

NANOPERM® - Design Considerations for advanced EMI filter chokes



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Fritz Rauscher
MAGNETEC GmbH, Booth 525 in Hall 12

Content of presentation

- Nanocrystalline material NANOPERM®
- Current compensated chokes
- Comparison Nanocrystalline and Ferrite core chokes

Considerations about softmagnetic material for EMI filter chokes

Material properties of NANOPERM®

Alloy composition	Fe _{73,5} Cu ₁ Nb ₃ Si _{15,5} B ₇
Saturation flux density B _{sat}	1,2 T
Permeability levels μ	20.000 - 200.000
Saturation magnetostriction λ_s	< 0,5 ppm
Specific electrical resistivity σ	115 $\mu\Omega\text{cm}$
Density γ	7,35 g/cm ³
Curie temperature T _c	~ 600 °C
Max. operational temperature T _{max}	~ 120 °C (180°C)
Core losses (0,3T, 100kHz, sine) P _v	< 110 W/kg
Tape thickness d	17 / 23 μm

Considerations about softmagnetic material for EMI filter chokes

Choice of softmagnetic material

Main requirement on a EMC filter choke:

High impedance $Z(f)$, $f = 150\text{kHz}$ to 30MHz

$$Z(f) = \omega * L(f) = 2\pi * f * L(f)$$

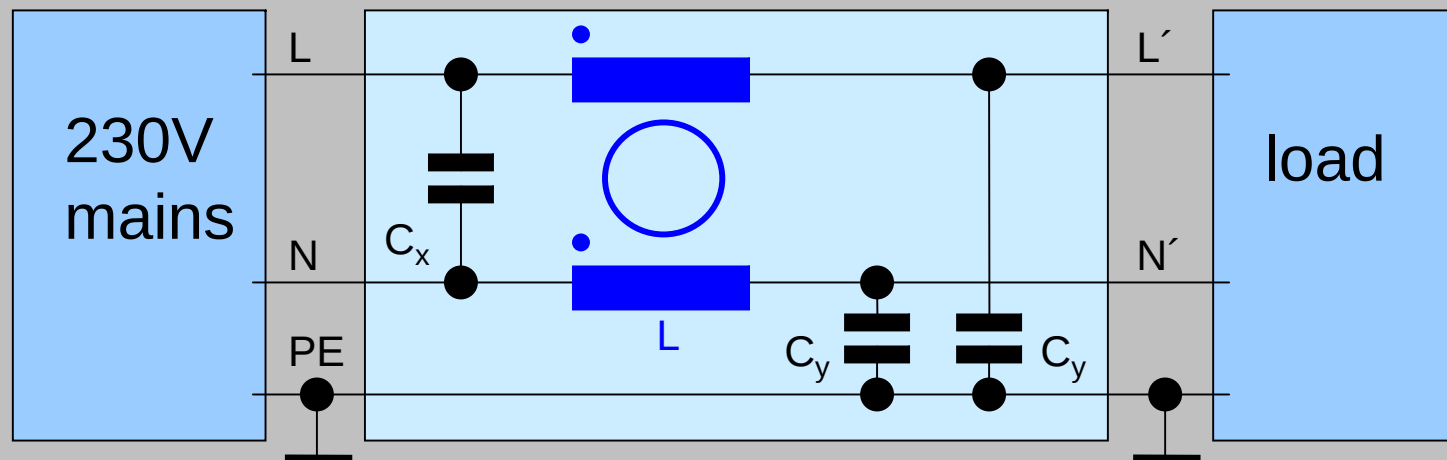
$$L(f) = A_L * n^2 \text{ with } A_L = \mu_0 * \mu_r(f) * A_{fe} / l_f$$

