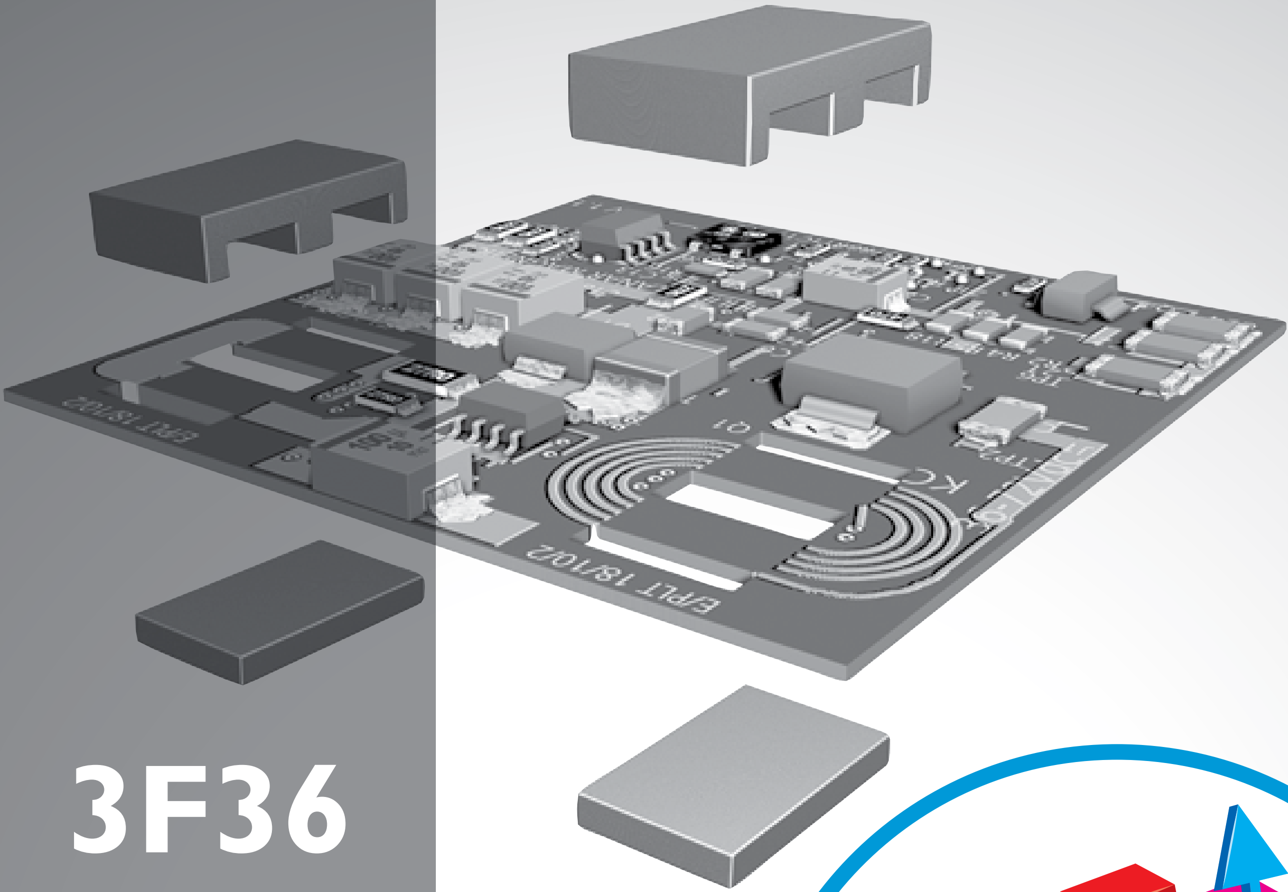
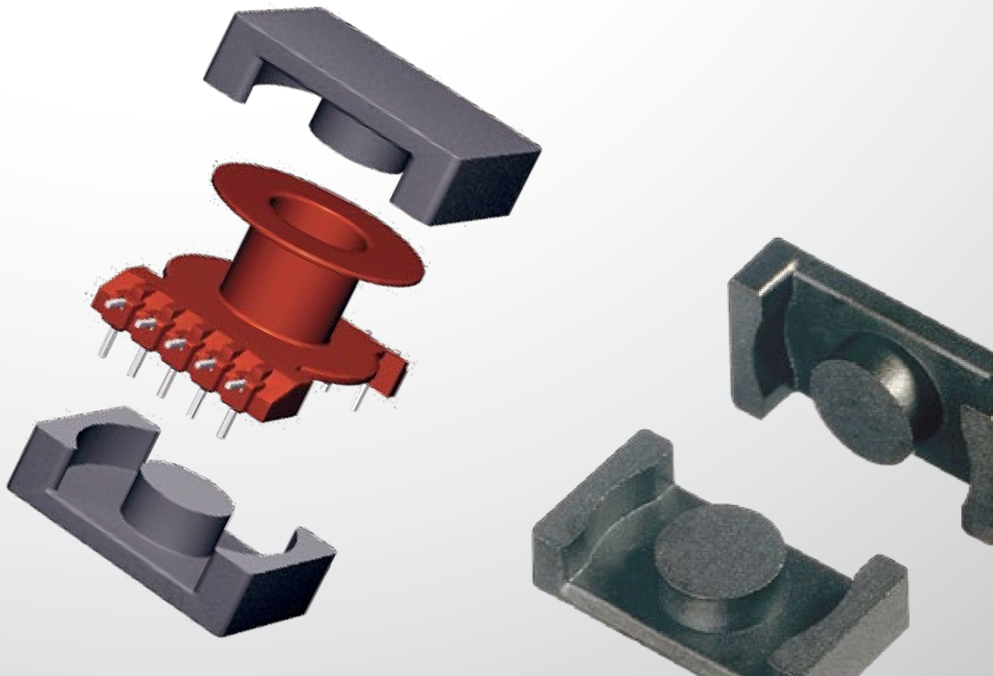
