and amorphous material solutions.

Nanocrystalline cores and components have already been used with great success for many years in common mode suppression chokes (CMC) in automotive applications due to their superior soft magnetic properties. Through the use of cost-effective alloying elements (Fe based) and modern large-scale series production, VITROPERM has already established itself as a competitive solution in many diverse applications.
## Toroidal cores

<table>
<thead>
<tr>
<th>Type</th>
<th>Dimension (d_x \times d_i \times h) [mm]</th>
<th>(A_{10}), nominal* [µH]</th>
<th>Saturation current (I_{cm}) [A], typical**</th>
<th>Iron cross section (A_{ez}) [cm(^2)]</th>
<th>Mean path length (l_{ez}) [cm]</th>
<th>Weight (m_{ez}) [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>T60006-L...</td>
<td>23.0 x 9.8 x 11.1</td>
<td>20</td>
<td>10 kHz 1.0 100 kHz 1.7</td>
<td>0.25</td>
<td>5.1</td>
<td>9.2</td>
</tr>
<tr>
<td>2020-V311</td>
<td>59.4 x 13.7</td>
<td>23.7</td>
<td>100 kHz 1.3 10 kHz 1.3</td>
<td>0.37</td>
<td>6.4</td>
<td>17.4</td>
</tr>
<tr>
<td>2025-V313</td>
<td>28.1 x 13.1 x 13.1</td>
<td>30.5</td>
<td>20 kHz 1.6 10 kHz 1.6</td>
<td>0.58</td>
<td>7.9</td>
<td>33.6</td>
</tr>
<tr>
<td>2025-V314</td>
<td>70.2 x 16.2</td>
<td>90.4</td>
<td>80 kHz 0.3 50 kHz 0.4</td>
<td>0.87</td>
<td>10.2</td>
<td>65.4</td>
</tr>
<tr>
<td>2030-V315</td>
<td>33.1 x 17.0 x 18.1</td>
<td>35.2</td>
<td>150 kHz 2.0 100 kHz 2.1</td>
<td>1.23</td>
<td>17.8</td>
<td>160</td>
</tr>
<tr>
<td>2030-V316</td>
<td>104 x 24.0</td>
<td>28.6</td>
<td>250 kHz 3.5 200 kHz 3.6</td>
<td>0.20</td>
<td>7.1</td>
<td>10.6</td>
</tr>
<tr>
<td>2040-V317</td>
<td>66.8 x 46.1 x 28.4</td>
<td>85</td>
<td>300 kHz 0.7 250 kHz 0.8</td>
<td>0.41</td>
<td>5.7</td>
<td>17.2</td>
</tr>
<tr>
<td>2040-V318</td>
<td>121 x 6.4</td>
<td>12.1</td>
<td>400 kHz 1.4 300 kHz 1.4</td>
<td>0.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2025-V321</td>
<td>36.4 x 0.3</td>
<td>12.1</td>
<td>500 kHz 1.4 400 kHz 1.4</td>
<td>0.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2025-V322</td>
<td>30 x 1.1</td>
<td>30</td>
<td>600 kHz 1.4 500 kHz 1.4</td>
<td>0.7</td>
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<td></td>
</tr>
<tr>
<td>2022-V323</td>
<td>90.6 x 20.6</td>
<td>90.6</td>
<td>700 kHz 0.2 600 kHz 0.3</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2022-V324</td>
<td>24.9 x 11.6 x 16.0</td>
<td>24.9</td>
<td>800 kHz 0.1 700 kHz 0.2</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other designs available upon request.

*\(A_{10}\): inductance for \(N = 1\) (tolerance +45% / -25%)

**\(I_{cm}\): the listed saturation currents are guidelines, only. They are calculated for nominal core dimensions at room temperature and for approx. 70% saturation flux density.

### Example: T60006-L2025-V314

\[ m_{ez} \approx 14.7 \text{ g} \]

Fig. 1: Impedance \(|Z|\) [Ω] / frequency [MHz]

Fig. 2: Inductance \(A_e\) [µH] / frequency [MHz]
Oval cores

<table>
<thead>
<tr>
<th>Type</th>
<th>Dimension d_x x d_y x h (mm)</th>
<th>$A_{L0}$ nominal* [µH]</th>
<th>Saturation current $I_{cm}$ [A], typical**</th>
<th>Iron cross section [cm²]</th>
<th>Mean path length [cm]</th>
<th>Weight [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>T60006-</td>
<td></td>
<td>10 kHz</td>
<td>100 kHz</td>
<td>DC</td>
<td>10 kHz</td>
<td>100 kHz</td>
</tr>
<tr>
<td>L…</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2071-V280</td>
<td>75.2 x 42.2 x 25.0</td>
<td>51.3</td>
<td>15.2</td>
<td>1.1</td>
<td>1.2</td>
<td>2.3</td>
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<tr>
<td>2071-V380</td>
<td>25.3 x 42.2 x 25.0</td>
<td>36.7</td>
<td>10.8</td>
<td>1.5</td>
<td>1.6</td>
<td>3.2</td>
</tr>
<tr>
<td>2071-V281</td>
<td>36.7 x 42.2 x 25.0</td>
<td>18.1</td>
<td>9.6</td>
<td>4.6</td>
<td>4.7</td>
<td>7.6</td>
</tr>
<tr>
<td>2071-V381</td>
<td>108.3 x 42.2 x 25.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other designs available upon request.

* $A_{L0}$: Inductance for N = 1 (tolerance +45% / -25%)

** $I_{cm}$: The listed saturation currents are guidelines, only. They are calculated for nominal core dimensions at room temperature and for approx. 70% saturation flux density.

Example: T60006-L2071-V280

$m_{Fe} = 123$ g

Fig. 3: Impedance $|Z|$ [Ohm] / frequency [MHz]

Fig. 4: Inductance $A_L$ [µH] / frequency [MHz]