$$Z(f) = 2\pi * f * n^2 * \mu_0 * \mu_r(f) * A_{fe} / l_{fe}$$

n : number of turns μ_r : permeability A_{fe} : Iron cross section

Considerations about softmagnetic material for EMI filter chokes

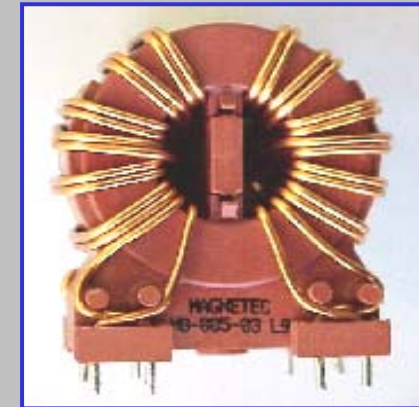
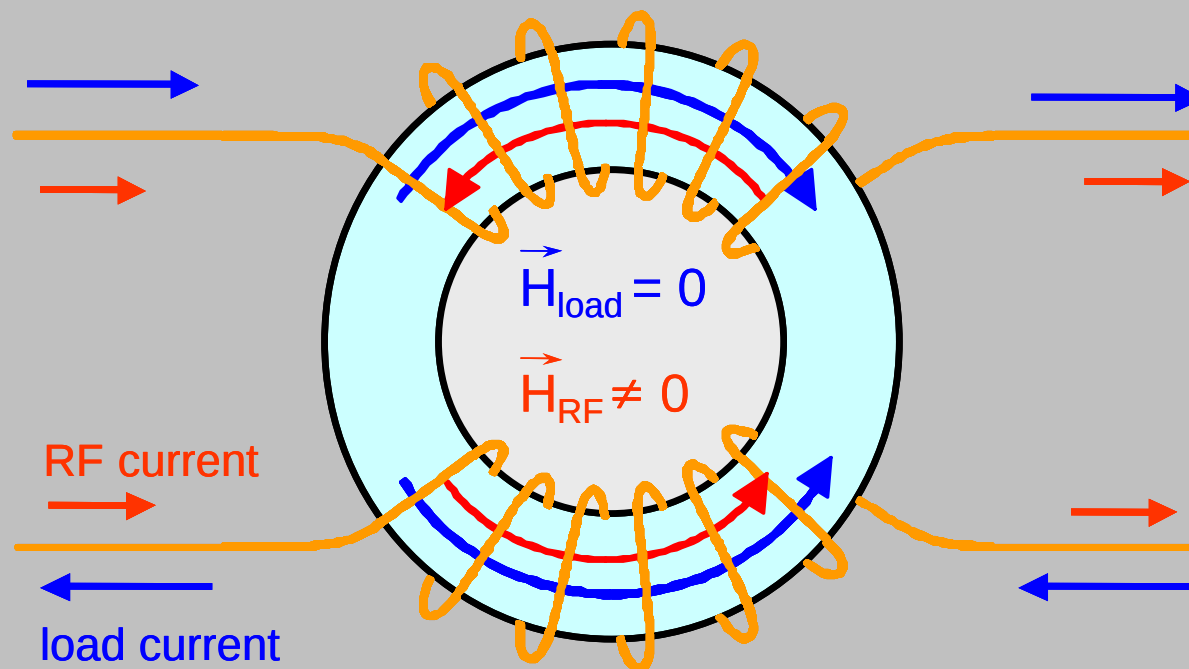
Basic circuitry of a EMI mains filter



C_x : X-capacitor, L : Current compensated choke, C_y : Y-capacitor

Considerations about softmagnetic material for EMI filter chokes

Principle of a CM choke



1-phase version



3-phase version

Considerations about softmagnetic material for EMI filter chokes

Benefits of NANOPERM products



- **High insertion losses**
- **Small build volume**
- **Low earth leakage currents**
- **High working temperature**
- **Best value for the money**