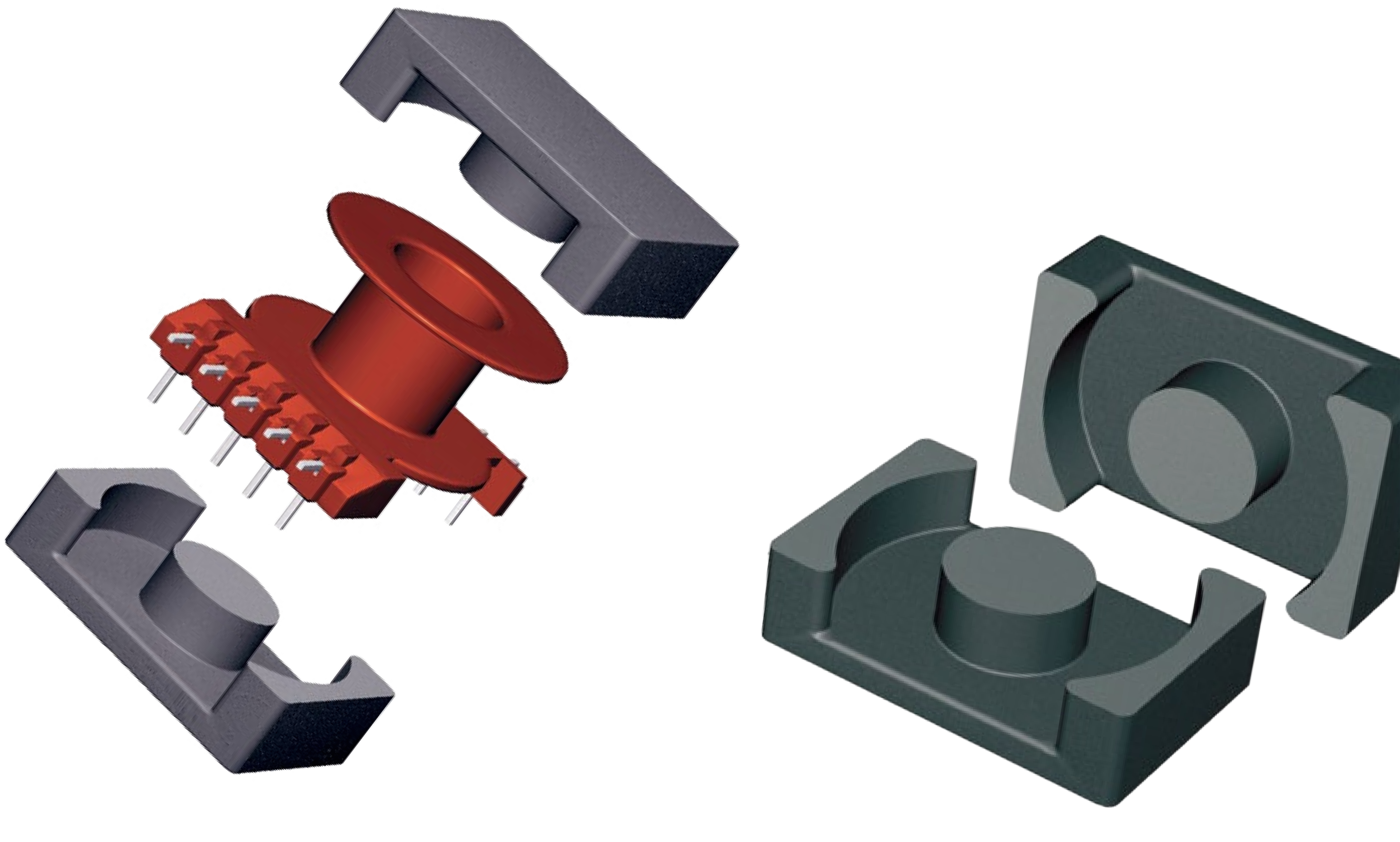


