Ferroxcube Roadmap

April 2025

Market links to roadmap

YAGEO GROUP
YAGEO Ferroxcube

Tiny gap inductor with pin

High freq >1MHz 3F48

Low loss 0.8 MHz 3F37

Low loss 0.3 MHz 3C97T

- DCDC / POL
- Power supply

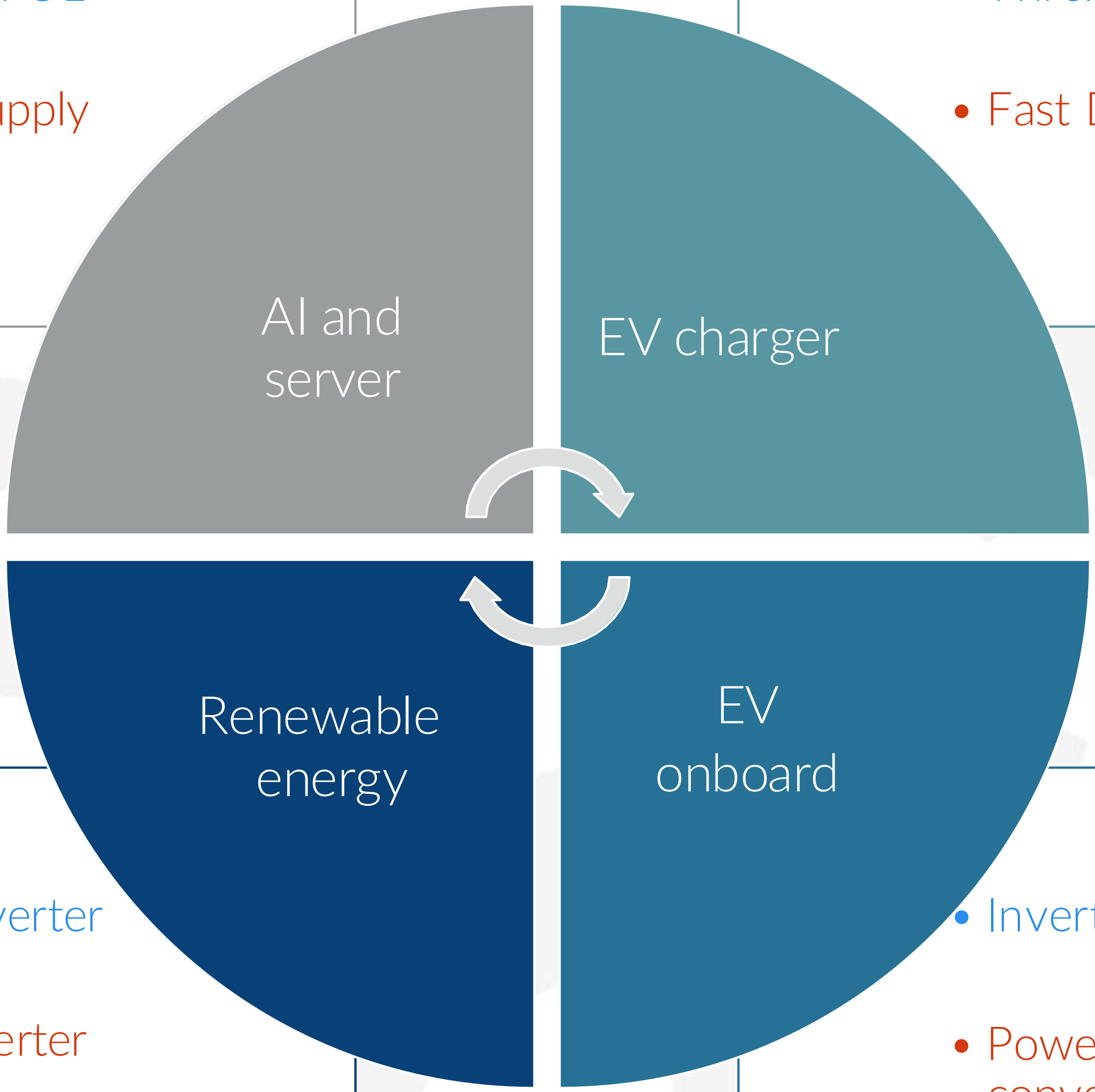
- Wireless
- Fast DC

Large tiles: big press, side grinding

Low loss 85/200 kHz: 3C97T

Transformer: low-cost big cores ⍰ automation

Choke: multigap



Reactor: multigap

Transformer: low-cost big cores ⍰ automation

CMC: High u shapes ⍰ automation / PK

Transformer: low-cost mid cores ⍰ automation

Reactor: low-cost planar size ⍰ automation

- String inverter
- Microinverter

- Inverter EMI
- Power conversion

CMC U: 3Nx

CMC/DMC E: 3Nx

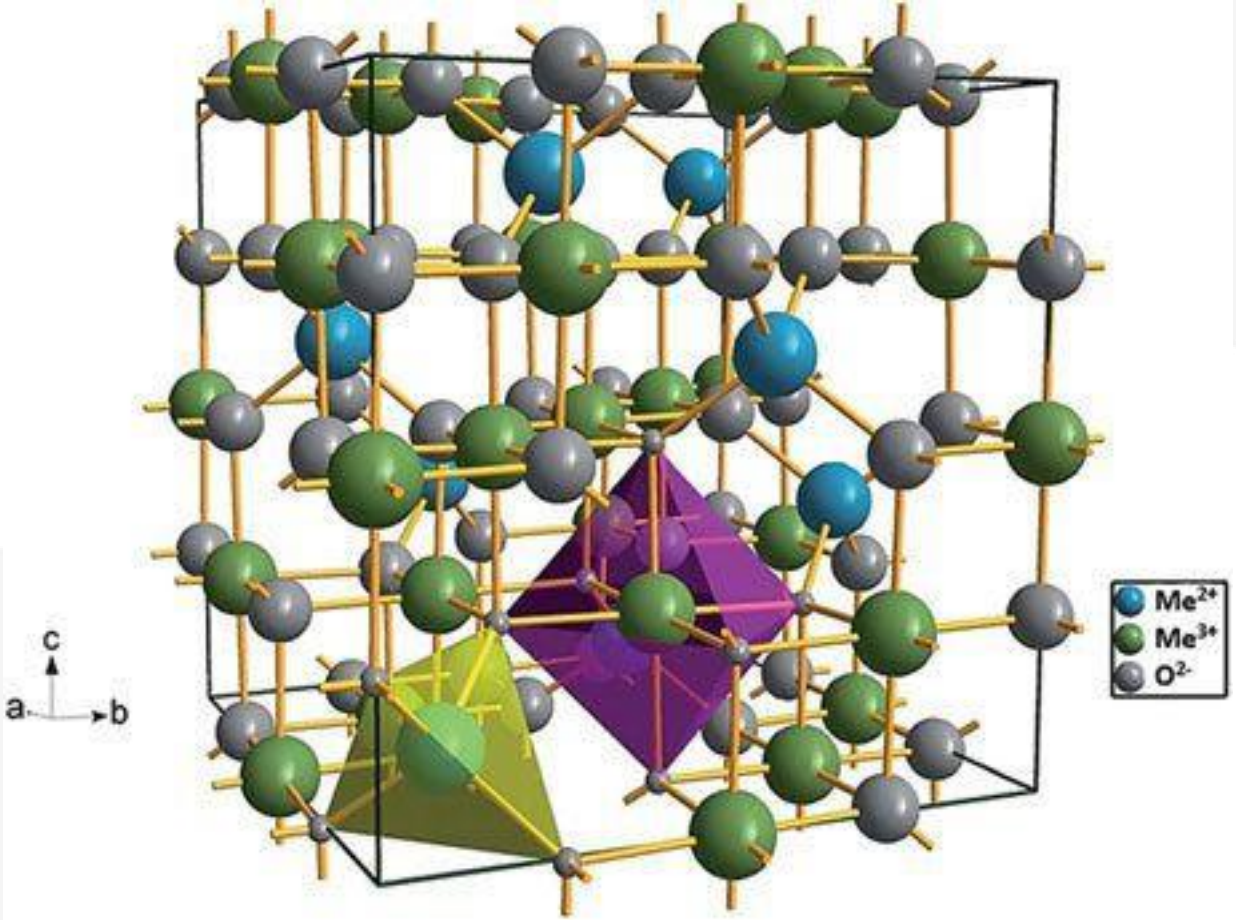
CMC CSF: 3Nx / NiZn

Transformer low loss: 3F37 / 3C97T / 3L95

Transformer integration: Multistage press

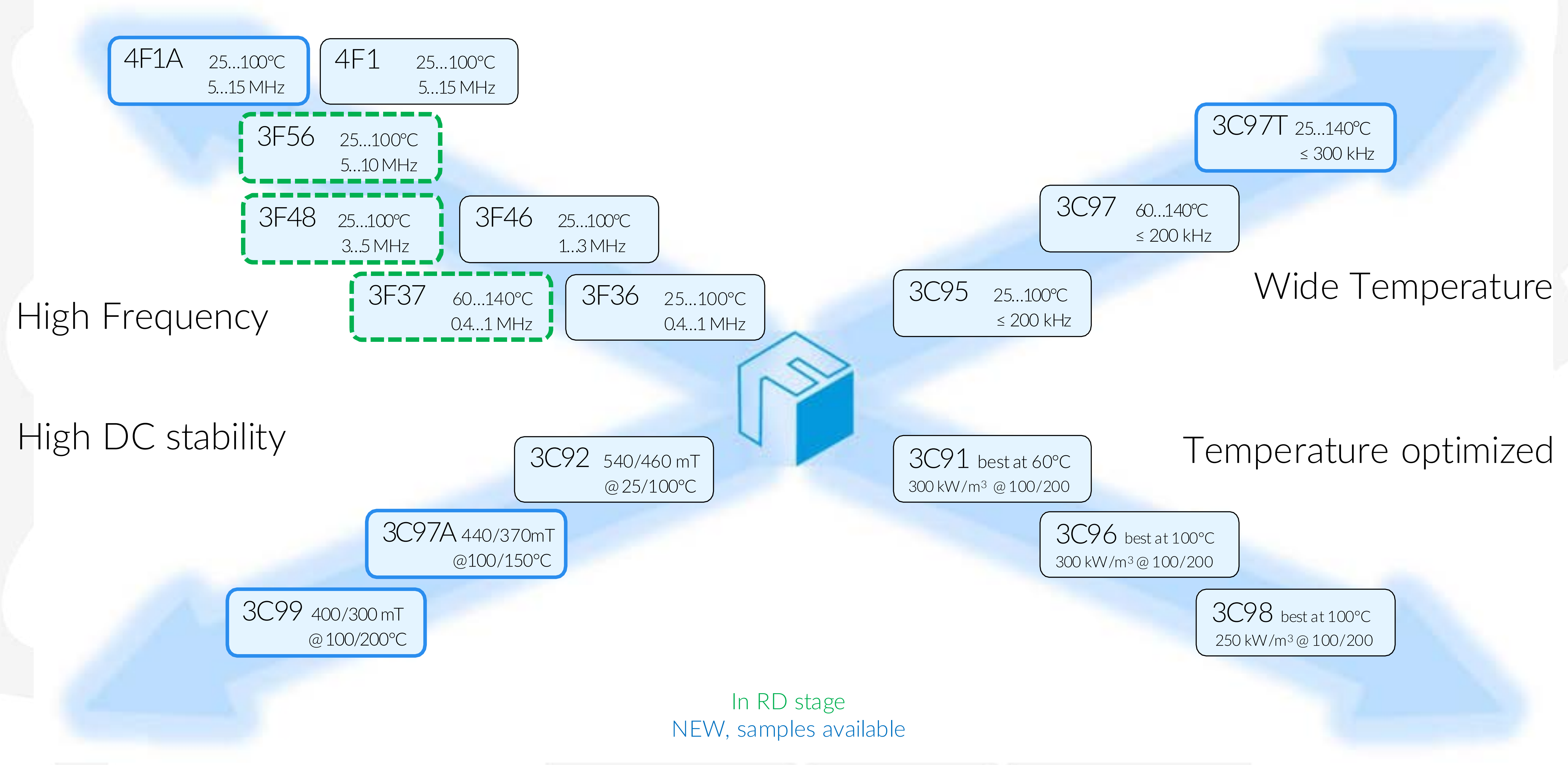
Material Portfolio

New materials



Power conversion materials

YAGEO GROUP
YAGEO Ferroxcube



EMI suppression materials

High Impedance

- 3N2T μ_i = 1100 — Tc ≥200°C 1-300 MHz
- 4S2 μ_i = 850 — Tc ≥150°C 30-1000 MHz
- 3N2 μ_i = 3000 — Tc ≥150°C 1-100 MHz
- 3N1 μ_i = 1800 — Tc ≥150°C 1-300 MHz
- 3N3 μ_i = 1250 — Tc ≥ 200°C 1-10 MHz
- 3N4 μ_i = 2500 — Tc ≥ 200°C 1-5 MHz
- 3N5 μ_i = 6000 — Tc ≥ 150°C 1-3 MHz
- 3N10 μ_i = 8000 — Tc ≥ 130°C < 1 MHz
- 4F5 μ_i = 400 340mT — Tc≥240°C 30-500MHz

High Permeability

- 3E15 μ_i = 15000 — Tc ≥ 130°C ≤ 15 MHz
- 3E12 μ_i = 12000 — Tc ≥ 130°C ≤ 15 MHz
- 3E10 μ_i = 10000 — Tc ≥ 130°C ≤ 15 MHz

High DC stability

- 3S5 μ_i = 3800 — Tc ≥ 255°C 545 mT
- 3E27 μ_i = 6000 — Tc ≥ 150°C 460 mT
- 3E65 μ_i = 5200 — Tc ≥ 165°C 480 mT
- 3E7T μ_i = 7000 — Tc ≥ 180°C 510 mT

Wide Temperature

- 3L5 μ_i ≈ 5000 — Tc ≥ 120°C -40...85°C
- 3L7 μ_i ≈ 7000 — Tc ≥ 120°C -40...85°C
- 3L10 μ_i ≈ 10000 — Tc ≥ 100°C -40...60°C
- 3L18 μ_i = 18000 — Tc ≥ 125°C 75...100°C

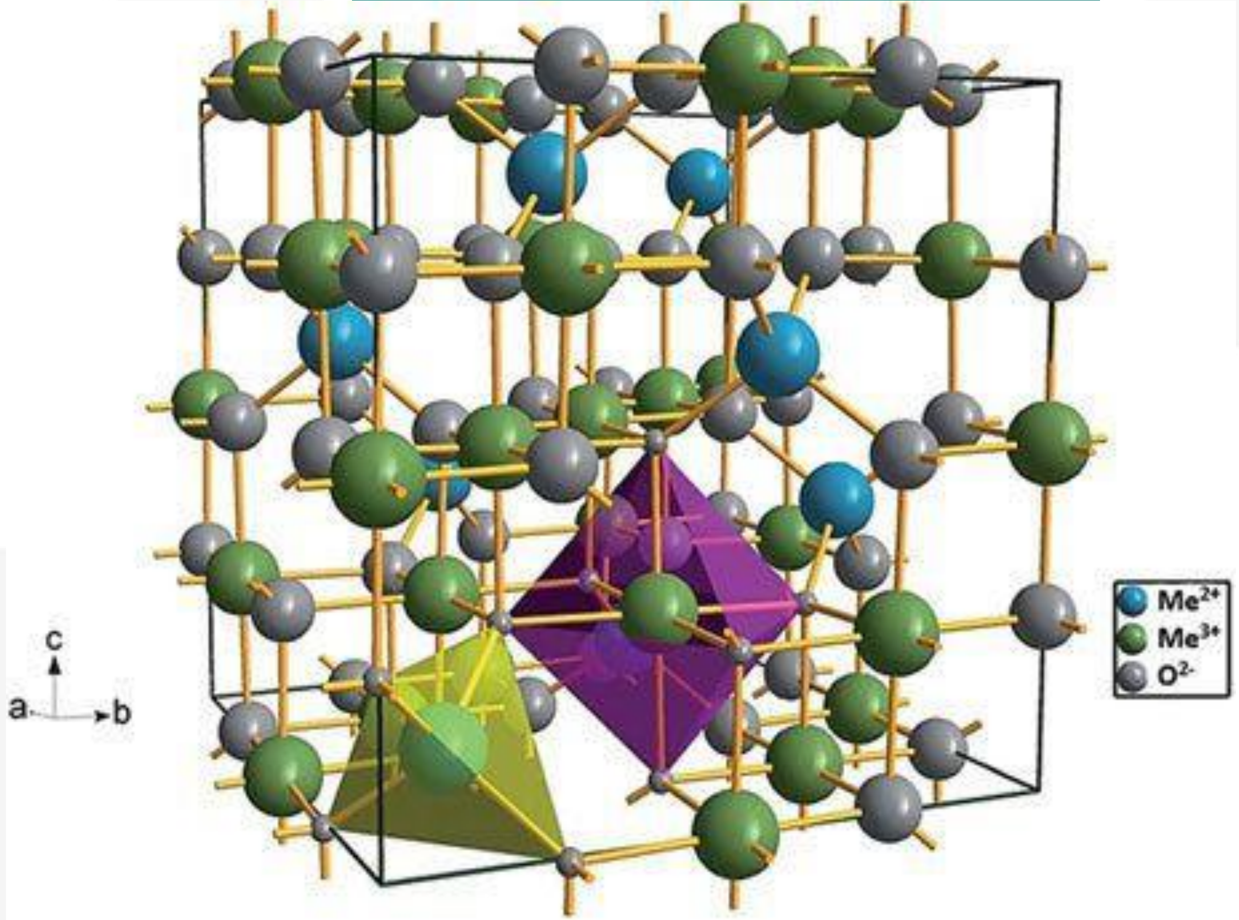
In RD stage
NEW, samples available

Material Portfolio

Power Materials

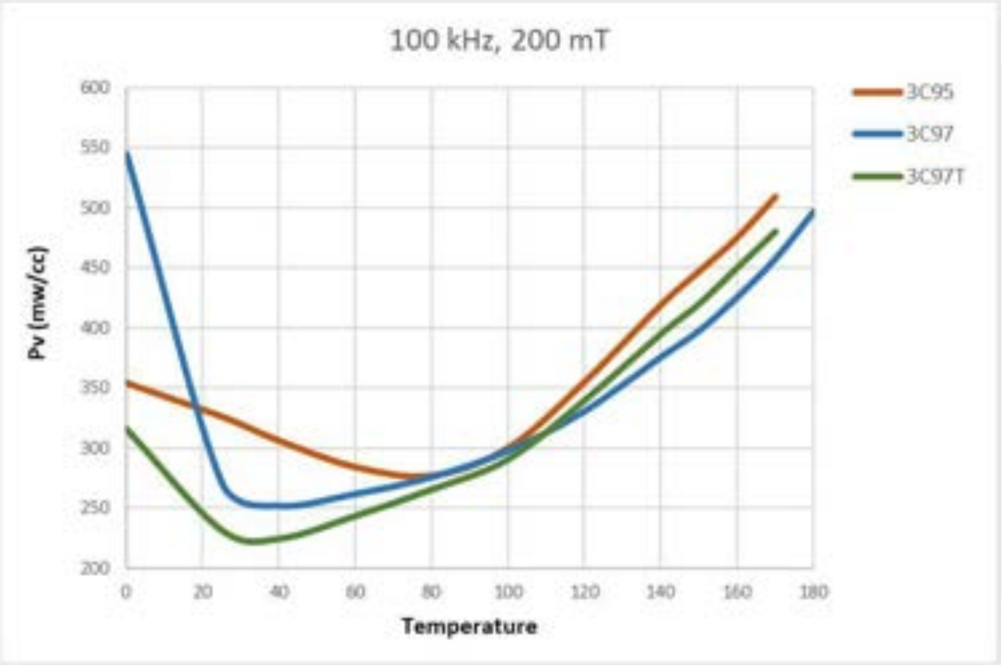
YAGEO GROUP
YAGEO Ferroxcube

THE MAGNETIC GATEWAY.