Considerations about softmagnetic material for EMI filter chokes

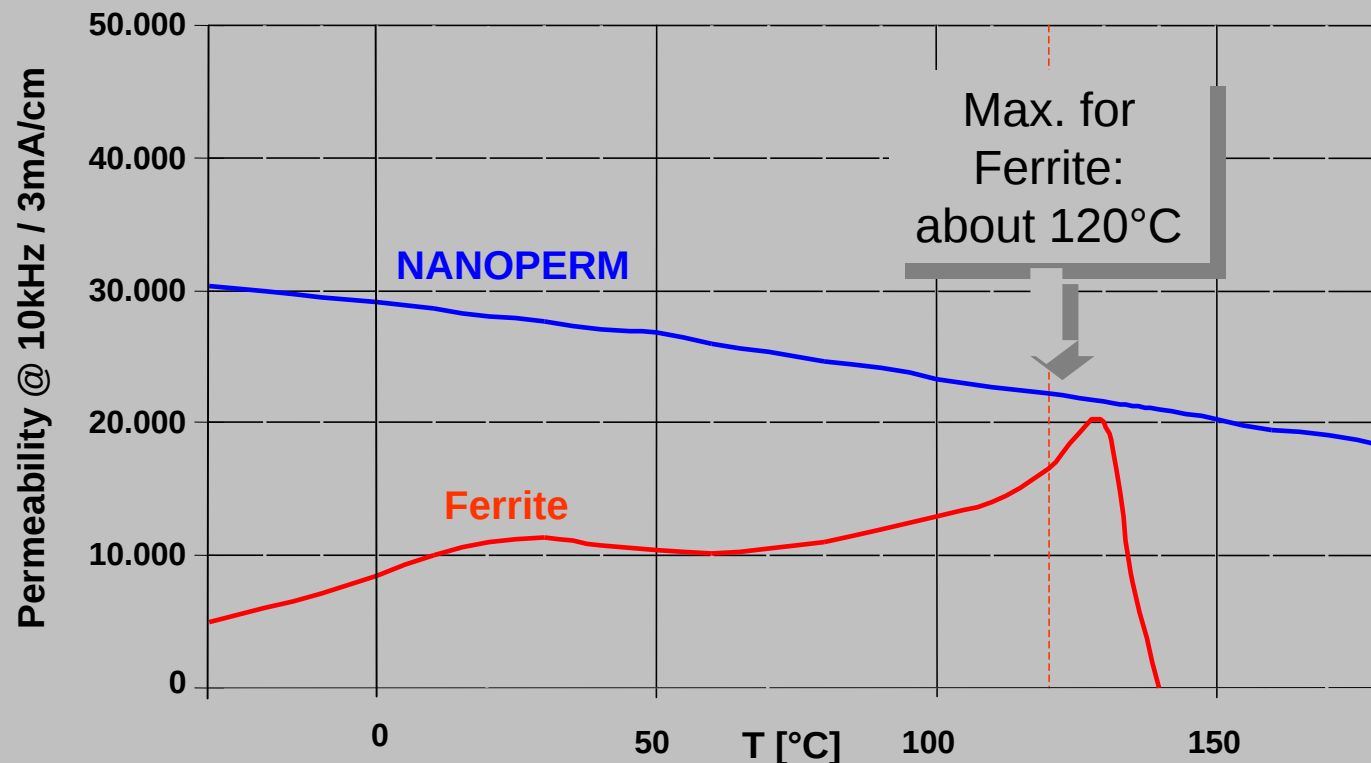
Comparison Ferrite - NANOPERM®

	Ferrite	NANOPERM®
Permeability (@ <u>100kHz</u>)	10.000 – 12.000	20.000 – 30.000
Saturation flux density B_{sat}	400 mT	1180 mT
Curie temperature T_c	~ 130 °C	~ 600 °C
Max. working temperature	95 °C	120 °C (180 °C)
Relative cost	1	~ 2

NANOPERM: ⇒ Advanced, smaller and lighter components!