3F36

FERROXCUBE

Flat loss, medium to high frequency power material for broad temperature range applications.

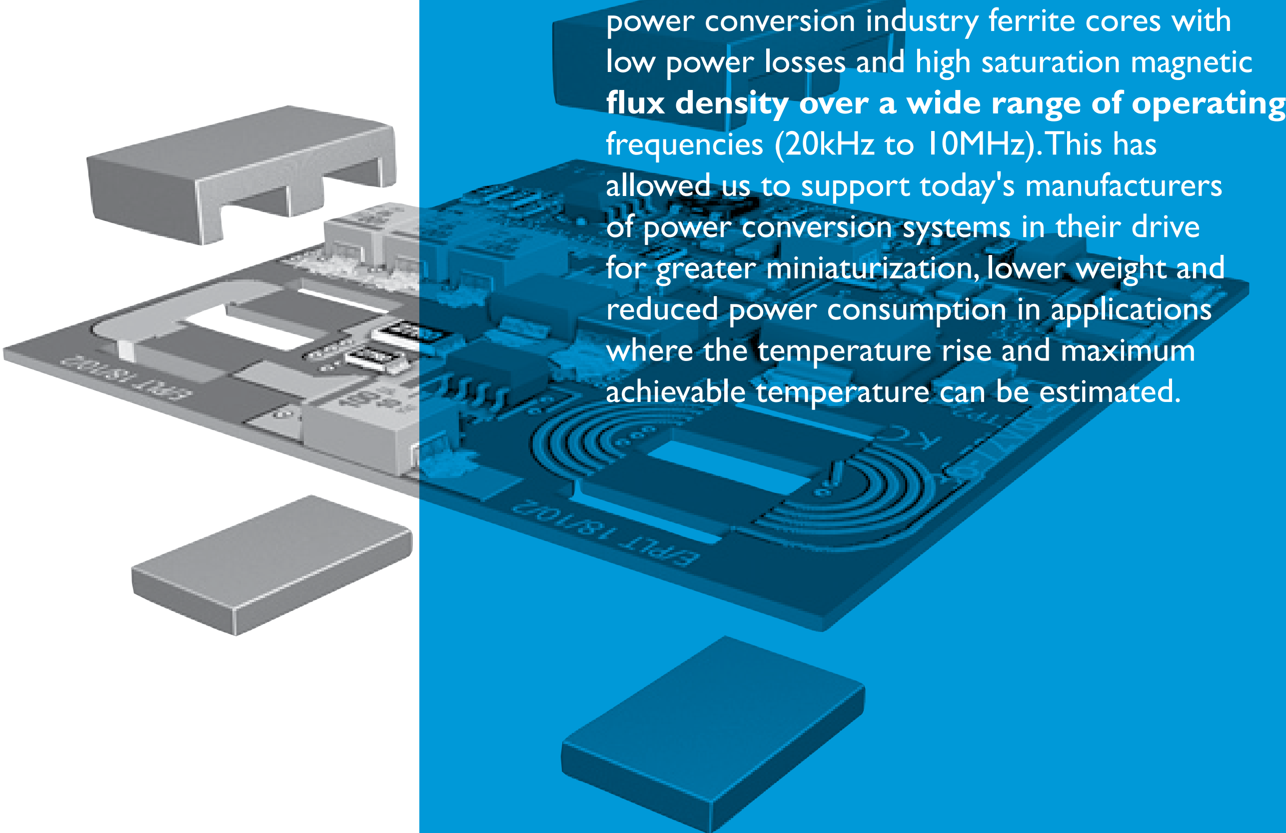




Formerly, a Philips Components company we now belong to the Yageo Group, one of the world's strongest suppliers of passive components. As a leading supplier of ferrite components, FERROXCUBE has manufacturing operations, sales offices, and customer service centers all over the world.

We supply one of he broadest ranges of high-quality, innovative products and place strong emphasis on miniaturization of magnetic functions. Ferrite components and accessories from FERROXCUBE are used in a wide range of applications, from telecommunications and computing electronics through consumer electronic products to automotive.