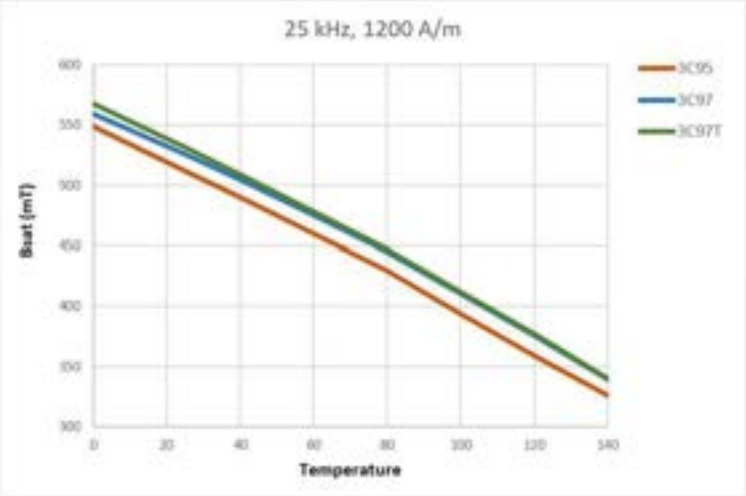


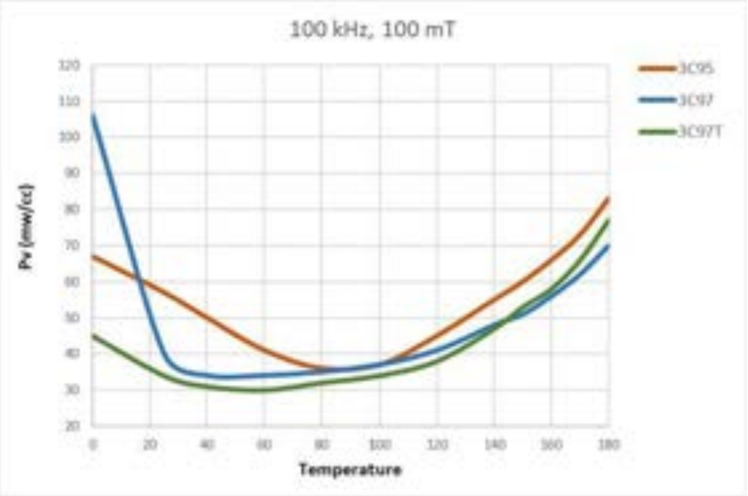
Flat Materials

- 3C95: first flat loss material.
  - Best for negative temperatures
- 3C97: optimized for high temperature
- 3C97T: lowest loss all over the range
  - Good performance at higher freq
  - NEW!



	CONDITIONS	UNIT	3C95	3C97	3C97T
μi	25°C; 10kHz; 0.25mT		3000	3000	**3300**
μa	100°C; 25kHz; 200mT		≈ 5000	≈ 5000	≈ 5000
B	25°C; 10kHz; 1200A/m	mT	≈ 530	≈ 550	≈ 550
	100°C; 10kHz; 1200A/m		≈ 410	≈ 430	≈ 435
	140°C; 10kHz; 1200A/m		≈ 320	**≈ 360**	≈ 360
Pv	25°C; 100kHz; 200mT	kW/m³	≈ 350	≈ 290	**≈ 230**
	100°C; 100kHz; 200mT		≈ 290	≈ 290	**≈ 270**
	140°C; 100kHz; 200mT		≈ 430	**≈ 380**	**≈ 370**
ρDC	25°C	Ωm	≈ 5	≈ 10	≈ 7
Tc		°C	≥ 215	≥ 215	≥ 250
density		kg/m³	≈ 4800	≈ 4850	≈ 4900

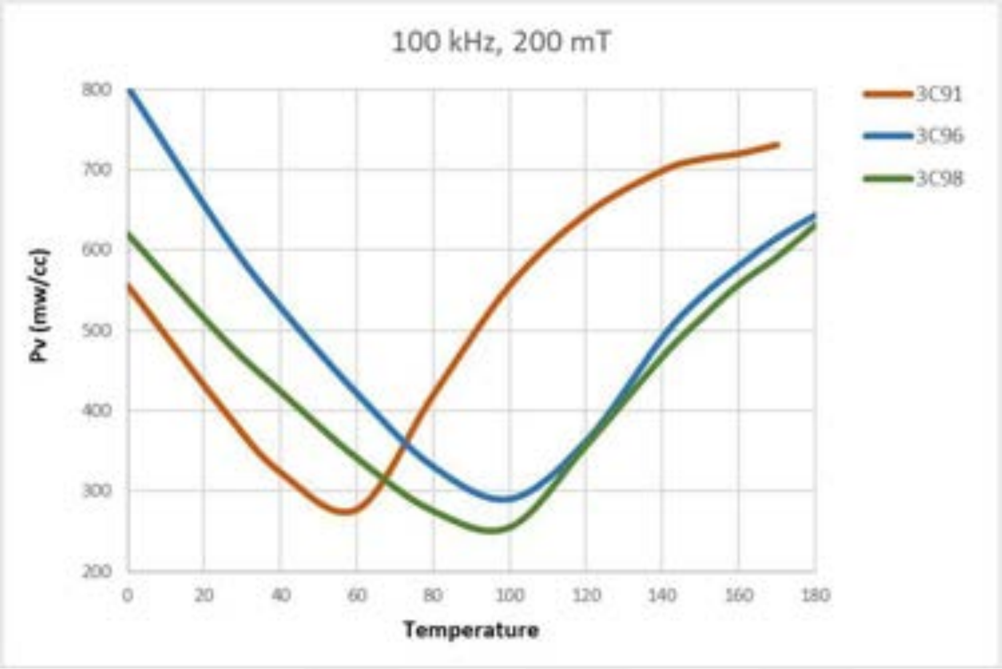


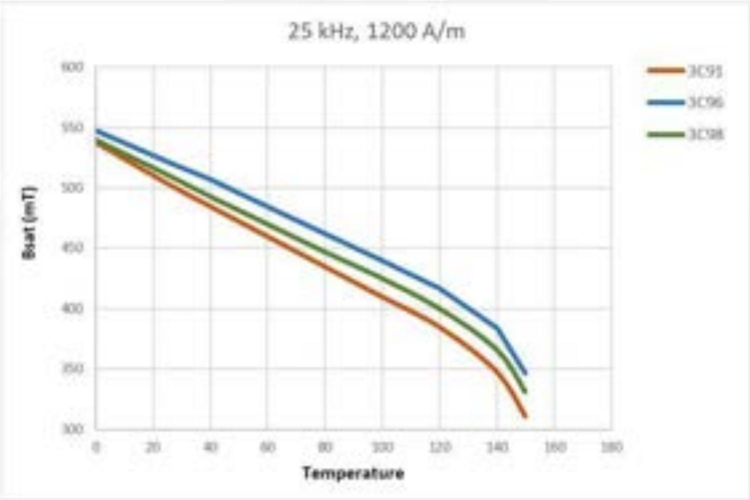


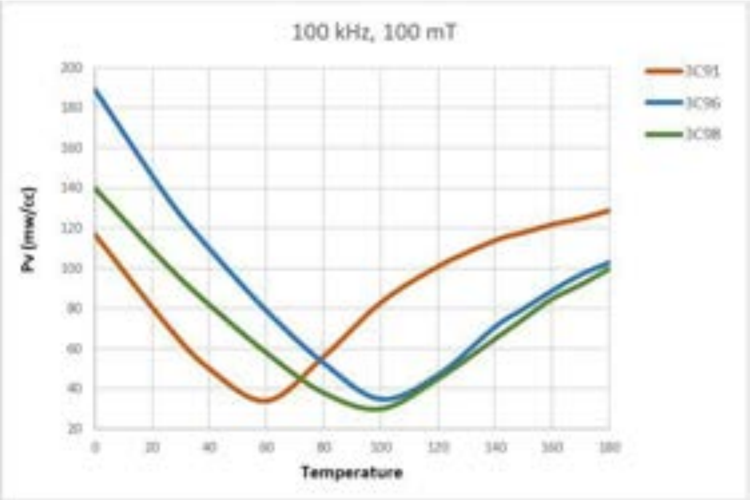
Temperature Optimized

- 3C91: low temperature optimized
  - Handheld devices
- 3C96: 100C optimized
  - Suitable up to 400 kHz
- 3C98: best 100C material
  - Reasonable low loss at low temperature

	CONDITIONS	UNIT	3C91	3C96	3C98
μi	25ºC; 10kHz; 0.25mT		**3000**	2000	**2500**
μa	100ºC; 25kHz; 200mT		≈ 5500	≈ 5500	≈ 5500
B	25ºC; 10kHz; 1200A/m	mT	≈ 470	≈ 500	**≈ 530**
	100ºC; 10kHz; 1200A/m		≈ 370	**≈ 440**	**≈ 440**
	140ºC; 10kHz; 1200A/m		≈ 330	≈ 370	≈ 380
Pv	60ºC; 100kHz; 200mT	kW/m³	**≈ 300**	≈ 450	≈ 350
	100ºC; 100kHz; 200mT		≈ 550	**≈ 300**	**≈ 250**
	140ºC; 100kHz; 200mT		≈ 700	≈ 500	≈ 480
ρDC	25ºC	Ωm	≈ 5	≈ 5	≈ 8
Tc		ºC	≥ 220	≥ 240	≥ 230
density		kg/m³	≈ 4800	≈ 4800	≈ 4850



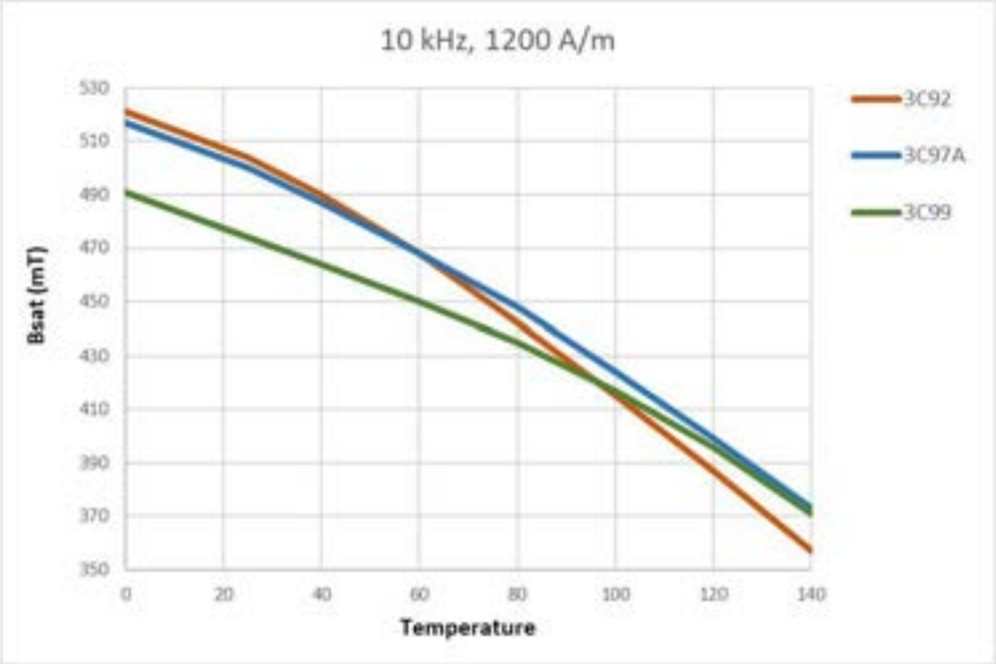


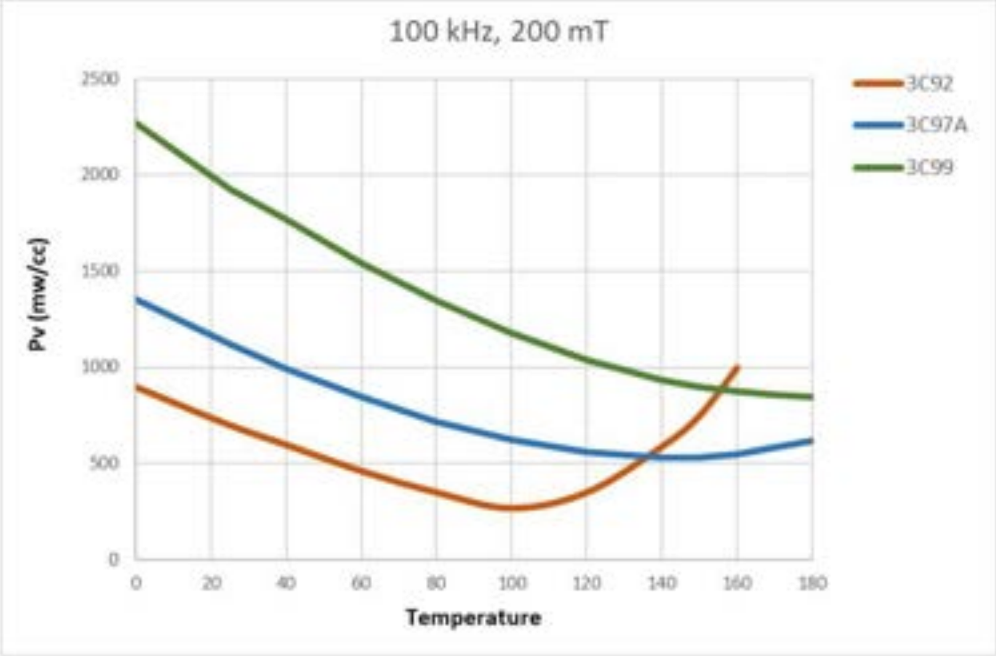


High Bsat

- 3C92: best balance for common applications
  - Low loss, high Bsat up to 140D
- 3C99: Optimized for 200C
- 3C97A: Optimized for operation 120 to 180
  - High Bsat with reasonable losses
  - New!

	CONDITIONS	UNIT	3C92	3C99	3C97A
μi	25°C; 10kHz; 0.25mT		1800	1100	1100
μa	100°C; 25kHz; 200mT		≈ 5500	≈ 4000	≈ 4000
B	100°C; 10kHz; 1200A/m	mT	≈ 460	≈ 450	≈ 440
	150°C; 10kHz; 1200A/m		≈ 350	≈ 370	**≈ 370**
	200°C; 10kHz; 1200A/m			**≈ 320**	≈ 320
Pv	60°C; 100kHz; 200mT	kW/m³	≈ 500	≈ 1500	≈ 350
	100°C; 100kHz; 200mT		**≈ 300**	≈ 1200	≈ 250
	150°C; 100kHz; 200mT		≈ 600	≈ 900	**≈ 500**
ρDC	25°C	Ωm	≈ 5	≈ 6	≈ 8
Tc		°C	≥ 270	**≥ 300**	≥ 280
density		kg/m³	≈ 4800	≈ 4800	≈ 4800

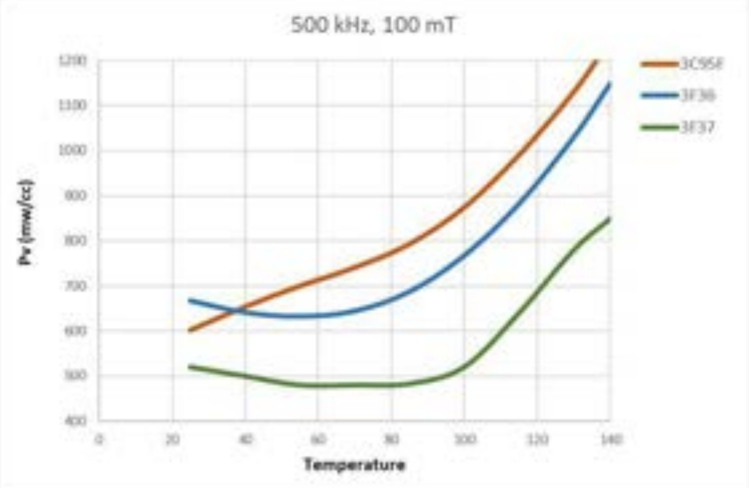


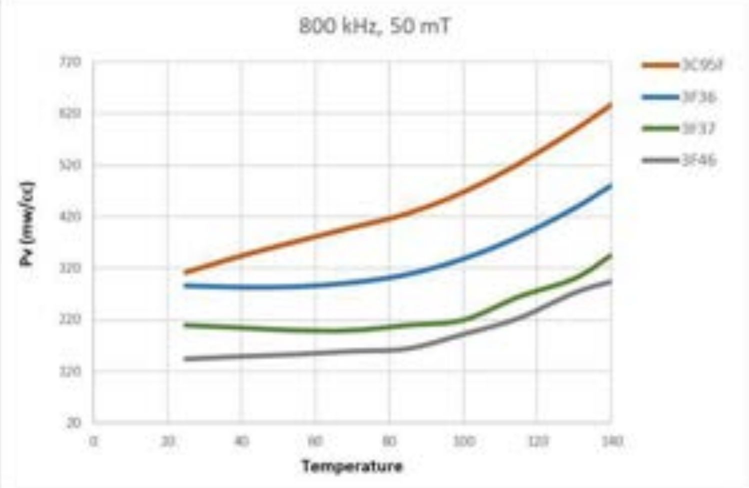


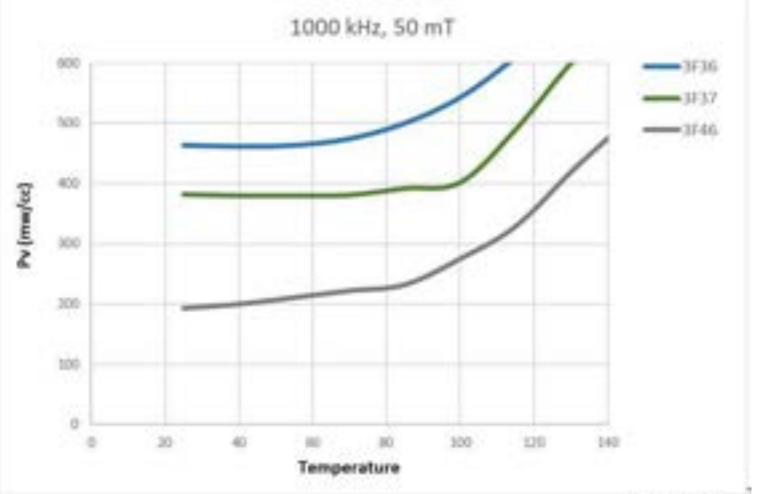
High Frequency: 400 to 1000 kHz

- 3Cxx materials are best up to 300 kHz
- 3F36: good for 400 to 700 kHz
  - Good for large size
- 3F37: best for 400 to 800 kHz
  - New! Launch on Q2
- 3F46: best 800 to 2000 kHz
  - Recommended for small sizes

	CONDITIONS	UNIT	3F36	3F37	3F46
µi	25ºC; 10kHz; 0.25mT		1600	1500	650
µa	100ºC; 25kHz; 200mT		≈ 2400	≈ 2500	≈ 1500
B	25ºC; 10kHz; 1200A/m	≈ 520 mT	≈ 450	≈ 550	
	100ºC; 10kHz; 1200A/m		≈ 420	≈ 370	**≈ 450**
Pv	100ºC; 500kHz; 100mT	kW/m³	≈ 700	≈ 520	
	100ºC; 800kHz; 50mT		≈ 350	≈ 220	≈ 200
	100ºC; 1 MHz; 50mT		≈ 550	≈ 400	**≈ 150**
ρDC	25ºC	Ωm	≈ 12	≈ 15	≈ 5
Tc		ºC	≥ 230	≥ 230	≥ 280
density		kg/m³	≈ 4750	≈ 4750	≈ 4750