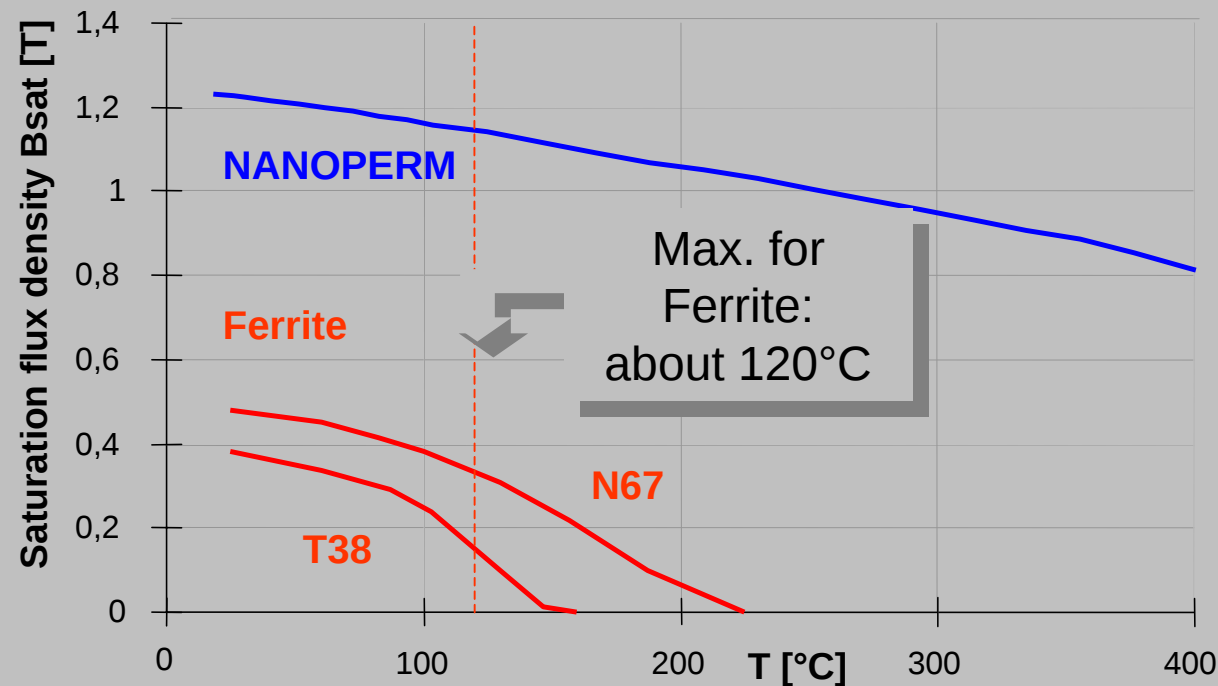
Considerations about softmagnetic material for EMI filter chokes

Permeability as a function of temperature



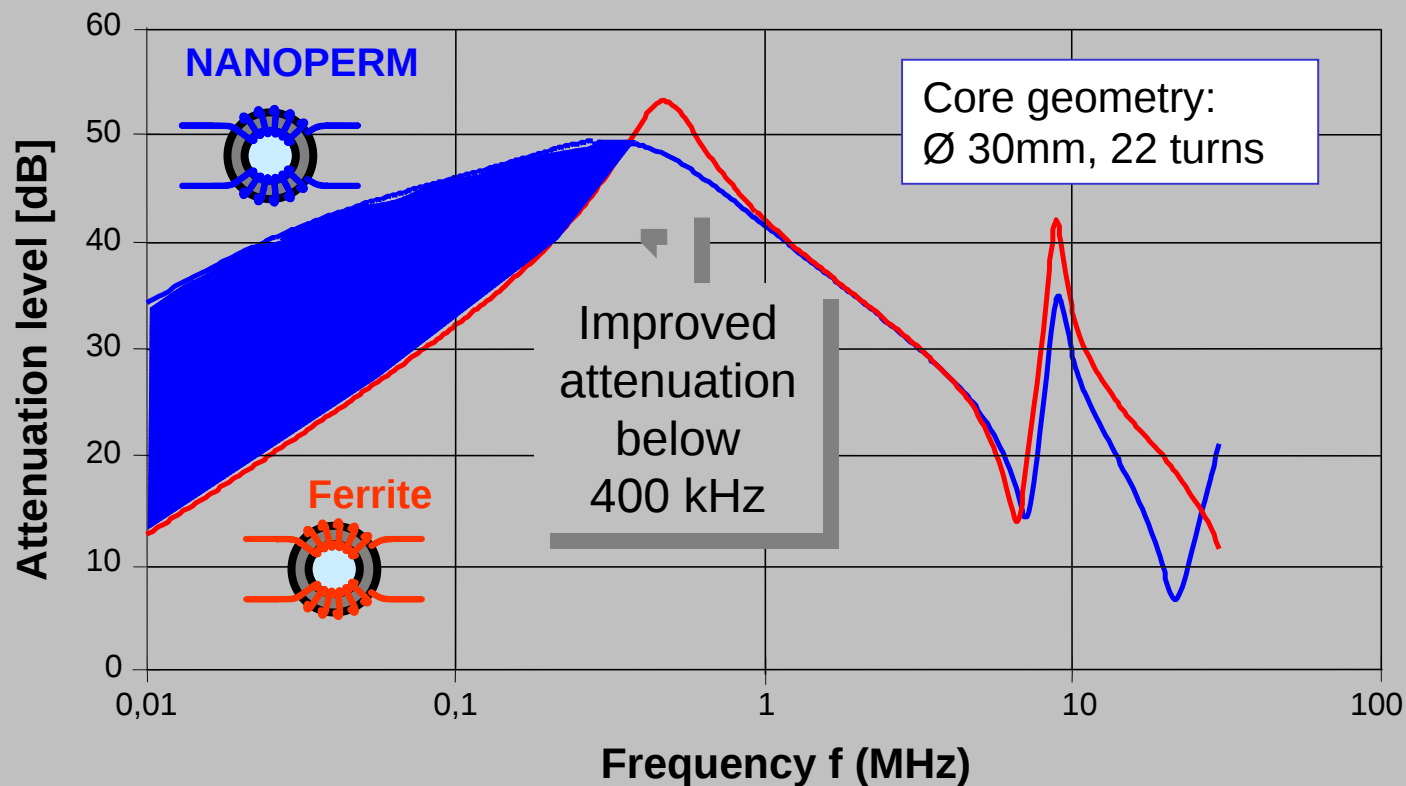
Considerations about softmagnetic material for EMI filter chokes