FERROXCUBE as the leading manufacturer in the ferrite industry, has been providing to the power conversion industry ferrite cores with low power losses and high saturation magnetic **flux density over a wide range of operating** frequencies (20kHz to 10MHz). This has allowed us to support today's manufacturers of power conversion systems in their drive for greater miniaturization, lower weight and reduced power consumption in applications where the temperature rise and maximum achievable temperature can be estimated.



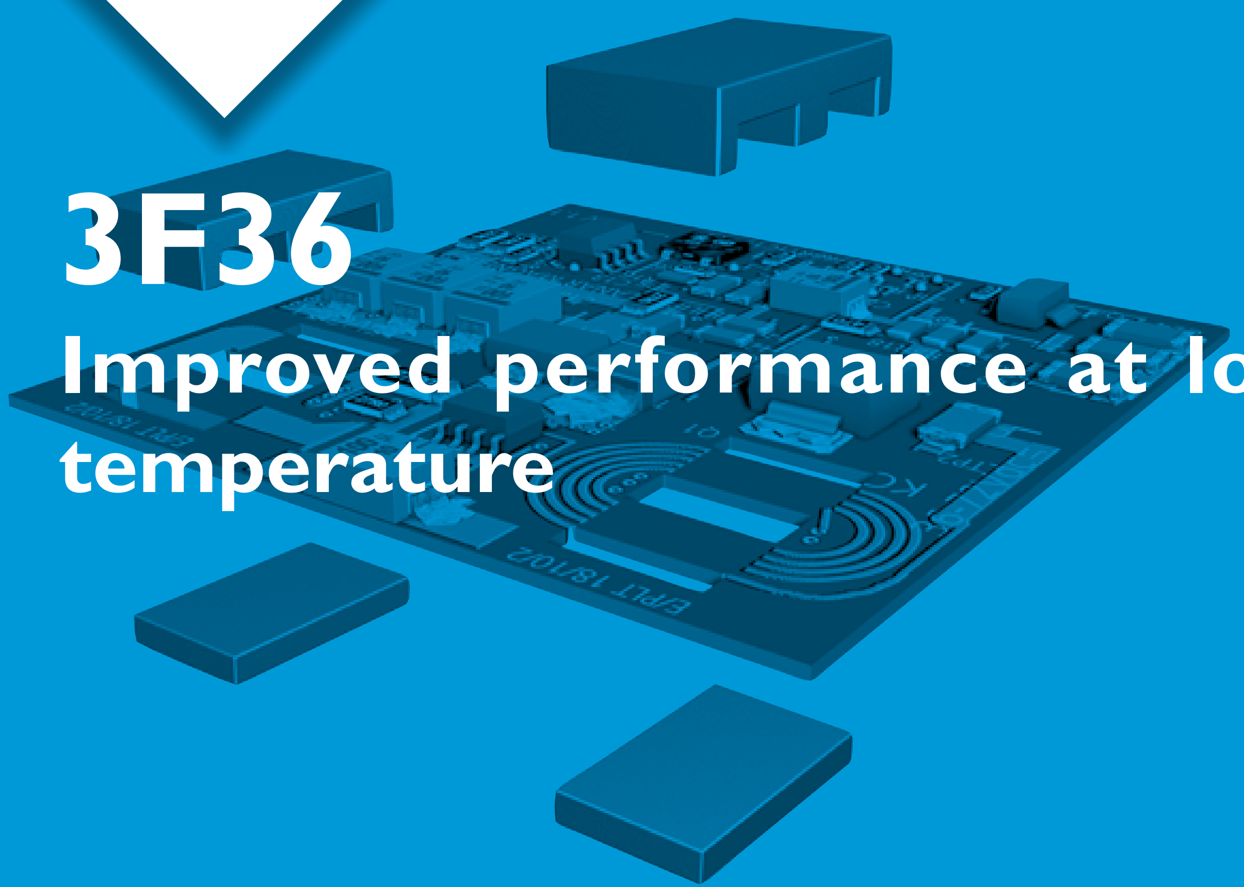
The switching frequency of power conversion equipment is continuously growing, searching for both efficiency and miniaturization. These working conditions require specific properties from the transformers and inductors in order to minimize magnetic power loss in the system: These properties include extended frequency bandwidth, high resistivity to prevent eddy currents and a flat response over a temperature range for reliable behavior in outdoor applications.