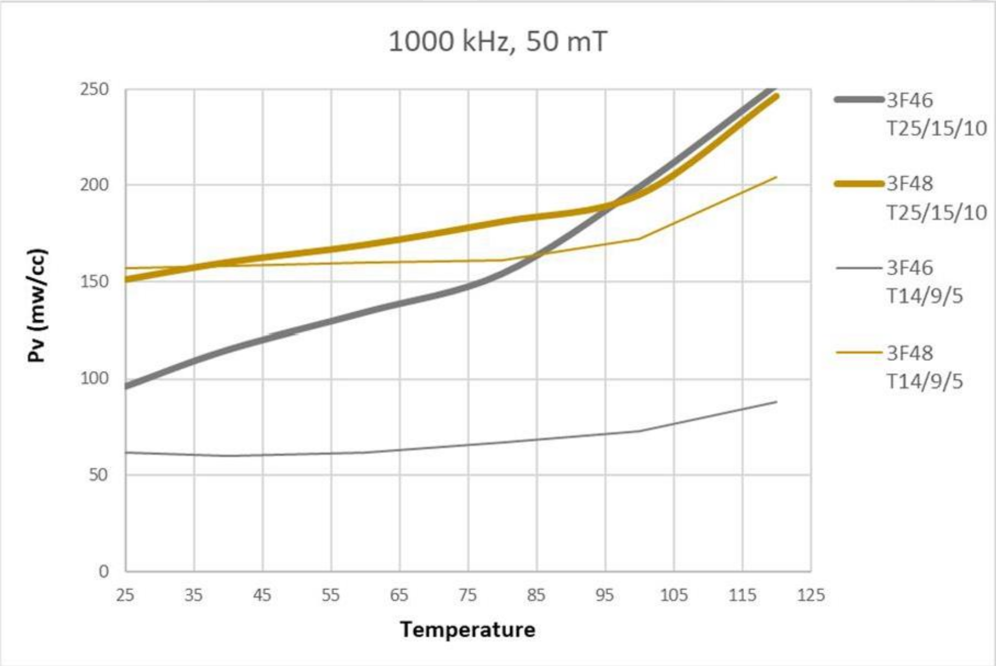
YAGEO GROUP
YAGEO Ferroxcube

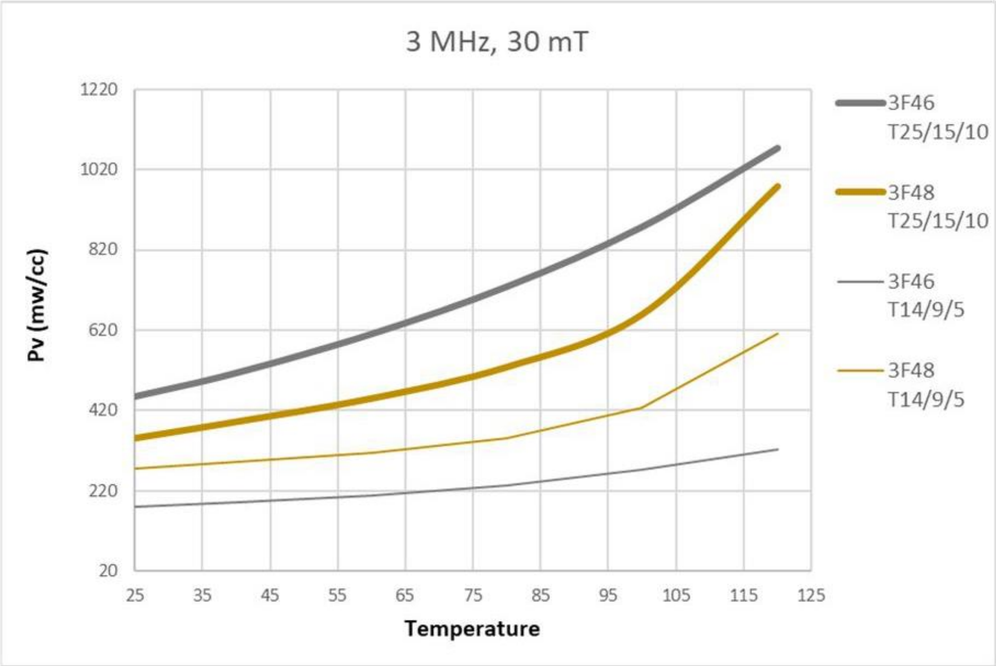
High Frequency: 1 to 3 MHz

- 3F48: best for large sizes
  - Specially in high frequency beyond 2 MHz
  - New! Still in development
- 3F46: best 800 to 2000 kHz
  - Recommended for small sizes

	CONDITIONS	UNIT	3F48	3F46
μi	25ºC; 10kHz; 0.25mT		600	650
μa	100ºC; 25kHz; 200mT		≈ 1500	≈ 1500
B	25ºC; 10kHz; 1200A/m	mT	≈ 550	≈ 550
	100ºC; 10kHz; 1200A/m		≈ 450	**≈ 450**
Pv	100ºC; 1 Mhz; 50mT	kW/m3	≈ 180	**≈ 150**
	100ºC; 3 MHz; 30mT		≈ 250	**≈ 500**
ρDC	25ºC	Ωm	≈ 20	≈ 5
Tc		ºC	≥ 280	≥ 280
density		kg/m^3	≈ 4750	≈ 4750

Data measured on T14/9/5



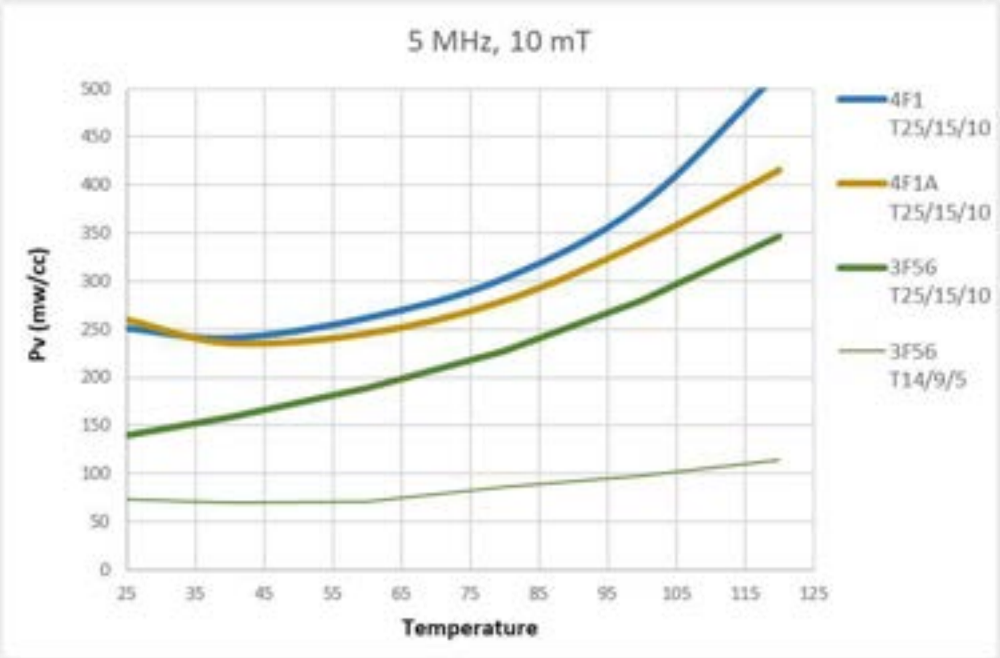


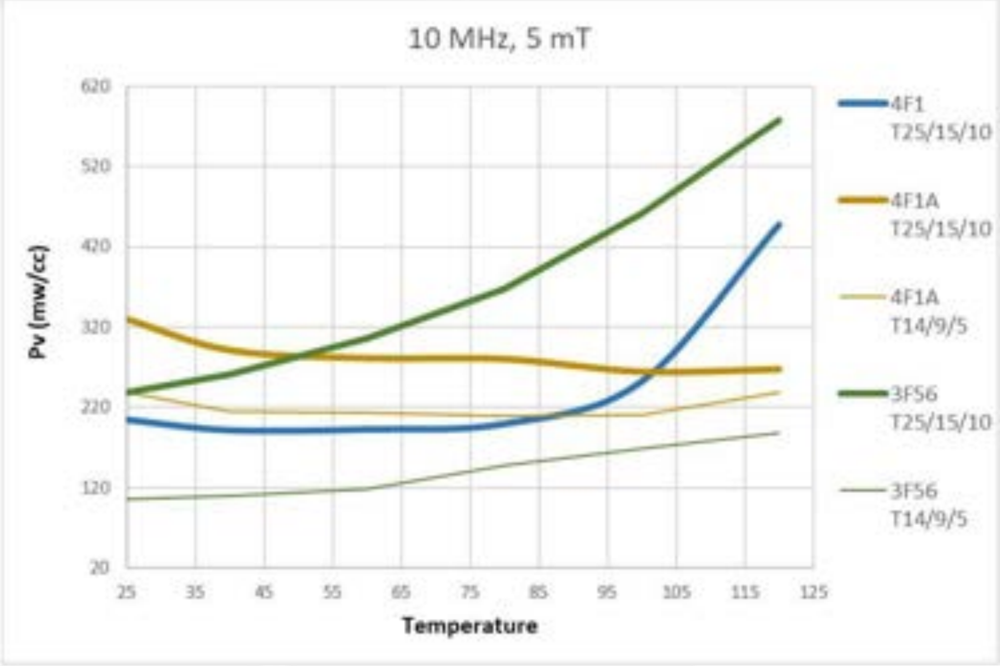
High Frequency: 5 to 15 MHz

- 3F56: MnZn material optimized for 5 MHz
  - Good up to 10 MHz on small sizes
  - New! Still in development
- 4F1: Best for 7 to 15 MHz, including ISM 13.56 MHz
  - NiZn: no significant impact of size
- 4F1A: flat version of 4F1 with improved losses at high temperature
  - New! Samples available on request

	CONDITIONS	UNIT	3F56	4F1A	4F1
μi	25°C; 10kHz; 0.25mT		500	80	80
μa	100°C; 25kHz; 200mT		≈ 2000	≈ 300	≈ 300
B	25°C; 10kHz; 1200A/m	mT	≈ 520	≈ 320	≈ 320
	100°C; 10kHz; 1200A/m		≈ 420	≈ 260	≈ 260
Pv	100°C; 3 MHz; 30mT	kW/m³	≈ 700		
	100°C; 5 MHz; 10mT		≈ 100	≈ 350	≈ 400
	100°C; 10 MHz; 5mT		≈ 170	≈ 200	≈ 250
ρDC	25°C	Ωm	≈ 100	≈ 10^6	≈ 10^6
Tc		°C	≥ 230	≥ 260	≥ 260
density		kg/m³	≈ 4750	≈ 4600	≈ 4600

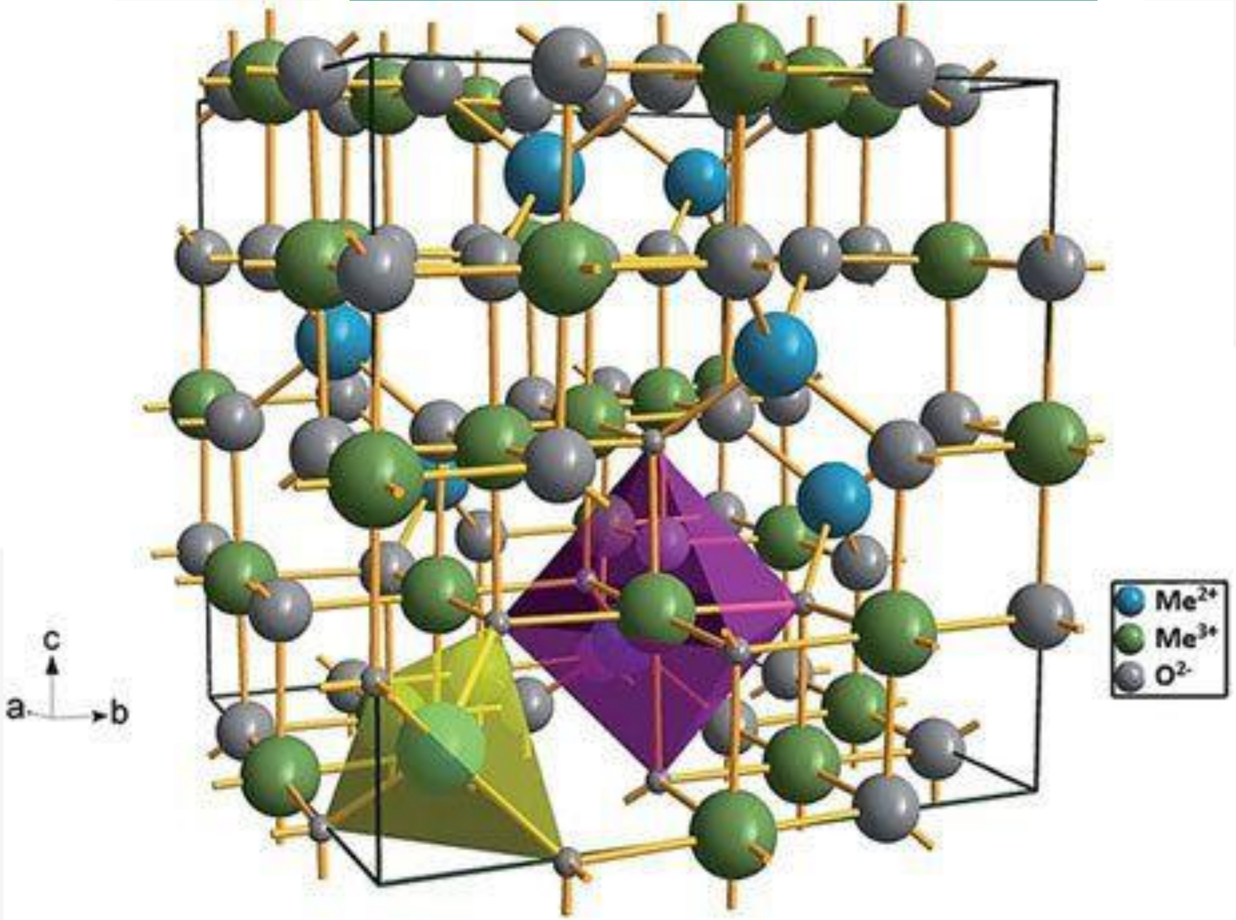
Data measured on T14/9/5





Material Portfolio

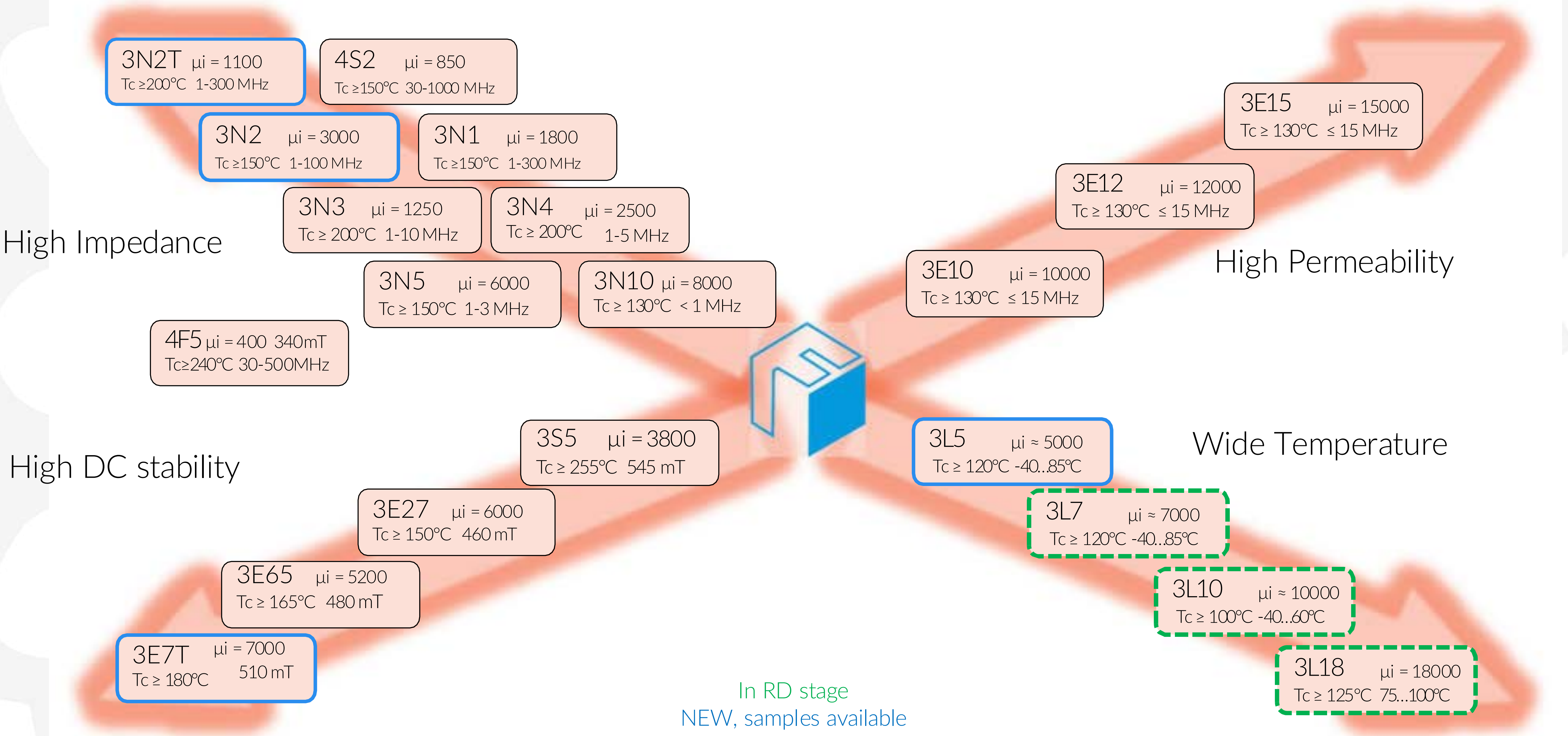
EMI Materials



YAGEO GROUP
YAGEO Ferroxcube

THE MAGNETIC GATEWAY.

EMI Suppression Materials



3E7T – High Perm with highest Tc

Highest permeability (7k) with Tc >180°C

Wide band EMI suppression up to 10 MHz

SYMBOL	CONDITIONS	VALUE	UNIT
μi	25°C; 10kHz; 0.25mT	7000 ± 20%	
B	25°C; 10kHz; 1200A/m	≈ 510	mT
	100°C; 10kHz; 1200A/m	≈ 360	
tanδ/μi	25°C; 30kHz; 0.25mT	≤ 3 · 10⁻⁶	
	25°C; 100kHz; 0.25mT	≤ 9 · 10⁻⁶	
ρDC	25°C	≈ 0.1	Ωm
Tc		≥ 180	°C
density		≈ 4900	kg/m3