Saturation flux density as a function of temperature



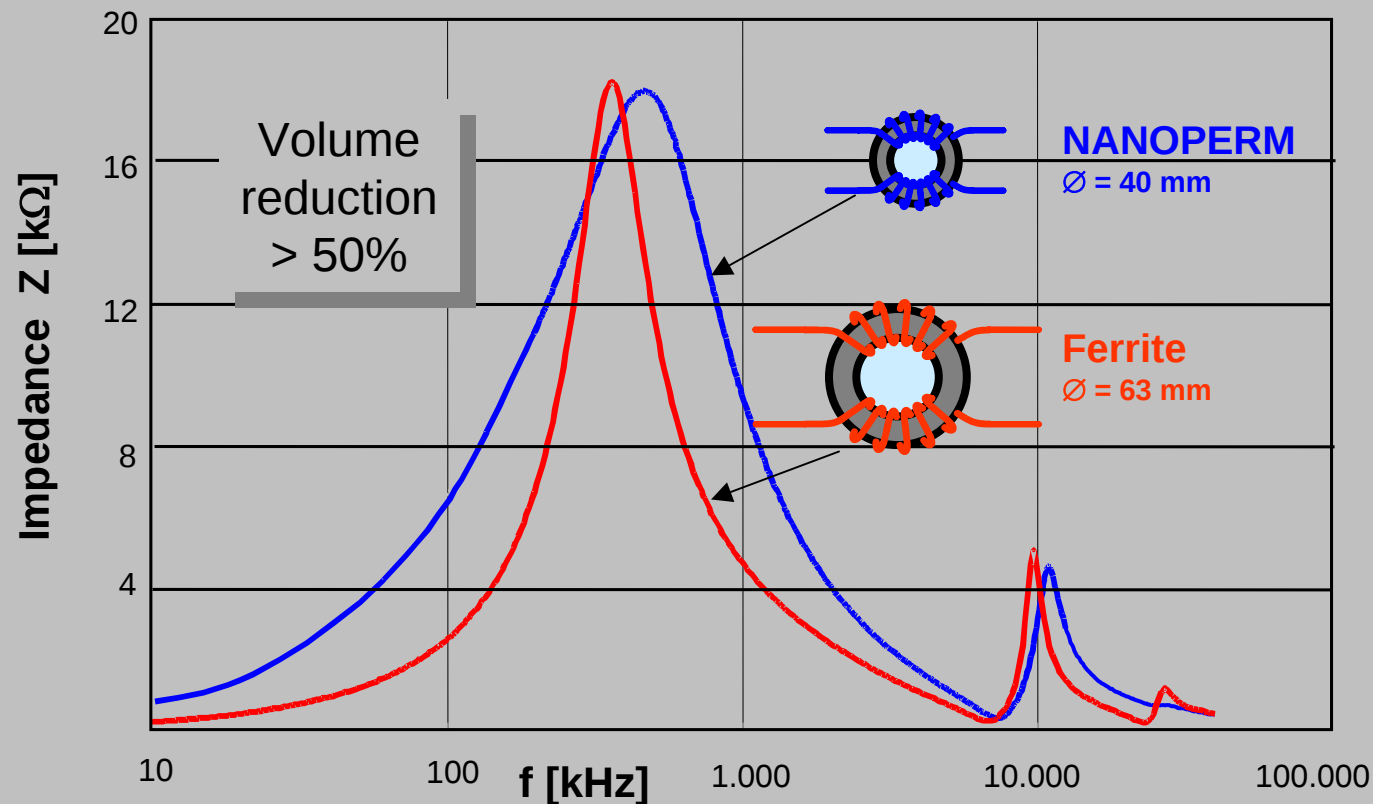
Considerations about softmagnetic material for EMI filter chokes