Temperature stability is also a key design parameter in reaching the highest efficiency awards when tested under light load conditions when the system is not heating itself.

Ferroxcube 3F36 has been developed to work in this field with a flat response over a temperature range and optimal operating frequency spanning from 300 kHz to 1 MHz keeping a maximum magnetic flux density as high as 420 mT (at 100 deg C, 1200 A/m).

Target applications are many: automotive DC/DC converters in hybrid and electric vehicles, photovoltaic micro-inverters, DC/DC converters in telecommunication and computing equipment or high power LED drivers for public lighting are among some of the potential applications.

3F36
Improved performance at low temperature



Material Specifications

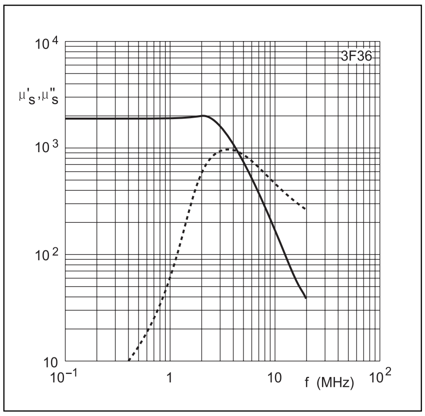


Fig. 1 Complex permeability as a function of frequency

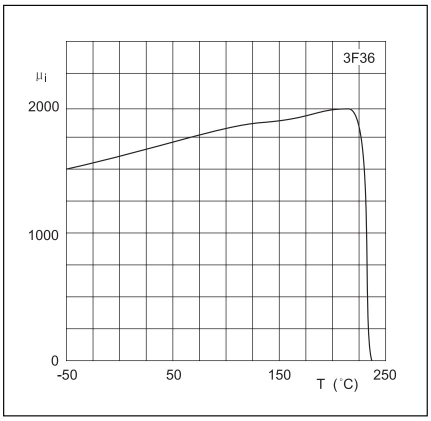


Fig. 2 Initial permeability as a function of temperature

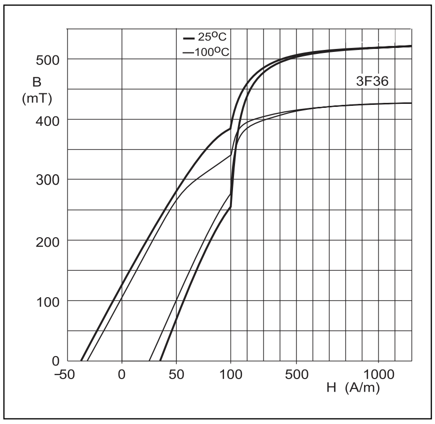


Fig. 3 Typical B-H loops

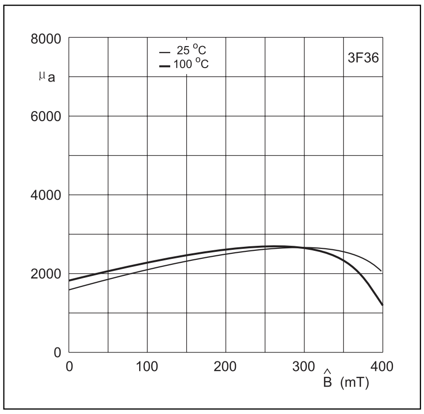


Fig. 4 Amplitude permeability as function of peak flux density