Typical performance of unstressed ring T25/15/10

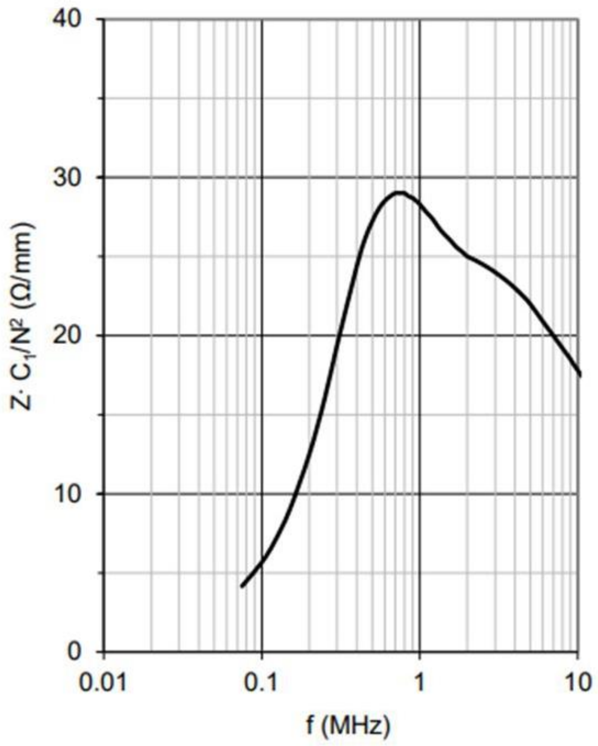


Fig.5 Normalized impedance as a function of frequency

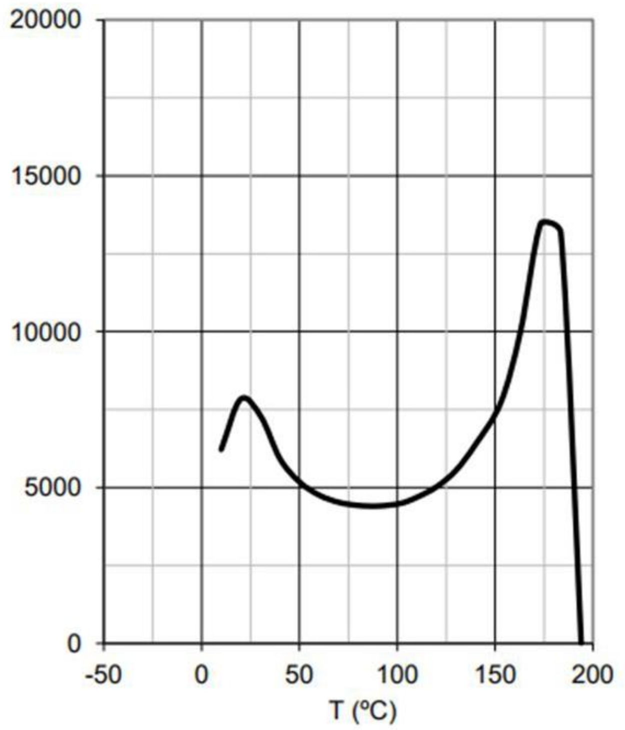


Fig.2 Initial permeability as a function of temperature

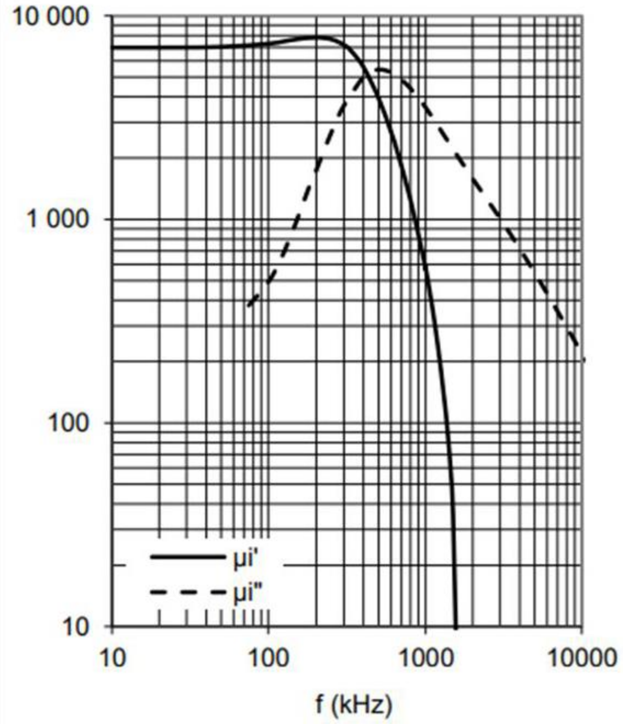
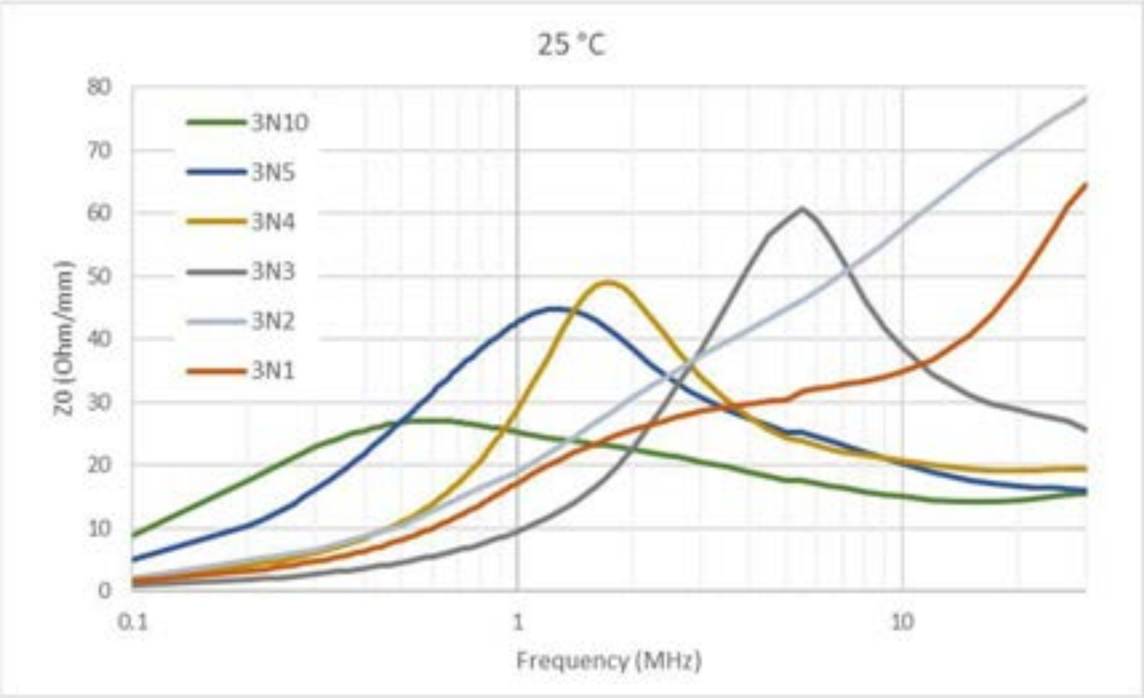
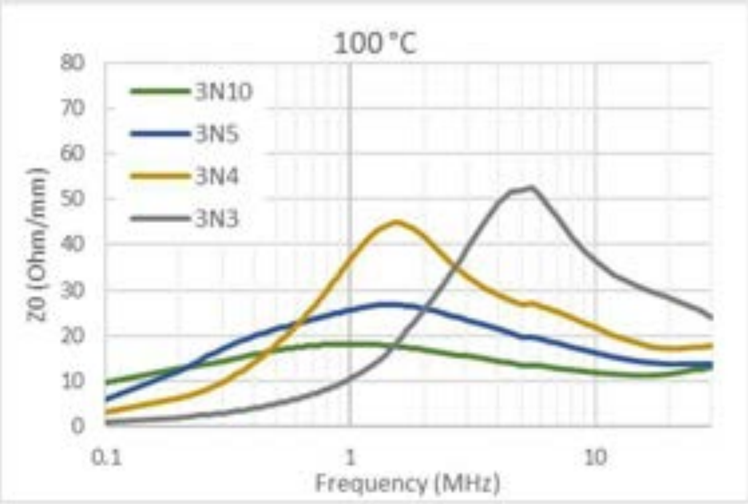


Fig.1 Complex permeability as a function of frequency

3N series for low frequency up to 30 MHz

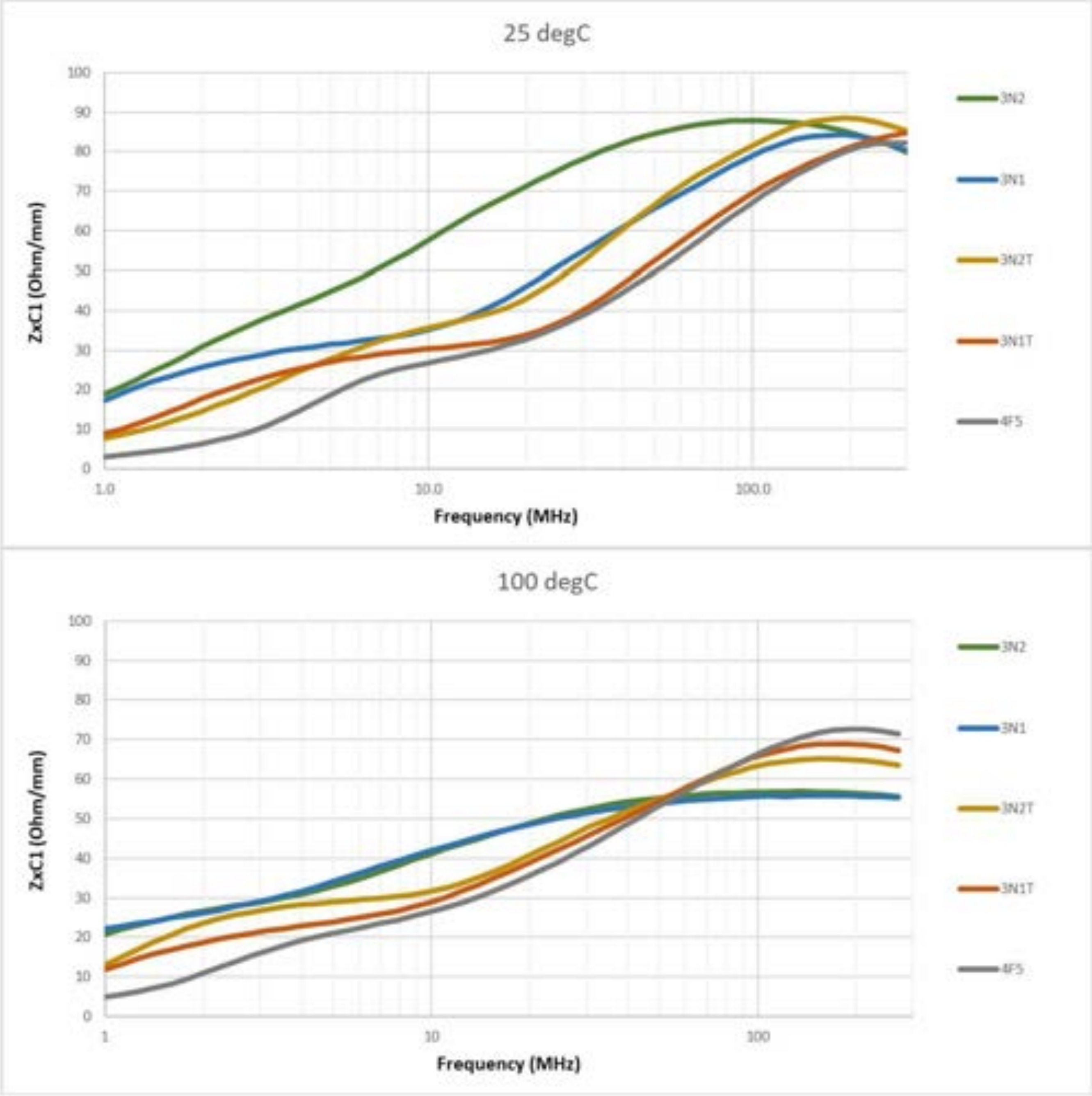
- High resistivity MnZn materials
- 3N1: Reasonable impedance 10 to 30 MHz
- 3N2: Highest impedance 10 to 30
  - Not affected by eddy currents (high resistivity)
  - New! Preferred for broadband filtering
- 3N3: High Tc (200), high Bsat, low perm
- 3N4: High Tc (200), High Bsat, μ=3000
- 3N5: Broad band LF, Tc >150
- 3N10: Highest low freq impedance <1 MHz
  - Performance dependent on cross section (eddy currents)





High frequency suppression: up to 300 MHz

- High resistivity MnZn materials
- 3N1: Optimized for 100 MHz
- 3N2: Highest impedance 10 to 100
  - High μ, also effective at low freq
  - New! Preferred for broadband filtering
- 3N1T: High Tc (200)
- 3N2T: High Tc with improved Z
  - New! Preferred for high temperature
- 4F5: NiZn high Tc high Bsat

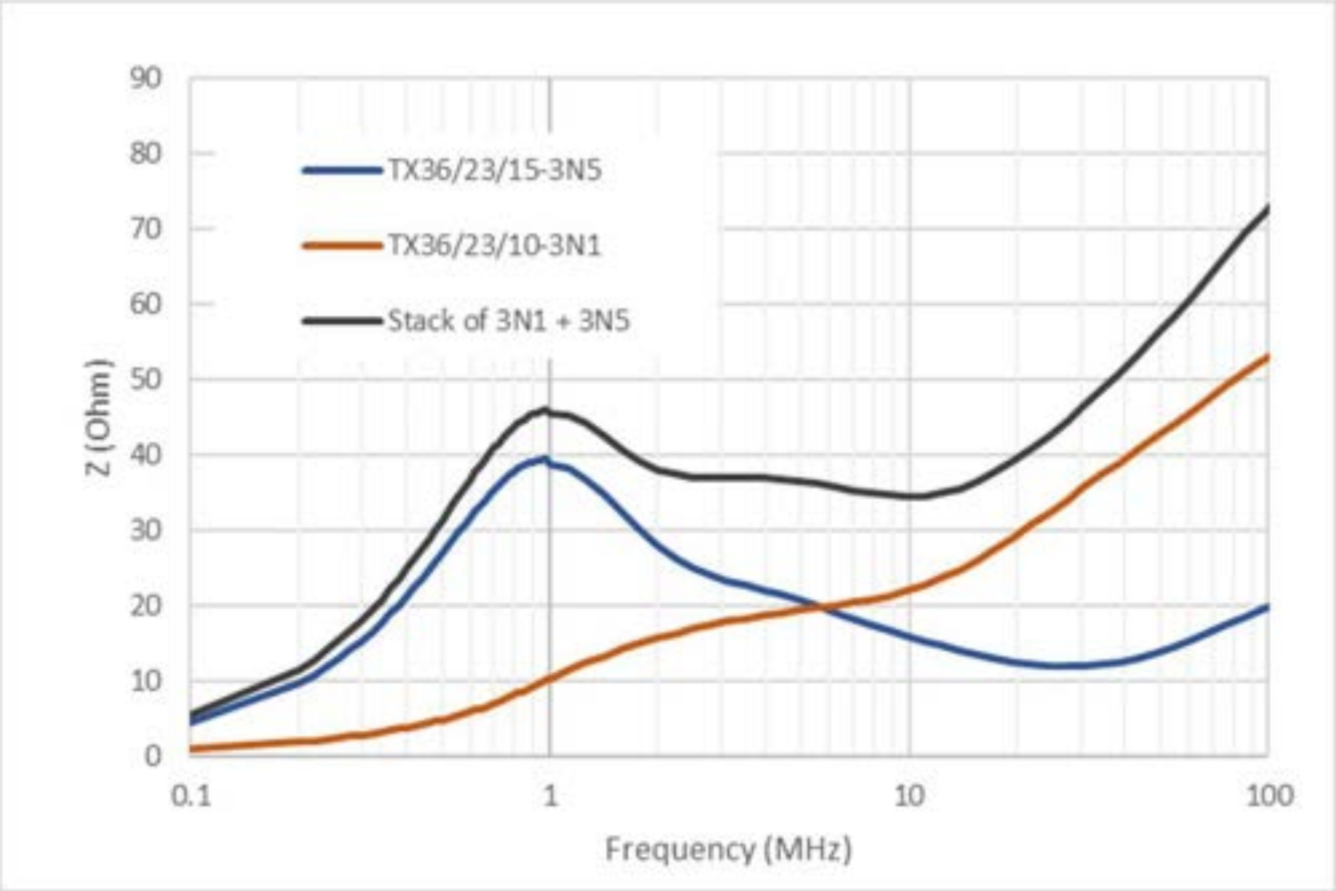


Material selection: common or differential mode

Common	Common & Differential	Common	CM, DM and Insert in NanoC	Common	Common
Very high Z 10 ~ 100 MHz High rho Tc > 150 Alternative to NiZn	High Z 10 ~ 100 MHz High rho Tc > 200 High Bsat Alternative to NiZn	Very high Z 0.3 ~ 100 MHz High rho Tc > 150 µi = 3000 Alternative to NiZn	Z 0.3 ~ 10 MHz High Bsat Tc > 200 µi = 2500 3N4 µi = 1250 3N3	Z 0.3 ~ 10 MHz Tc > 150 µi = 6000	Z 0.3 ~ 5 MHz Tc > 150 µi = 6000
			3N3 µi = 1250 *Tc ≥ 200°C* *3-20 MHz*		
3N1 µi = 1800 *Tc ≥150°C* *30-100 MHz*	**3N2T** µi = 1100 *Tc ≥200°C* *30-100 MHz*	**3N2** µi = 3000 *Tc ≥200°C* *30-100 MHz*	**3N4** µi = 2500 *Tc ≥ 200°C* *1-5 MHz*	**3N5** µi = 6000 *Tc ≥ 150°C* *0.5-3 MHz*	**3N10** µi = 8000 *Tc ≥ 130°C* *0.1-1 MHz*

Material stack for Wide Filter

- Full bandwidth EMI filtering can be achieved by stacking 2 materials:
  - Low frequency (3N5/3N10) for optimal suppression below 5 MHz
  - High frequency (3N1/3N2) for >5 MHz filtering
- Core dimensions can be adjusted to match the ideal Z curve at low and high frequency



4F5 – EMI at high frequency with bias

NiZn wide band EMI suppression 30 to 500 MHz High resistivity

High saturation at high temperature

4F5 SPECIFICATION

Medium permeability NiZn ferrite material suitable for EMI applications, but also recommended for particle acceleration applications with high bias currents at elevated temperatures.

SYMBOL	CONDITIONS	VALUE	UNIT
μi	25°C; 10kHz; 0.25mT	400±20%	
B	25°C; 10kHz; 1200A/m	≈ 420	mT
	100°C; 10kHz; 1200A/m	≈ 340	
	150°C; 10kHz; 1200A/m	≈ 300	
tanδ/μi	25°C; 0.1MHz; 0.250mT	≈ 20	10^{6}
	25°C; 1MHz; 0.250mT	≈ 40	
Z	25°C; 30MHz; 0.250mT	≈ 36	Ω
	25°C; 100MHz; 0.250mT	≈ 72	
Df	0.25mT; 10kHz; 25°C	≈ 2	10^{6}
ρDC	25°C	≈ 10^{6}	Ωm
Tc		≥ 240	°C
density		≈ 5200	kg/m³

typical paremeters measured on T25/15/10

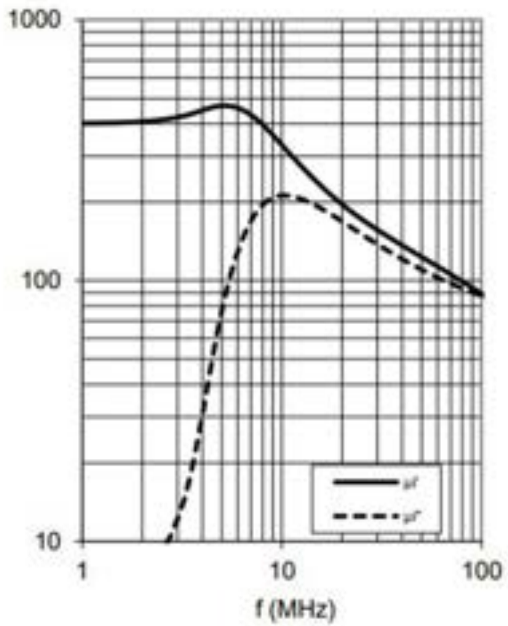


Fig.1 Complex permeability as a function of frequency

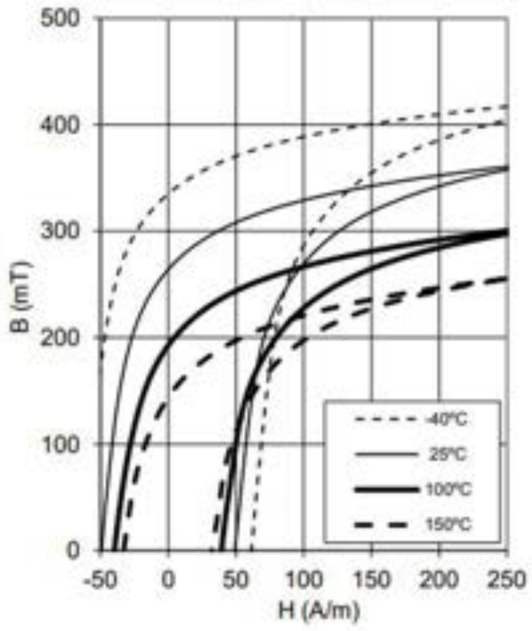


Fig.3 Typical BH loop

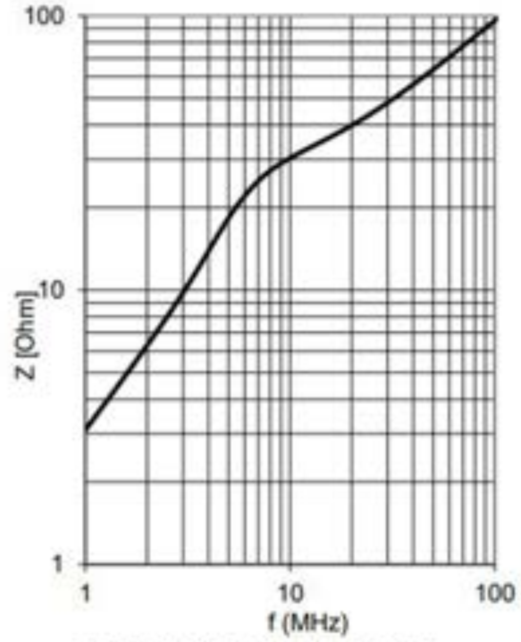


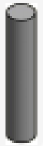
Fig.5 Impedance as a function of frequency