Better impedance with same core geometries



Considerations about softmagnetic material for EMI filter chokes

Same impedance at smaller volume



Considerations about softmagnetic material for EMI filter chokes

Build volume - real example

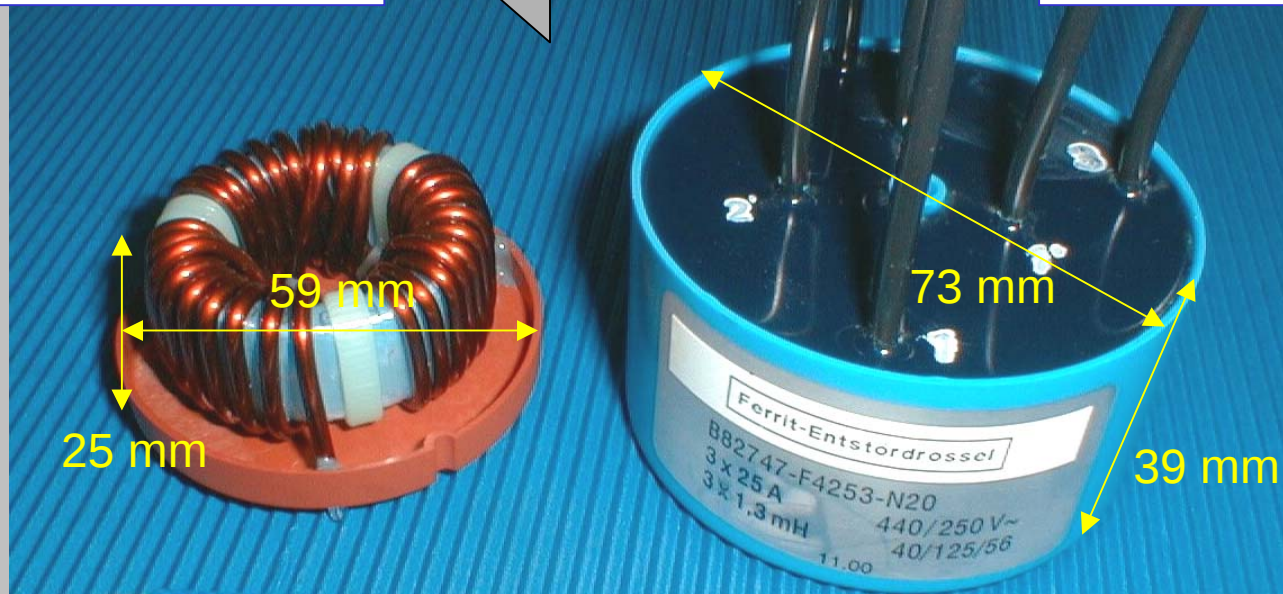
NANOPERM® choke

$I_N = 3 \times 25\text{A} @ 60^\circ\text{C}$
 $L_N = 3 \times 1,6\text{mH} @ 10\text{kHz}$
 $m = 120\text{g}$