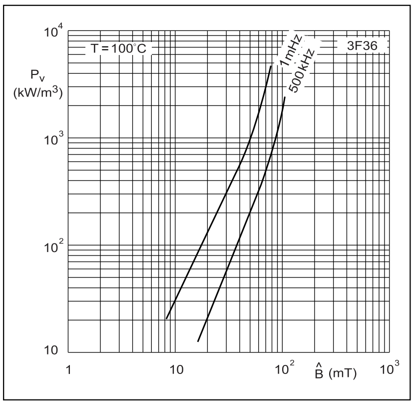


Fig. 5 Specific power loss as a function of peak flux density with frequency as a parameter

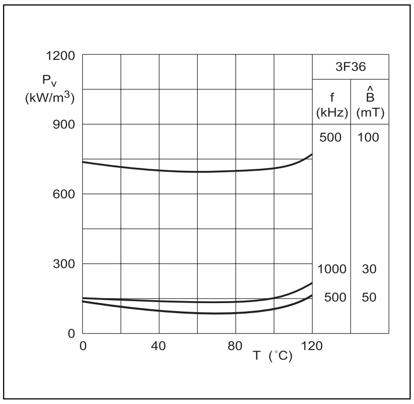
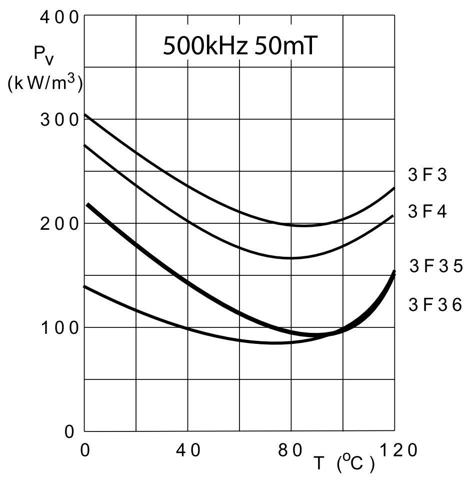


Fig. 6 Specific power loss for several frequency/flux density combinations as a function of temperature

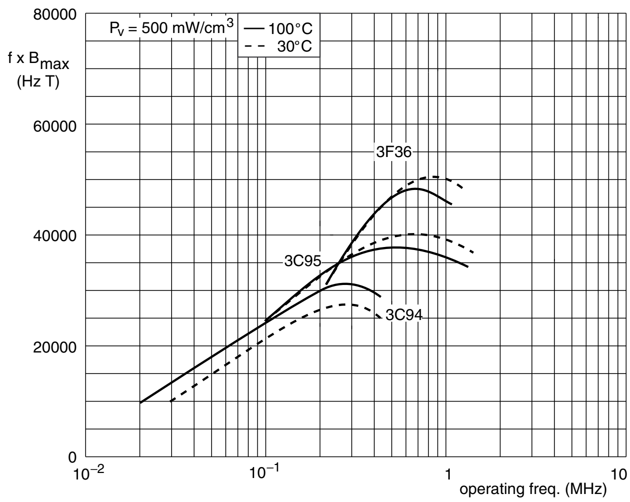
3F36 vs 3F35

Symbol	Conditions	Value		Unit
		3F36	3F35	
μ_i	25 °C; ≤10 kHz, 0.25 mT	1600±25%	1400±25%	
μ_a	100 °C; 25 kHz, 200 mT	≈ 2400	≈ 2400	
Bsat	25 °C; 10 kHz, 1200 A/m	≈ 520	≈ 500	mT
	100 °C; 10 kHz, 1200 A/m	≈ 420	≈ 420	
P_V	25 °C; 400 kHz; 50 mT	≈ 70	≈ 120	kW/m^3
	100 °C; 400 kHz; 50 mT	≈ 60	≈ 60	
	25 °C; 500 kHz; 50 mT	≈ 110	≈ 170	
	100 °C; 500 kHz; 50 mT	≈ 90	≈ 90	
	25 °C; 500 kHz; 100 mT	≈ 700	≈ 900	
	100 °C; 500 kHz; 100 mT	≈ 700	≈ 700	
ρ	DC; 25 °C	≈ 12	≈ 10	Ωm
T_C		≥230	≥240	°C
Density		≈ 4750	≈ 4750	kg/m^3

Power Loss Comparison



Ferroxcube provides also 3C95, a flat loss material optimized for frequencies up to 400 kHz. Graph below shows 3C95 performance factor data to help select the optimum material when the frequency is in the overlapping area.