Product Overview

New Technologies

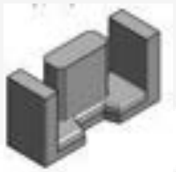
Traditional Automotive Applications

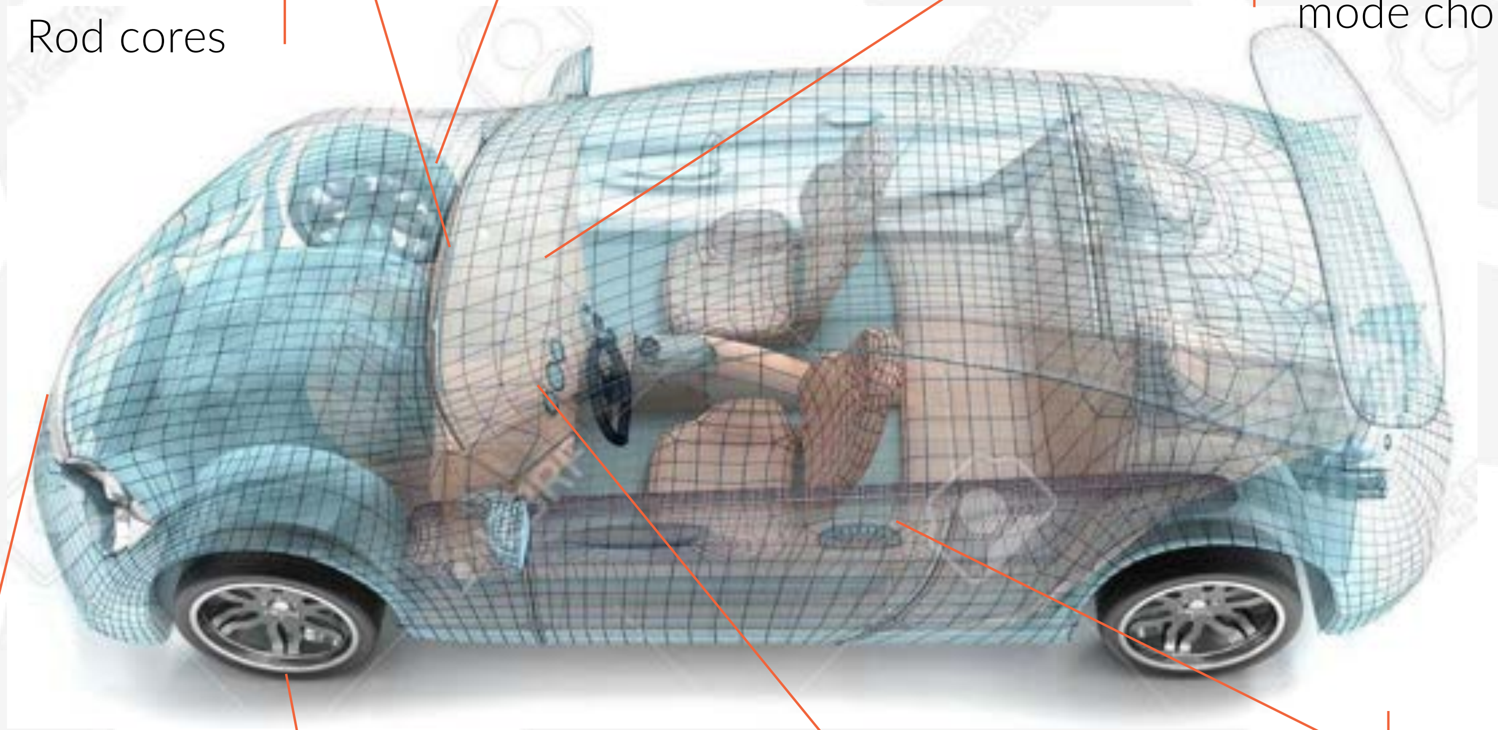
Electric motors
Wipers, windows, seats, mirrors...
Rod cores



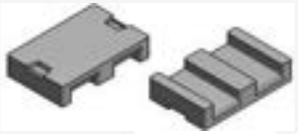
Airbag EMI
Small bead
Amphenol

Electric control units
Standard shapes for transformer, common mode choke



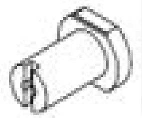


Brushless fan
Bus bar inductor

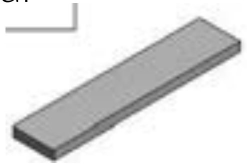


Tire pressure monitor
Tiny antenna

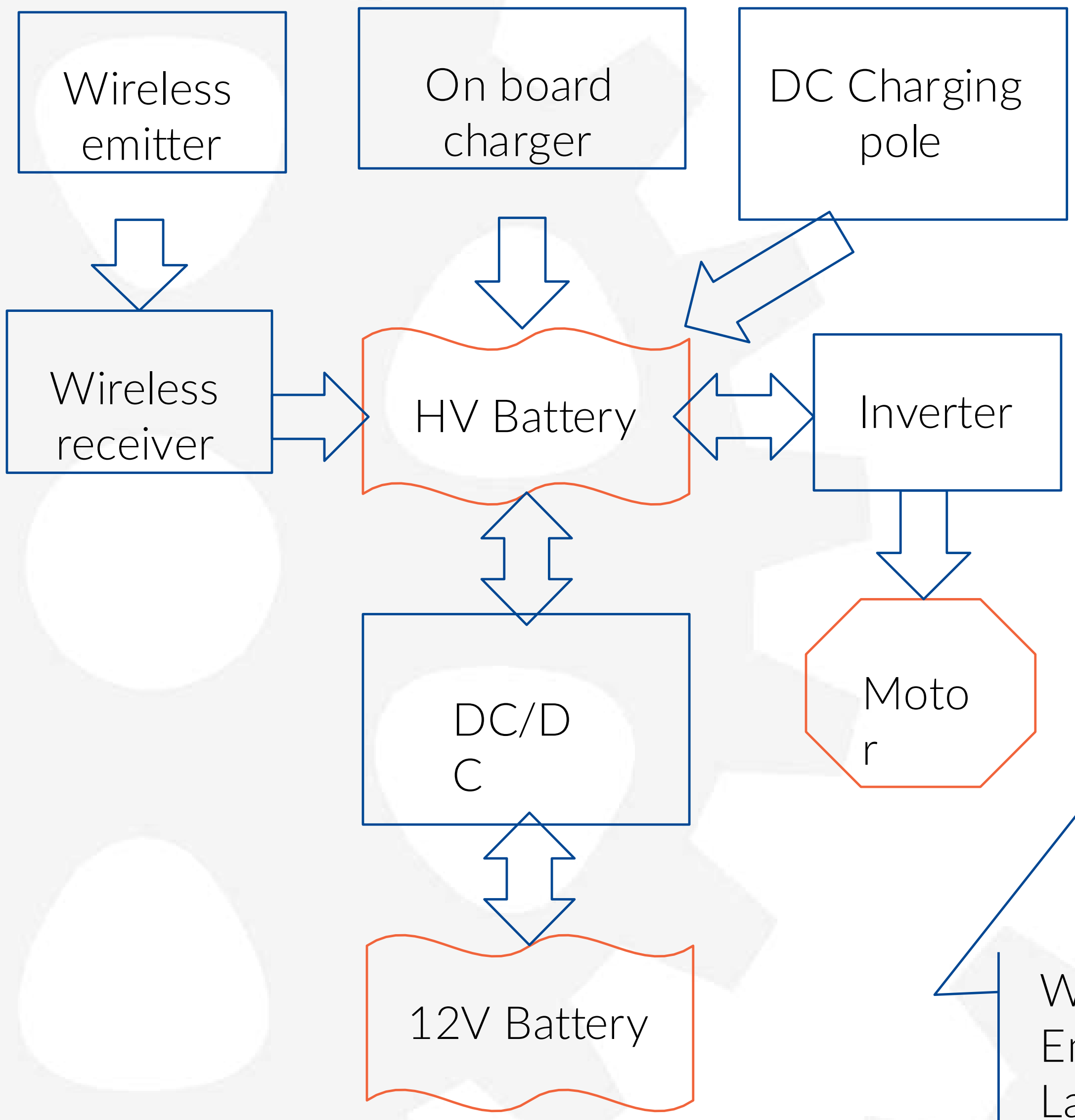
Aided steering
Mushroom core

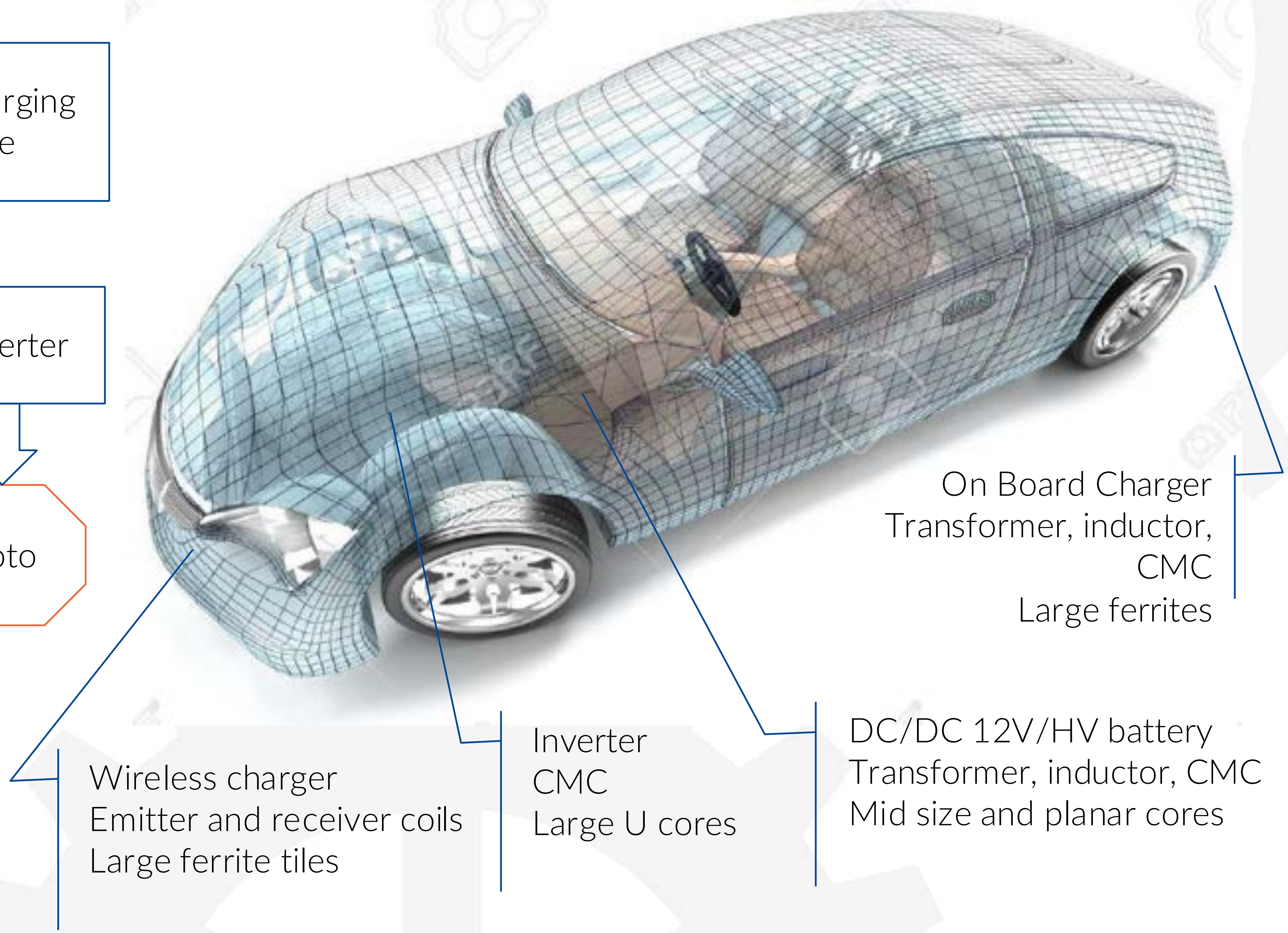


Keyless entry antenna
Long flat bar cores



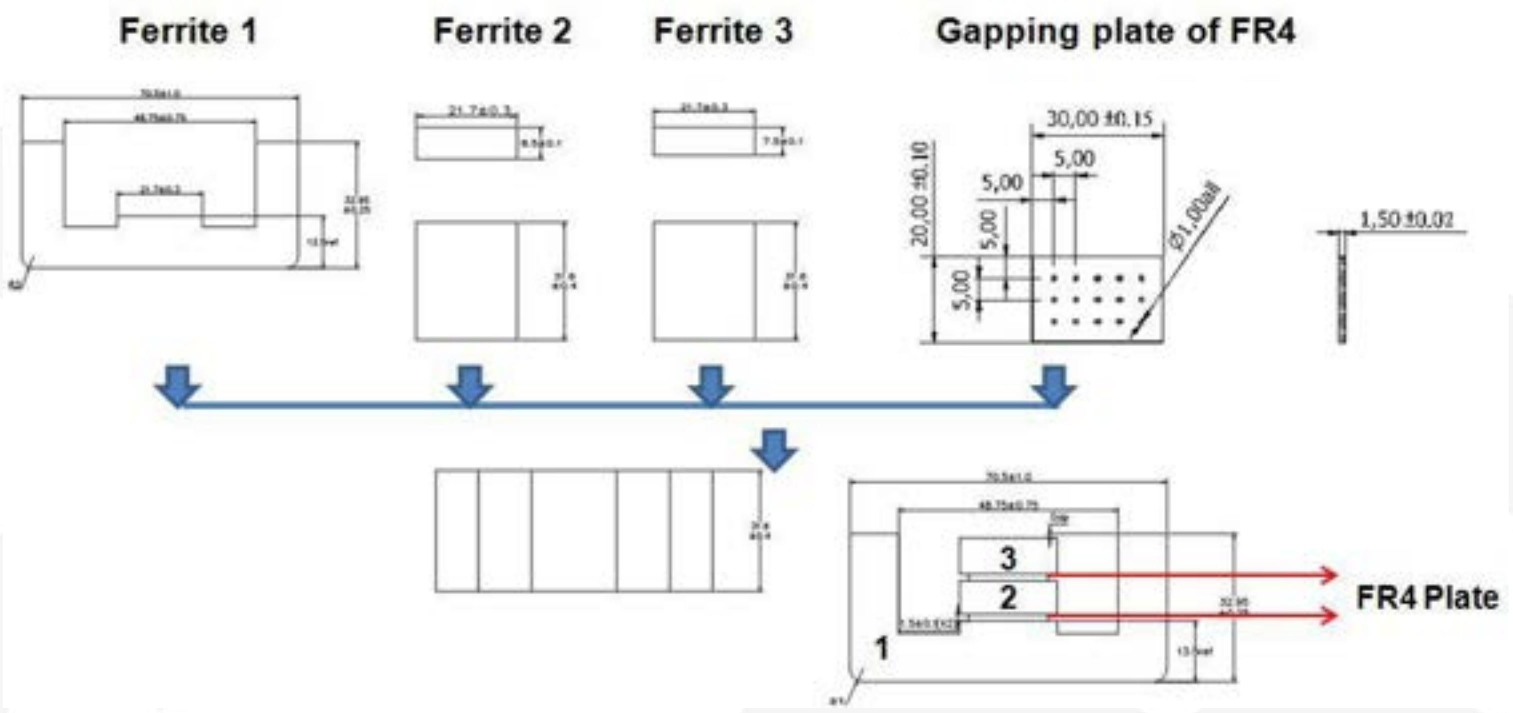
Electric Vehicle Applications





Multigap

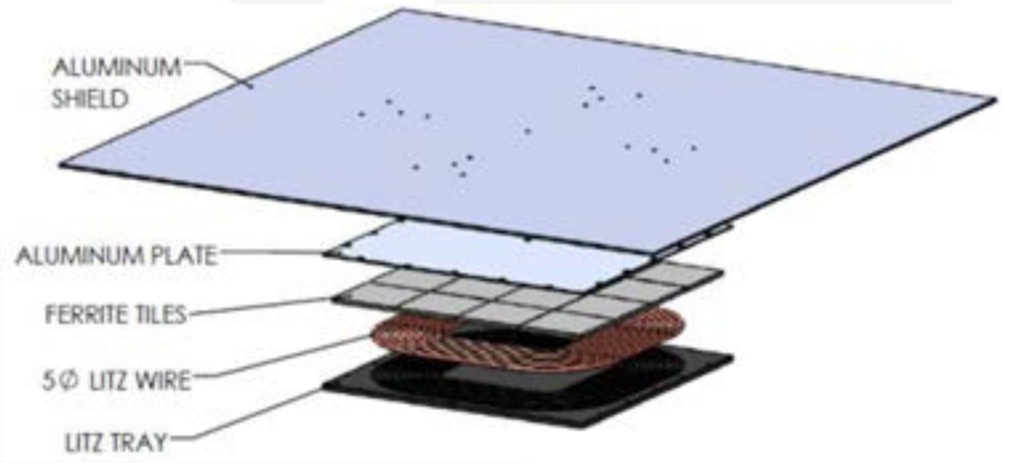
- Distributed air gaps improve the flux density distribution, thus reducing winding losses
- Realized via non-magnetic spacers (Alumina or FR4) glued between the ferrite parts
  - Alumina helps to transfer the heat out of the center leg
  - Customizable spacer thickness
- Other ferrite assemblies available on request



EV Wireless charger ferrite tiles: SAE J2954

- SAE J2954 defines the standard for wireless charger requirements
- Ferroxcube 3C97T exhibits excellent performance, even at high temperature
- Custom sizes available

Surface	Thickness	Ground sides	Ground top/bottom
100 x 100	5 / 10	No	Yes
120 x 120	5 / 10	No	Yes
160 x 86	5 / 10	No	Yes
130 x 130	5 / 10	Yes	Yes
150 x 100	5 / 10	Yes	Yes
100 x 100	5 / 10	Yes	Yes
50 x 50	5 / 10	Yes	Yes



Quality

Both factories ISO14001, ISO9001 and IATF certified
Released by several Tier 1 suppliers (Valeo, Bosch, Borg Warner…)

bsi.

Certificate of Registration

QUALITY MANAGEMENT SYSTEM - ISO 9001:2015

This is to certify that: FERROXCUBE Polska Sp. z o.o.
ul. Zwierzyniecka 2
Skierniewice
96-100
Poland

Holds Certificate No: FM 57772

Design and production of ferrous cores.
Design and production of ferrous granulated.

For and on behalf of BSI:

Original Registration Date: 2001-03-15
Latest Revision Date: 2018-02-27

bsi.

Certificate of Registration

QUALITY MANAGEMENT SYSTEM - IATF 16949:2016

This is to certify that: FERROXCUBE Polska Sp. z o.o.
ul. Zwierzyniecka 2
Skierniewice
96-100
Poland

Design and manufacture of ferrous cores and ferrous granulated.

For and on behalf of BSI:

Andrew Launn, EMEA Systems Certification Director

bsi.

Certificate of Registration

QUALITY MANAGEMENT SYSTEM - ISO 9001:2008

This is to certify that: Ferroxcube (Dongguan) Ltd.
Yulangwei Village
Qingxi Town
Dongguan
Guangdong
523649
China

Holds Certificate No: FM 68346

The design and manufacture of ferrite cores.

For and on behalf of BSI:

Original Registration Date: 12/07/2002
Latest Revision Date: 04/08/2015

bsi.

Certificate of Registration

QUALITY MANAGEMENT SYSTEM - IATF 16949:2016

This is to certify that: Ferroxcube (Dongguan) Ltd.
Yulangwei Village
Qingxi Town
Dongguan
Guangdong
523649
China

The design and manufacture of ferrite cores.

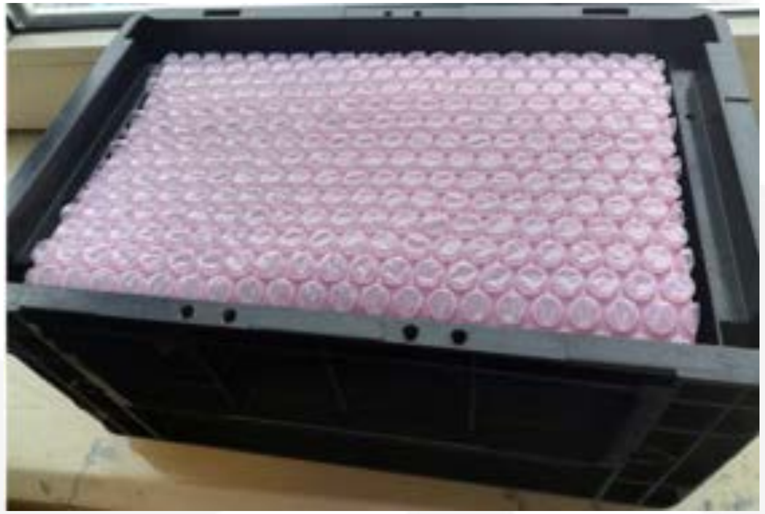
For and on behalf of BSI:

...making excellence a habit.