Volume reduction 60%
Weight reduction 65%

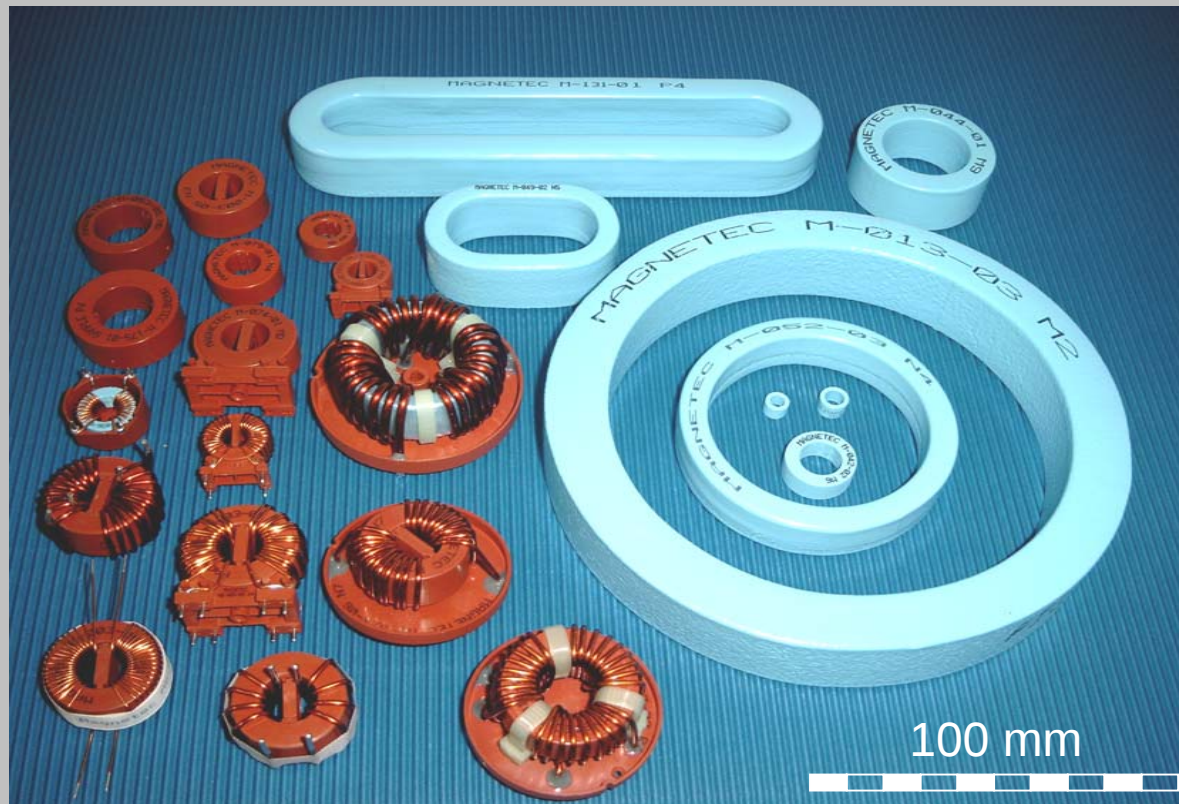
Ferrite choke

$I_N = 3 \times 25\text{A} @ 40^\circ\text{C}$
 $L_N = 3 \times 1,3\text{mH} @ 10\text{kHz}$
 $m = 350\text{g}$



Considerations about softmagnetic material for EMI filter chokes

Available products - cores & chokes



Tape wound
cores from $\varnothing$
12 ... 300mm

1-phase EMC
chokes up to
 $I = 2 \times 60A$

3-phase EMC
chokes up to
 $I = 3 \times 200A$

Considerations about softmagnetic material for EMI filter chokes

Thank you for your attention!

Come and visit us at booth 525!

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