The performance factor (f x Bmax) is a measure of the throughput power that a ferrite core can handle at a certain loss level.

Each material has its optimum operating frequency range. Above 300kHz 3F36 will benefit in higher throughput power than Ferroxcube well known 3C95 material.

In typical ferrite materials like 3C94 performance factor at room temperatures drops down due to the saddle shape of the losses versus temperature curve.

3F36 and 3C95 exhibits no drop at room temperatures, and this is what makes of them best materials for broad temperature applications.

Design remarks: Power loss curve fit parameters

It may be necessary to calculate the core loss density in different conditions when designing a transformer or inductor. An approximation of the core loss density for any combination of operating temperature (T) in [° C], frequency (f) in [Hz] and flux density (B) in [T] can be obtained from the following empirical fit formula :

Material	Freq min	Freq max	Cm	x	y	Ct_2	Ct_1	Ct
3F35	100000	500000	6.83E-03	1.4390	3.2672	1.614E-04	3.352E-02	2.759E+00
3F35	500000	800000	1.12E-07	2.1952	2.7199	1.284E-04	2.105E-02	1.801E+00
3F35	800000	1200000	2.24E-10	2.6105	2.4977	8.170E-05	1.011E-02	1.152E+00
3F36	100000	500000	6.83E-03	1.4390	3.2672	8.395E-05	1.078E-02	1.233E+00
3F36	500000	800000	1.12E-07	2.1952	2.7199	8.926E-05	1.172E-02	1.282E+00
3F36	800000	1200000	2.24E-10	2.6105	2.4977	6.119E-05	6.142E-03	1.011E+00

$$Pv = Cm \cdot f^x \cdot B^y \cdot (Ct_2 \cdot T^2 - Ct_1 \cdot T + Ct) \left[\frac{\text{mW}}{\text{Cm}^3}\right]$$

Results obtained with this formula are an estimation of typical material performance. Product specs will show higher power loss density.

FERROXCUBE - A GLOBAL COMPANY

HQ

Taipei, Taiwan
Ferroxcube Taiwan
Tel: +886 963 767 858
Fax: +886 2 6629 9999
Mail: wiki.hsiung@ferroxcube.com

ASIA

Dongguan, China
Ferroxcube China
Tel: +86 769 8681 8777
Fax: +86 769 8733 9561
Mail: King.lee@ferroxcube.com

Suzhou, China
Ferroxcube China
Tel: +86 512 6841 2350
Ext.203
Fax: +86 512 6841 2356
Mail: Eric.Xu@ferroxcube.com

Singapore
Ferroxcube South Asia
Tel : +65 6412 0875
Fax : +65 6412 0808
Mail:
adrian.toh.wee.yong@ferroxcube.com

Europe

Hamburg, Germany
Ferroxcube Germany
Tel: +49 40 883 66 020
Fax: +49 40 883 66 022
Mail:
saleseurope@ferroxcube.com

Lissone, (MB), Italy
Ferroxcube Italy
Tel: +39 0392 143 599
Fax: +39 0392 459 472
Mail:
saleseurope@ferroxcube.com

North America

El Paso (TX), USA
Tel: +1 915 599 2328
Fax: +1 915 599 2555
Mail: juan.carlos.gardea@ferroxcube.com

San Diego (CA), USA
Tel: +1 619 207 0061
Fax: +1 619 207 0062
Mail: joel.salas@ferroxcube.com

Vancouver (WA), USA
Tel:+1 915 599 2616
Mail: dan.pizarro@ferroxcube.com

Pittsburgh (PA), USA
Tel: +1 412 226 0048
Mail: michael.horgan@ferroxcube.com

Rochester (NY), USA
Tel:+1 585 364-3395
Mail: owen.davies@ferroxcube.com

For a complete listing of all Ferroxcube sales offices, distributors, and representatives, please visit "contact us" at

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