Custom packaging for cleanliness and automation

- Returnable
  - PET ESD tray, returnable
  - KLT box, returnable
  - Handling unit, returnable
  - Plastic pallet, returnable

- Disposable
  - EPE tray stack: best for protection
  - PET tray stack: best for automation
  - Double plastic bag
  - Carton box
  - Wooden pallet



In house testing: environmental (AEC-Q200)

Temperature / Humidity test chamber

Thermo-cycle
test chamber

In house testing: cleanliness

Sample extraction chamber

Microscope with software
and report function

3C97 – Premium material for power conversion

Optimized for 50 – 400 kHz

Flat response 50 to 140 °C

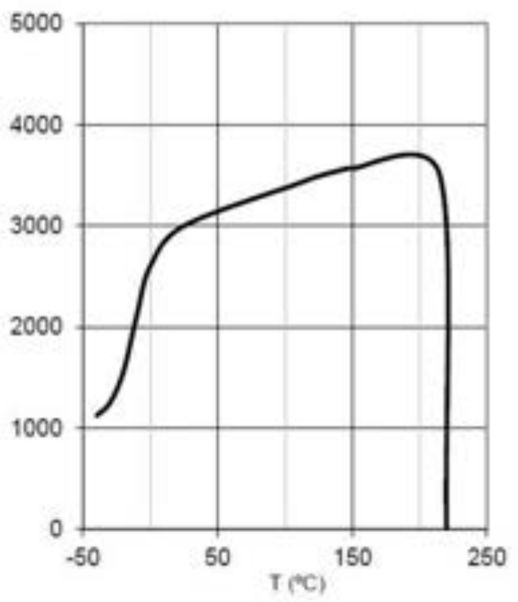


Fig.2 Permeability as function of temperature

3C97 SPECIFICATION

A low to medium frequency power material with low power losses from 50 to 150 °C. For use in power and general purpose transformers at frequencies up to 0.5MHz. Material should not be exposed to temperatures exceeding 150°C for long time.

SYMBOL	CONDITIONS	VALUE	UNIT
μi	25°C; 10kHz; 0.25mT	3000 ± 25%	
μa	25°C; 25kHz; 200mT	≈ 5000	
B	25°C; 10kHz; 1200A/m	≈ 550	mT
	100°C; 10kHz; 1200A/m	≈ 430	
	140°C; 10kHz; 1200A/m	≈ 360	
Pv	60°C; 100kHz; 200mT	≈ 320	kW/m^3
	140°C; 100kHz; 200mT	≈ 380	
ρDC	25°C	≈ 10	Ωm
Tc		≥ 215	°C
density		≈ 4850	kg/m^3

Typical performance of unstressed ring T25/15/12

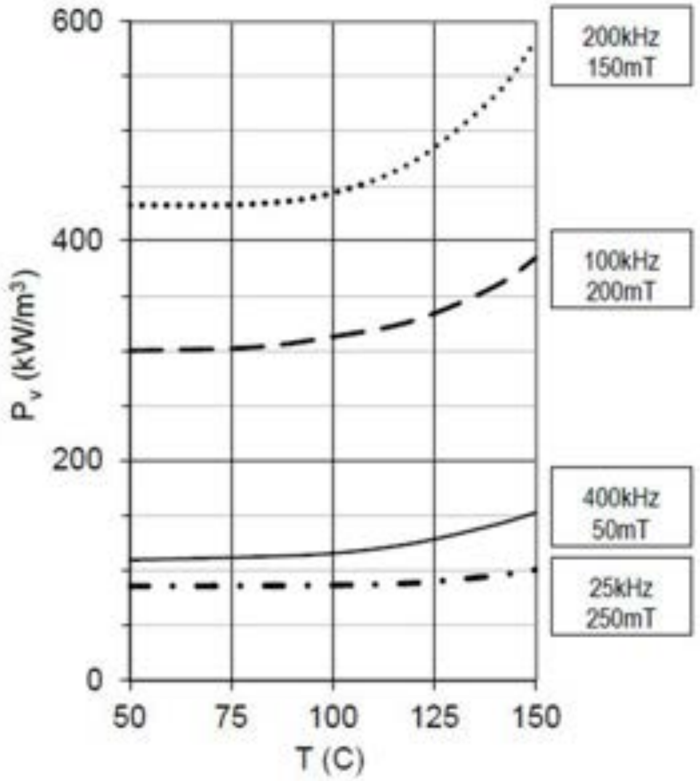


Fig.6 Power loss as function of temperature

3C97T – Lowest losses over temperature

Lowest losses in the range 25 to 100°C

Optimized operation up to 300 kHz thanks to high resistivity

R&D!

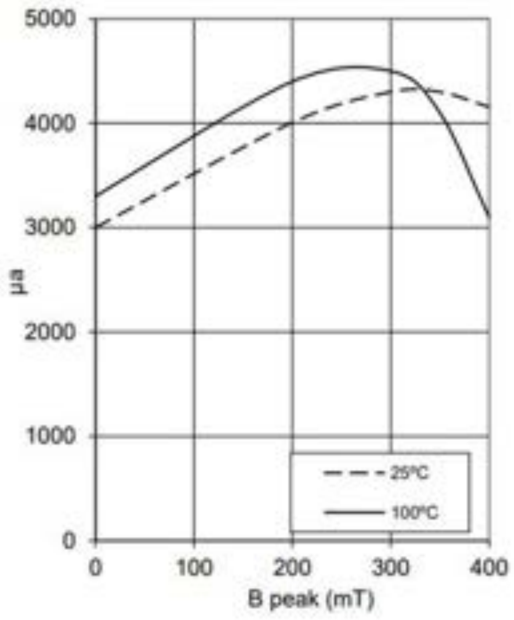


Fig.4 Amplitude permeability

SYMBOL	CONDITIONS	VALUE	UNIT
μi	25°C; 10kHz; 0.25mT	3300 ± 25%	
μa	100°C; 25kHz; 200mT	≈ 4500	
B	25°C; 10kHz; 1200A/m	≈ 550	mT
	100°C; 10kHz; 1200A/m	≈ 435	
Pv	25°C; 100kHz; 200mT	≈ 230	kW/m³
	60°C; 100kHz; 200mT	≈ 235	
	80°C; 100kHz; 200mT	≈ 245	
	100°C; 100kHz; 200mT	≈ 280	
	120°C; 100kHz; 200mT	≈ 320	
	140°C; 100kHz; 200mT	≈ 380	
Pv	25°C; 200kHz; 125mT	≈ 185	kW/m³
	60°C; 200kHz; 125mT	≈ 180	
	80°C; 200kHz; 125mT	≈ 185	
	100°C; 200kHz; 125mT	≈ 210	
	120°C; 200kHz; 125mT	≈ 260	
	140°C; 200kHz; 125mT	≈ 320	
Pv	25°C; 300kHz; 120mT	≈ 355	kW/m³
	60°C; 300kHz; 120mT	≈ 375	
	80°C; 300kHz; 120mT	≈ 395	
	100°C; 300kHz; 120mT	≈ 435	
	120°C; 300kHz; 120mT	≈ 520	
Pv	25°C; 400kHz; 100mT	≈ 415	kW/m³
	60°C; 400kHz; 100mT	≈ 430	
	80°C; 400kHz; 100mT	≈ 445	
	100°C; 400kHz; 100mT	≈ 490	
	120°C; 400kHz; 100mT	≈ 600	
ρDC	25°C	≈ 15	Ωm
Tc		≥ 230	°C
density		≈ 4850	kg/m³

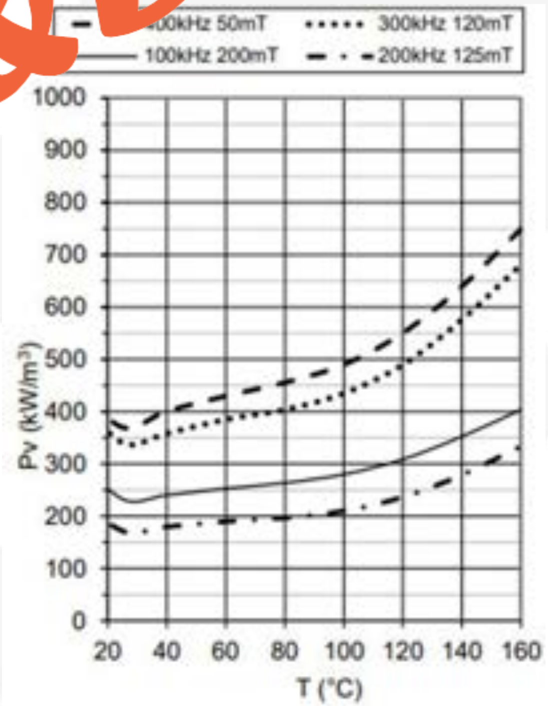


Fig.5 Power loss as a function of Temperature

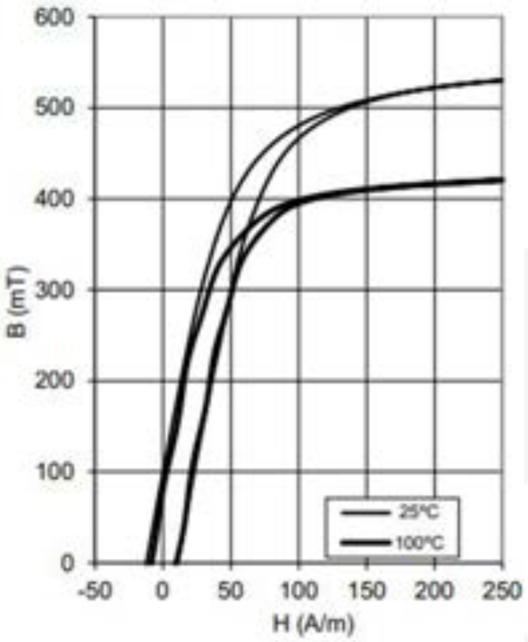


Fig.3 Typical BH loops

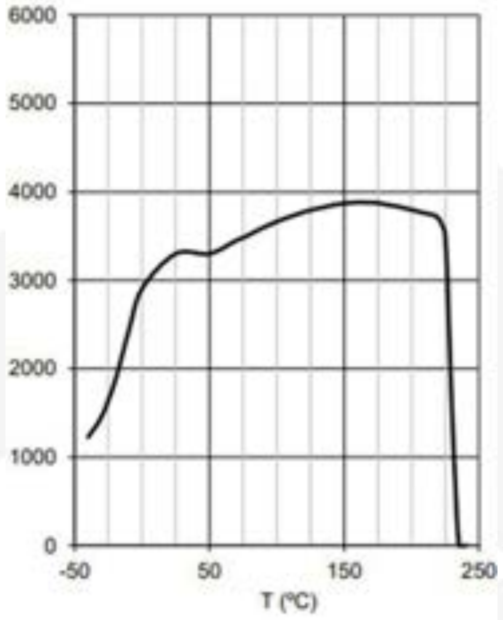


Fig.2 Permeability as a function of temperature

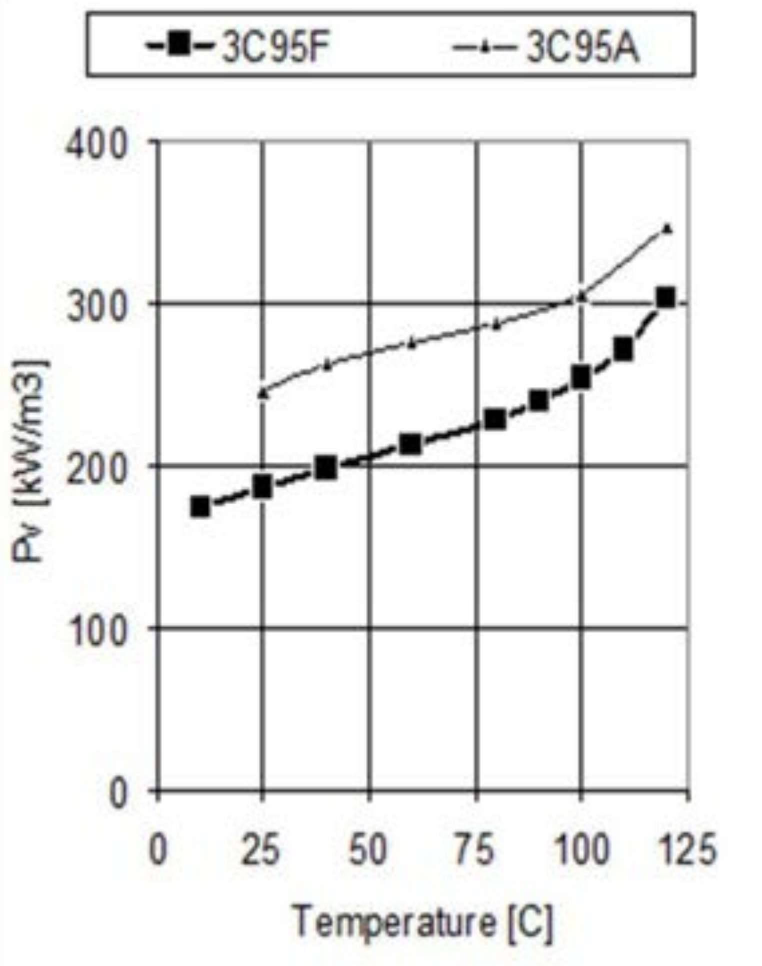
3C95F – Premium material for power conversion

Optimized for 200 - 400 kHz

Flat response 0 to 100 °C

High Bsat

	CONDITIONS	UNIT	3C95F	3C95A
μi	25ºC; 10kHz; 0.25mT		**3000 ± 20%**	3300 ± 20%
μa	100ºC; 25kHz; 200mT		**≈ 4500**	≈ 5000
B	25ºC; 10kHz; 1200A/m	mT	**≈ 550**	≈ 550
	100ºC; 10kHz; 200A/m		**≈ 430**	≈ 430
Pv	100ºC; 100kHz; 200mT	kW/m³	**≈ 310***	≈ 290
	100ºC; **200kHz**; 125mT		**≈ 250**	≈ 400*
	100ºC; **300kHz**; 100mT		**≈ 270**	≈ 350*
ρDC	25ºC	Ωm	**≈ 10**	≈ 10
Tc		ºC	**≥ 210**	≥ 210
density		kg/m³	**≈ 4850**	≈ 4850



Power loss at 300kHz 100mT in a function of temperature.

3C91A – Low temperature power conversion

Up to 300 kHz

Flat in 0 – 60 °C temperature range

Highest μ_i and μ_a

High Bsat at low temperature

SYMBOL	CONDITIONS	VALUE	UNIT
µi	25ºC; 10kHz; 0.25mT	3200 ± 25%	
µa	100ºC; 25kHz; 200mT	≈ 4800	
B	25ºC; 10kHz; 1200A/m 100ºC; 10kHz; 1200A/m	≈ 530 ≈ 410	mT
Pv	25ºC; 100kHz; 200mT 60ºC; 100kHz; 200mT	≈ 250 ≈ 260	k W / m ³
ρDC	25ºC	≈ 5	Ωm
Tc		≥ 215	ºC
density		≈ 4850	k g / m 3

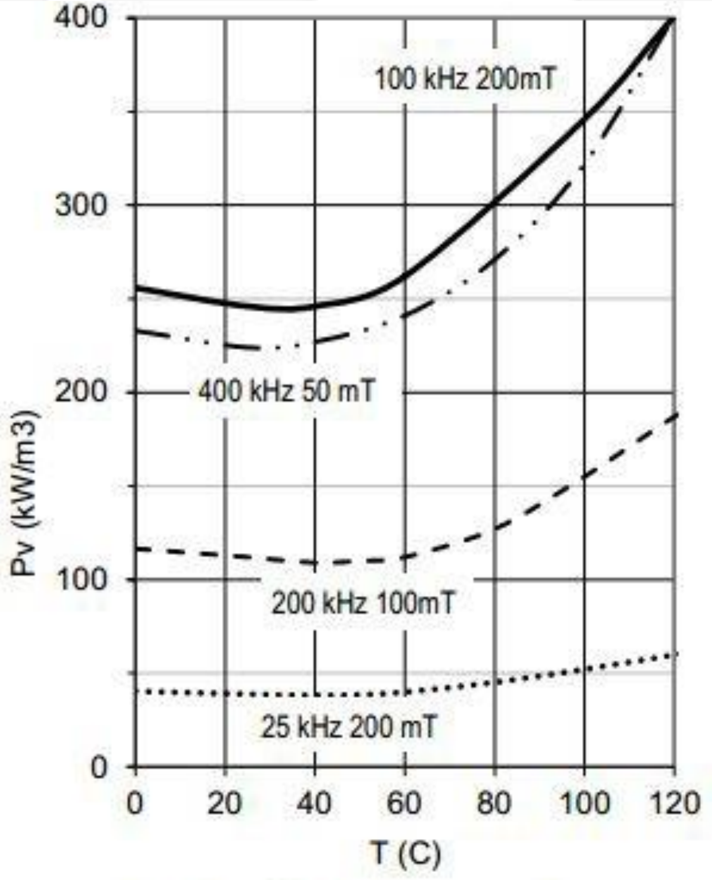


Fig.6 Power loss as function of Temperature

3C97A – Power conversion at high temperature

Minimum loss at 160 C

High and stable saturation below 160 C

New!

3C97A SPECIFICATION

A medium frequency, high temperature power material with minimum power losses at 140 - 160°C for use in power and general purpose transformers.

SYMBOL	CONDITIONS	VALUE	UNIT
μi	25°C; 10kHz; 0.25mT	1100 ± 25%	
μa	25°C; 25kHz; 200mT	≈ 4000	
B	25°C; 10kHz; 1200A/m	≈ 520	mT
	100°C; 10kHz; 1200A/m	≈ 440	
	150°C; 10kHz; 1200A/m	≈ 370	
Pv	100, 150°C; 100kHz; 200mT	≈ 500	kW/m³
	100, 150°C; 200kHz; 125mT	≈ 400	
	100, 150°C; 400kHz; 50mT	≈ 150	
ρDC	25°C	≈ 8	Ωm
Tc		≥ 280	°C
density		≈ 4800	kg/m³

Typical performance of unstressed ring T25/15/12

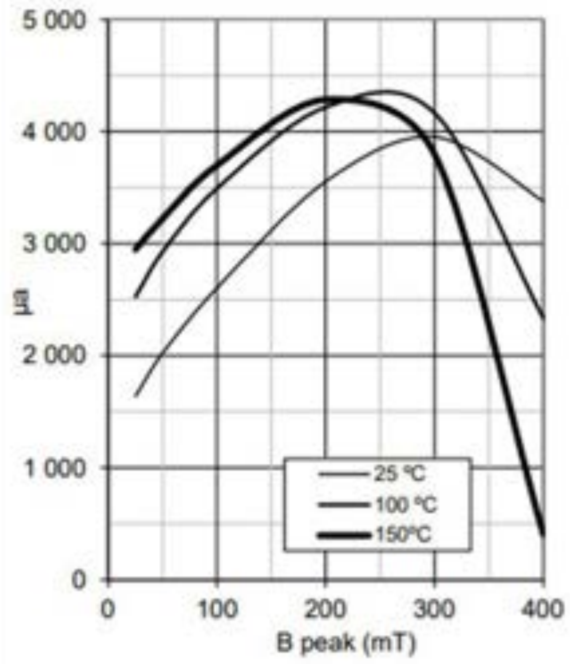


Fig.4 Amplitude permeability

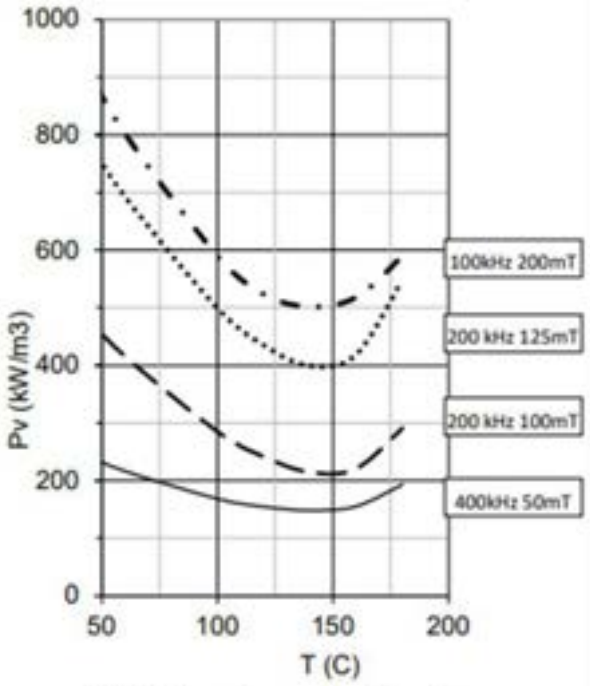


Fig.6 Power loss as function of Temperature at 50mT

3C99 – Power conversion at 200 C

Decreasing losses up to 200C

Ideal to prevent thermal runaway

Frequency range 50 to 400 kHz

New!

3C99 SPECIFICATION

A medium frequency power material with high Curie temperature, optimized for 200°C working temperature.

SYMBOL	CONDITIONS	VALUE	UNIT
μi	25ºC; 10kHz; 0.25mT	800 ± 20%	
μa	200ºC; 10kHz; 200mT	≈ 4000	
B	25ºC; 10kHz; 1200A/m 100ºC; 10kHz; 1200A/m 200ºC; 10kHz; 1200A/m	≈ 500 ≈ 450 ≈ 320	mT
Pv	200ºC; 25kHz; 200mT 200ºC; 100kHz; 100mT 200ºC; 400kHz; 50mT	≈ 140 ≈ 140 ≈ 220	kW/m³
ρDC	25ºC	≈ 6	Ωm
Tc		≥ 300	ºC
density		≈ 4800	kg/m 3

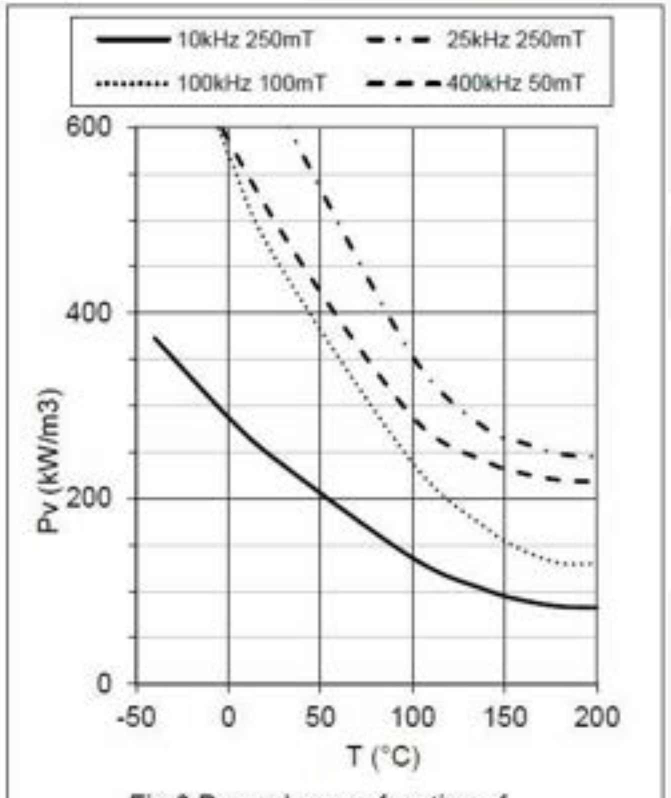


Fig.6 Power loss as function of Temperature

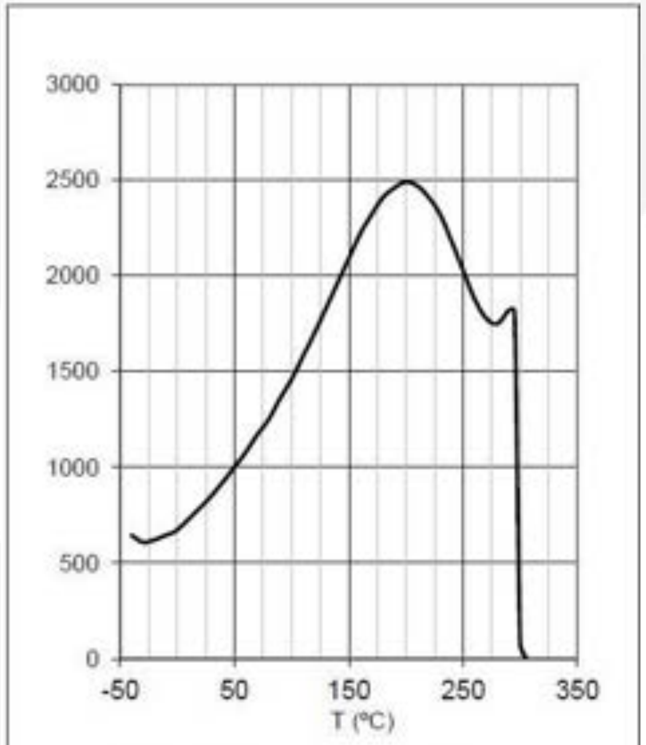


Fig.2 Permeability as function of temperature

3F36 – Flat response below 1 MHz

Optimum material for 400 kHz to 1 MHz

Flat power loss and permeability 25 to 100 C

High resistivity, ideal for large cores

	CONDITIONS	UNIT	3F36
μi	25ºC; 10kHz; 0.25mT		**1600 ± 20%**
μa	100ºC; 25kHz; 200mT		**≈ 2400**
B	25ºC; 10kHz; 1200A/m	mT	**≈ 520**
	100ºC; 10kHz; 1200A/m		**≈ 420**
Pv	100ºC; 400kHz; 50mT	kW/m³	**≈ 50**
	100ºC; 500kHz; 50mT		**≈ 90**
	100ºC; **500kHz**; 100mT		**≈ 700**
ρDC	25ºC	Ωm	**≈ 12**
Tc		ºC	**≥ 230**
density		kg/m³	**≈ 4750**

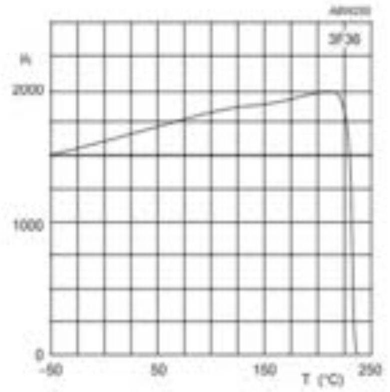


Fig.2 Initial permeability as a function of temperature.

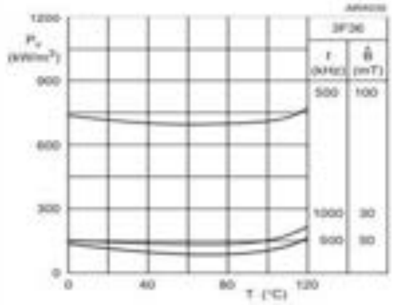


Fig.7 Specific power loss for several frequency/flux density combinations as a function of temperature.

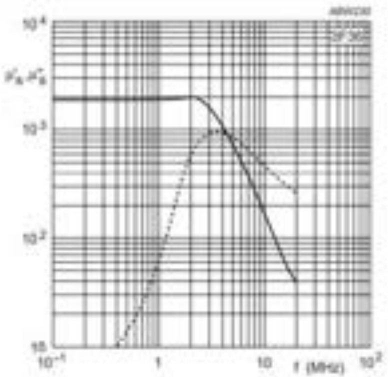


Fig.1 Complex permeability as a function of frequency.

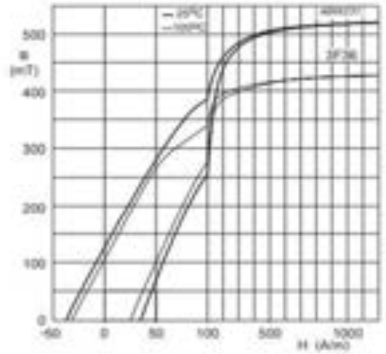


Fig.3 Typical B-H loops.

3F36P – Power inductors at high frequency

Low loss at low temperature

Optimized for 400 to 1000

kHz Highest Bsat

3F36P SPECIFICATION

A high frequency power material optimized for low loss with high DC signal for use in power inductors.

SYMBOL	CONDITIONS	VALUE	UNIT
μi	25°C; 10kHz; 0.25mT	1400 ± 25%	
μa	25°C; 25kHz; 200mT	≈ 1800	
B	25°C; 10kHz; 1200A/m 100°C; 10kHz; 1200A/m	≈ 550 ≈ 450	mT
Pv	25°C; 500MHz; 50mT 25°C; 1MHz; 50mT	≈ 50 ≈ 225	kW/m³
ρDC	25°C	≈ 6	Ωm
Tc		≥ 270	°C
density		≈ 4.75	kg/m 3

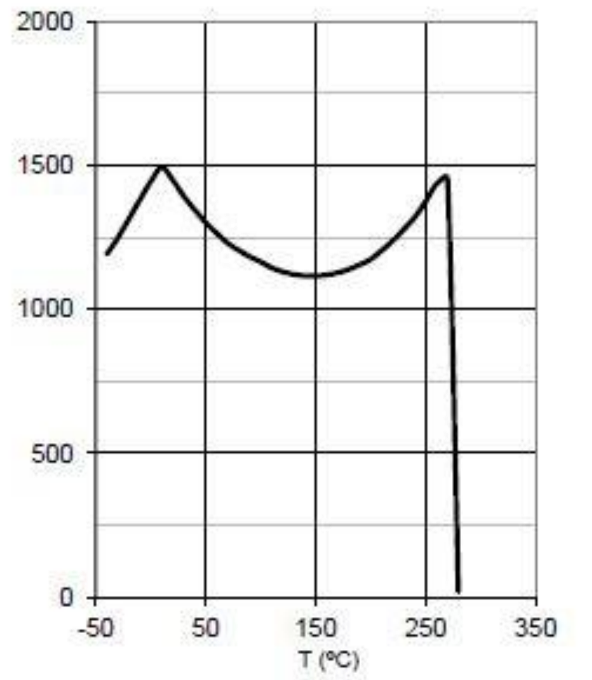


Fig.2 Permeability as function of temperature

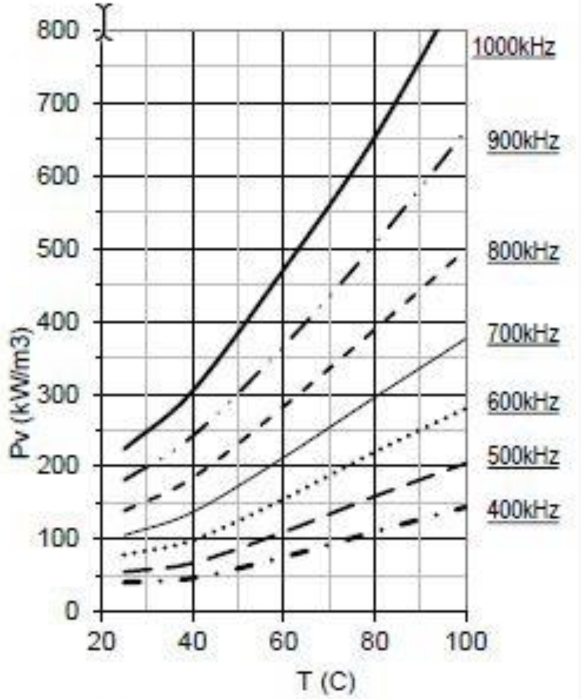


Fig.6 Power loss as function of Temperature at 50mT

3F46 – Power conversion beyond 1 MHz

Optimum performance 1 to 3 MHz

Flat response with high Bsat Small

and mid size

A high frequency power material for use in power and general purpose transformers at frequencies of 1-3MHz. Temperature characteristic tuned for stable operation in range 25-100°C. Available in product size up to 40mm.

SYMBOL	CONDITIONS	VALUE	UNIT
μi	25°C; 10kHz; 0.25mT	750 ± 20%	
μa	100°C; 25kHz; 200mT	≈ 1500	
B	25°C; 10kHz; 1200A/m 100°C; 10kHz; 1200A/m	≈ 520 ≈ 430	mT
Pv	100°C; 1MHz; 50mT 100°C; 3MHz; 10mT 100°C; 3MHz; 30mT	≈ 150 ≈ 50 ≈ 500	mW/cm^3
ρDC	25°C	≈ 5	Ωm
Tc		≥ 280	°C
density		≈ 4750	kg/m^3

based on T14/9/5

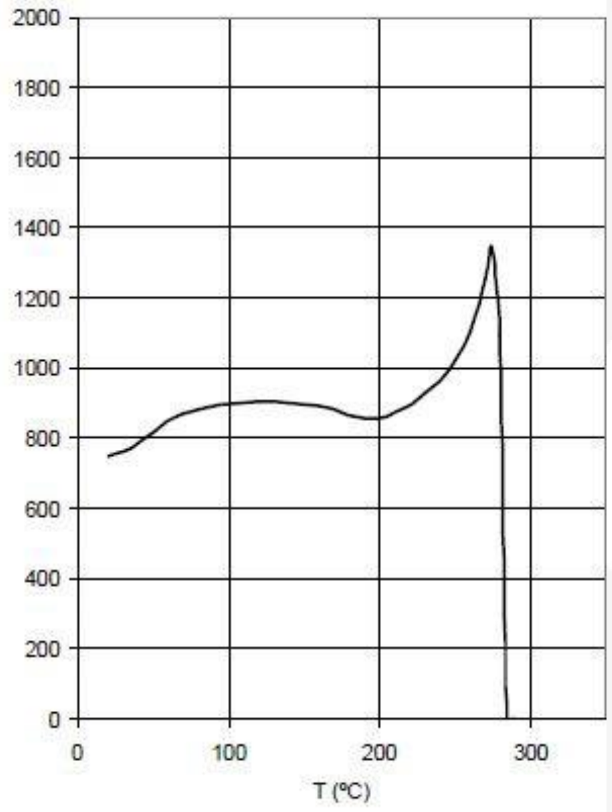


Fig.2 Permeability as a function of temperature

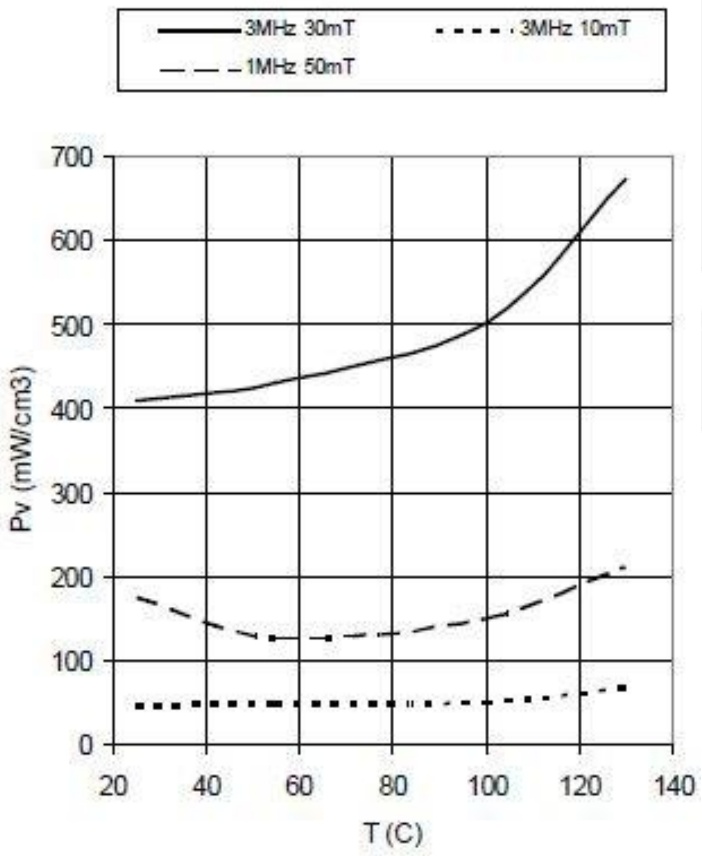


Fig.6 Power loss as a function of temperature

3F46A – Lowest power loss beyond 1 MHz

YAGEO GROUP
YAGEO Ferroxcube

Optimized 1 to 3 MHz Lowest power loss

Small and mid size

R&D!

3F46A SPECIFICATION

A high frequency power material for use in power and general purpose transformers at frequencies of 1-5 MHz. For best performance, saturation should be avoided. Available in product size up to 40 mm.

SYMBOL	CONDITIONS	VALUE	UNIT
μi	25°C; 10kHz; 0.25mT	750 ± 25%	
μa	100°C; 25kHz; 200mT	≈ 1400	
B	25°C; 10kHz; 1200A/m	≈ 540	mT
	100°C; 10kHz; 1200A/m	≈ 440	
Pv	25°C; 1MHz; 50mT	≈ 70	kW/m^3
	100°C; 1MHz; 50mT	≈ 100	
	25°C; 3MHz; 30mT	≈ 200	
	100°C; 3MHz; 30mT	≈ 300	
	25°C; 5MHz; 20mT	≈ 200	
	100°C; 5MHz; 20mT	≈ 360	
ρDC	25°C	≈ 5	Ωm
Tc		≥ 270	°C
density		≈ 4750	kg/m^3

Typical peformance of T14/9/5

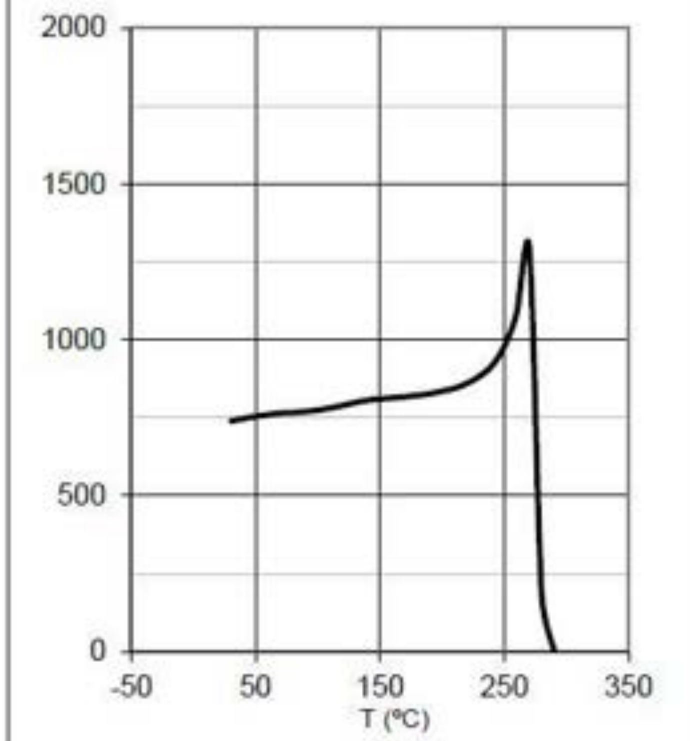


Fig.2 Permeability as a function of temperature

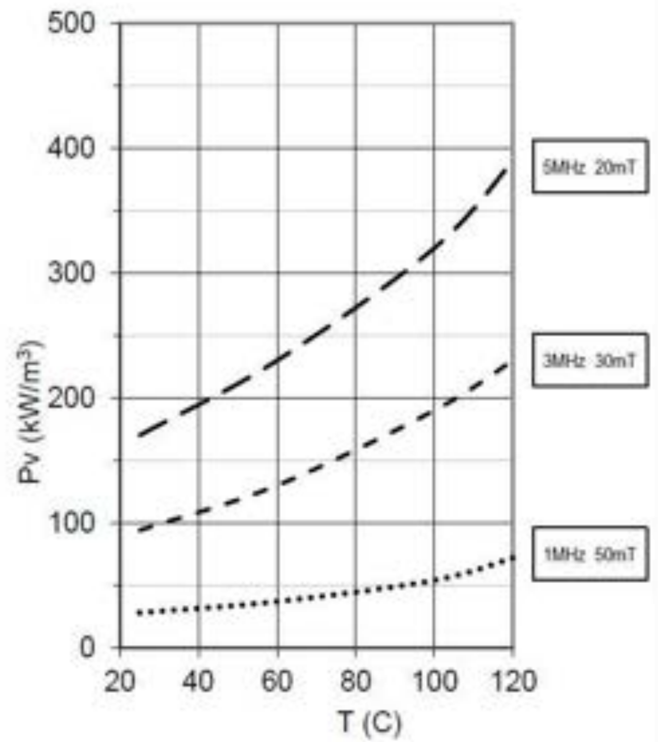


Fig.4 Power loss as a function of Temperature

3F56 – Power conversion 3 to 5 MHz

Highest frequency MnZn material

Flat response with stable Bsat over temp

Very high Tc

Compared to NiZn:

- Higher Bsat
- Higher Permeability
- Lower loss

R&D!

3F56 SPECIFICATION

A high frequency power material with flat permeability, optimized for 3MHz, 30mT up to 5 MHz, 15mT. For best performance, saturation should be avoided.

SYMBOL	CONDITIONS	T25/15/12	T14/9/5	UNIT
μi	25ºC; 10kHz; 0.25mT	250 ± 25%		
μa	25ºC; 25kHz; 200mT	≈ 750		
B	25ºC; 10kHz; 1200A/m	≈ 500		mT
	100ºC; 10kHz; 1200A/m	≈ 440		
Pv	100ºC; 3MHz; 10mT	≈ 70	≈ 40	kW/m³
	100ºC; 5MHz; 10mT	≈ 250	≈ 150	
ρDC	25ºC	≈ 5		Ωm
Tc		≥ 300		ºC
density		≈ 4700		kg/m³

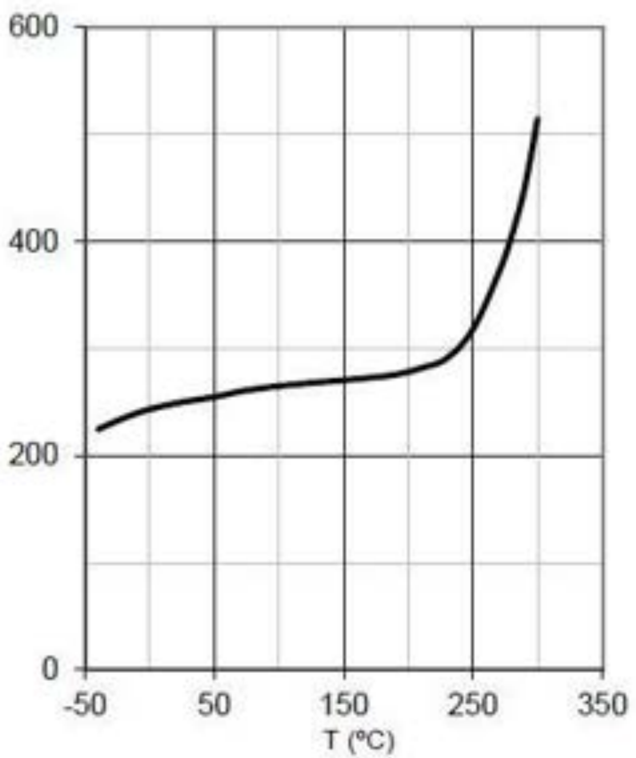


Fig.2 Permeability as function of temperature

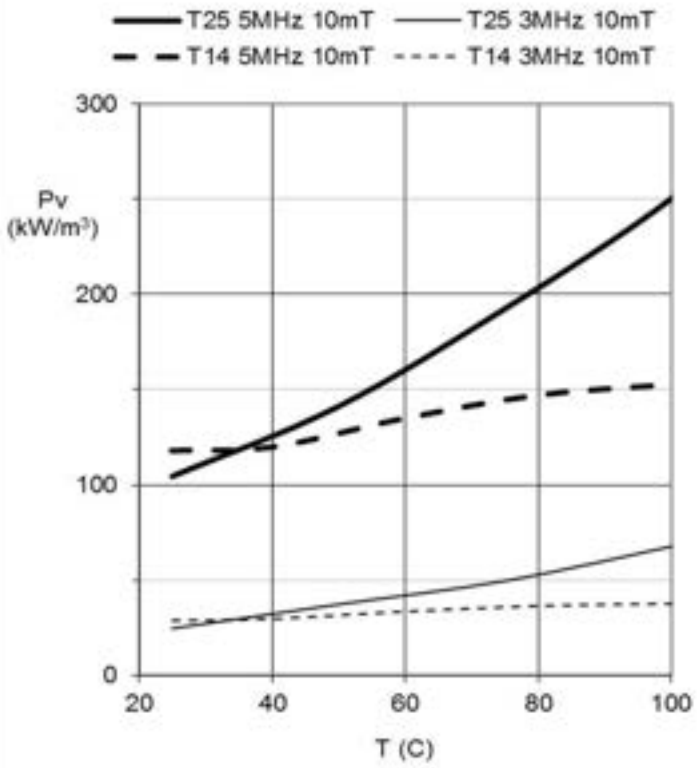


Fig.6 Power loss as function of Temperature

4F1 – Power conversion below 15 MHz

High resistivity NiZn material

Ideal for operation at 13.56 MHz

4F1 SPECIFICATIONS

A very high frequency NiZn power material for use in power and general purpose transformers optimized for frequencies of 4 - 10 MHz.

SYMBOL	CONDITIONS	VALUE	UNIT
μ_i	25 °C; ≤10 kHz; 0.25 mT	≈ 80	
μ_a	100 °C; 25 kHz; 200 mT	≈ 300	
B	25 °C; 10 kHz; 3000 A/m	≈ 320	mT
	100 °C; 10 kHz; 3000 A/m	≈ 260	
P_V	100 °C; 3 MHz; 10 mT	≤ 200	kW/m^3
	100 °C; 10 MHz; 5 mT	≤ 200	
ρ	DC; 25 °C	≈ 10^5	Ωm
T_C		≥ 260	°C
density		≈ 4600	kg/m^3

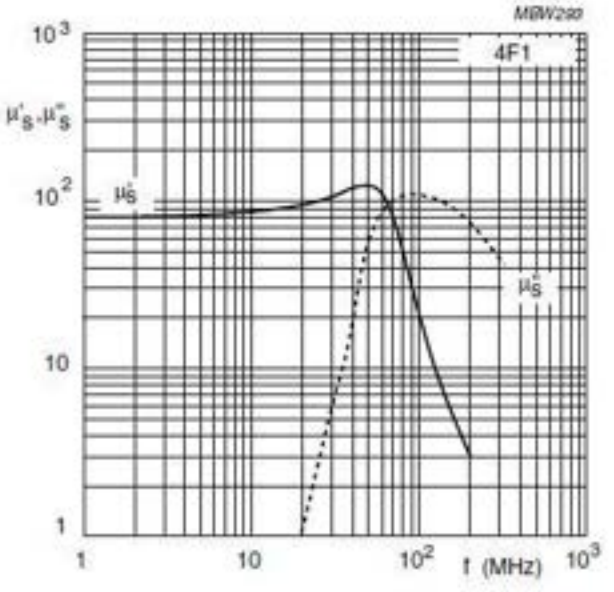


Fig.1 Complex permeability as a function of frequency.

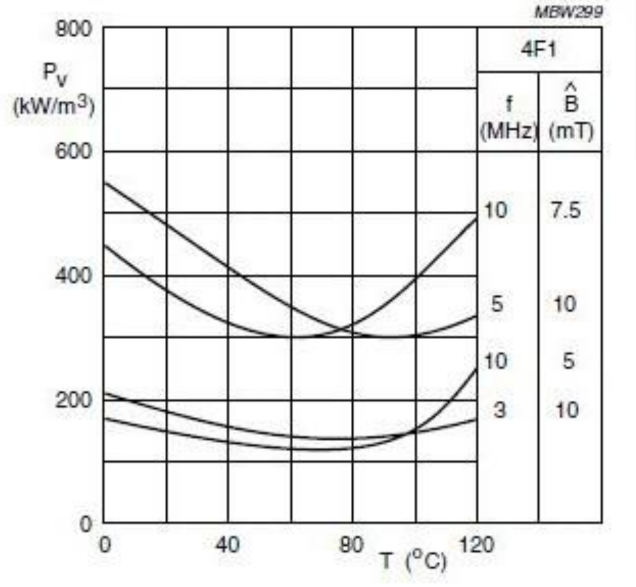


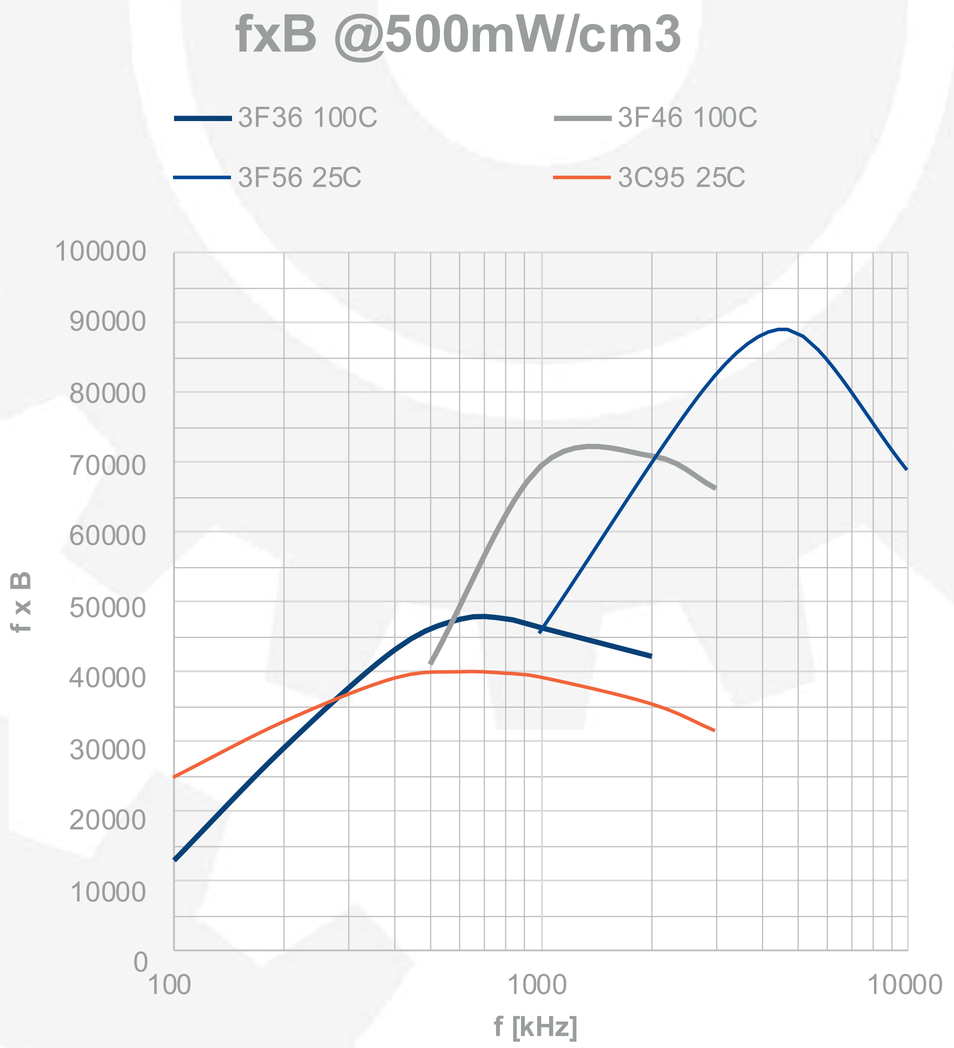
Fig.7 Specific power loss for several frequency/flux density combinations as a function of temperature.

Summary High Frequency

Material	High DC	Core size*	Temp**	Freq range
3C97A	Best	All	<160	< 300 kHz
3C97	Best	All	< 140	< 400 kHz
3C97T	Good	All	< 100	< 400 kHz
3F36	Good	All	< 100	< 1 MHz
3F46	Good	Small Mid	< 100	1 to 3 MHz
3F46A	No	Small Mid	< 80	1 to 3 MHz
3F56	No	Small Mid	< 80	3 to 5 MHz
4F1	Low	All	< 120	≤ 15 MHz

*Small Mid means roughly Ae <130 mm^2

**Recommended operating temp, can be exceeded if needed



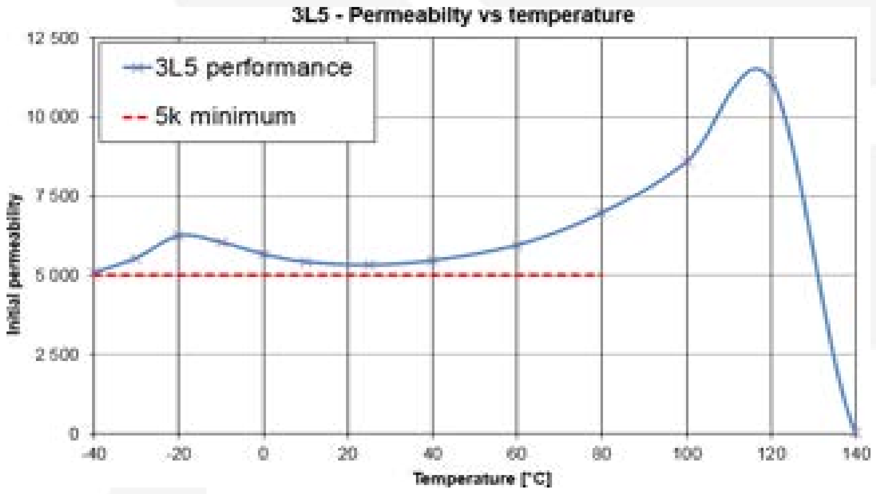
3L5 – High permeability below 0

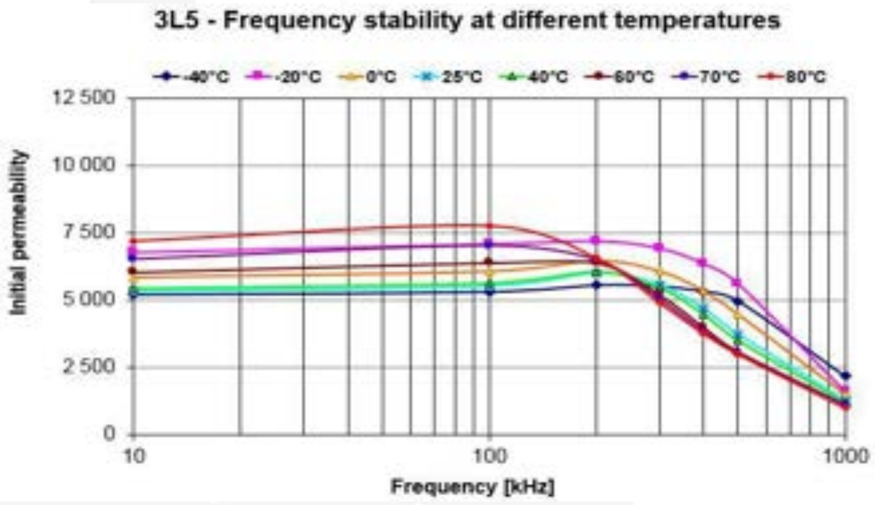
Permeability > 5k Optimized for -40 to 80 °C Full range of sizes

Operating temp up to 120 °C

Preliminary spec

Symbol		Conditions			Value	Unit
		f (kHz)	B (mT)	T (°C)		
μ_i	Initial permeability	10	0.25	-40 0 25 70	≈ 5000 ≈ 5500 ≈ 5000 ≈ 5500	-
		f (kHz)	H (A/m)	T (°C)		
B	Flux density	10	1200	25 100	≈ 400 ≈ 200	mT
		f (kHz)	B (mT)	T (°C)		
$\tan\delta/\mu_i$	Relative loss factor	100 200	0,25	25	≤ 15 ≤ 35	10^{-6}
ρ	Spec. Resistivity DC	-	-	25	≈ 0.5	Ωm
Tc	Curie temperature	10	0.1	-	> 120	°C
SD	Sinter density				≈ 4900	kg/m³





3E8T – Best balance high μ 8000 / high Tc > 150°C

High permeability (8k)

Low frequency range (0.1-10 MHz)

Small and mid size (<42 mm) range of toroid sizes and cable shields

High Tc>150C provides also high Bsat

SYMBOL	CONDITIONS	VALUE	UNIT
μi	25°C; 10kHz; 0.25mT	8000 ± 30%	
B	25°C; 10kHz; 1200A/m 100°C; 10kHz; 1200A/m	≈ 470 ≈ 300	mT
$\tan\delta/\mu_i$	25°C; 30kHz; 0.25mT 25°C; 100kHz; 0.25mT	$\leq 5 \cdot 10^{-6}$ $\leq 30 \cdot 10^{-6}$	
ρDC	25°C	≈ 0.5	Ωm
Tc		≥ 150	°C
density		≈ 5000	kg/m3

Typical performance of unstressed ring T25/15/12

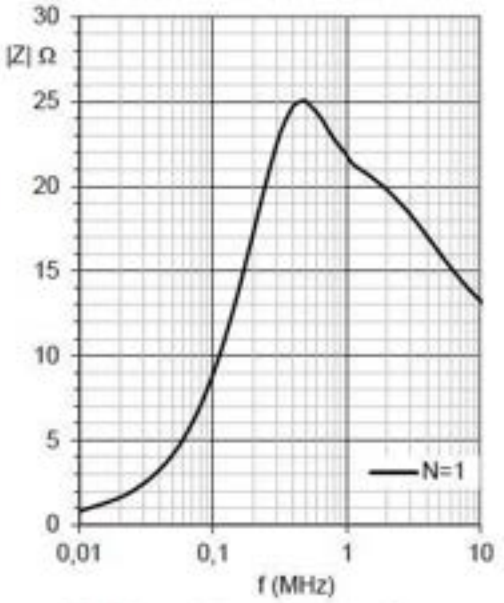


Fig.5 Impedance as function of frequency.

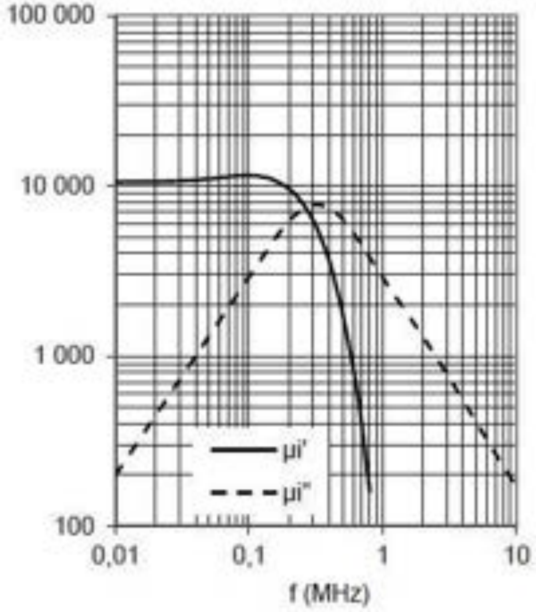


Fig.1 Complex permeability as function of frequency.

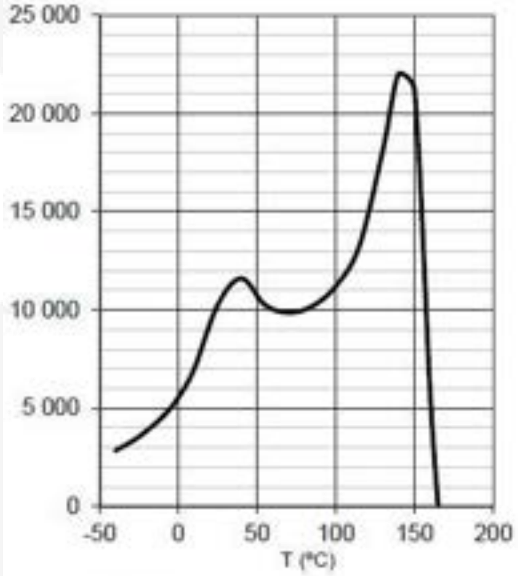


Fig.2 Initial permeability as function of temperature.

3N10 – High Impedance at Low Frequency

YAGEO GROUP
YAGEO Ferroxcube

High permeability (8k)

Low frequency range (0.1-10 MHz)

Full range of toroid sizes and cable shields

SYMBOL	CONDITIONS	VALUE	UNIT
μi	25ºC; 10kHz; 0.25mT	≈ 8000	
B	25ºC; 10kHz; 1200A/m	≈ 460	mT
	100ºC; 10kHz; 1200A/m	≈ 270	
$Z C_1 / N^2$	25ºC; 0.3MHz; 0.25mT	≈ 14	Ω/mm
	25ºC; 1MHz; 0.25mT	≈ 26	
ρDC	25ºC	≈ 0.5	Ωm
Tc		≥ 130	ºC
density		≈ 5000	kg/m3

Measured on T14/9/5

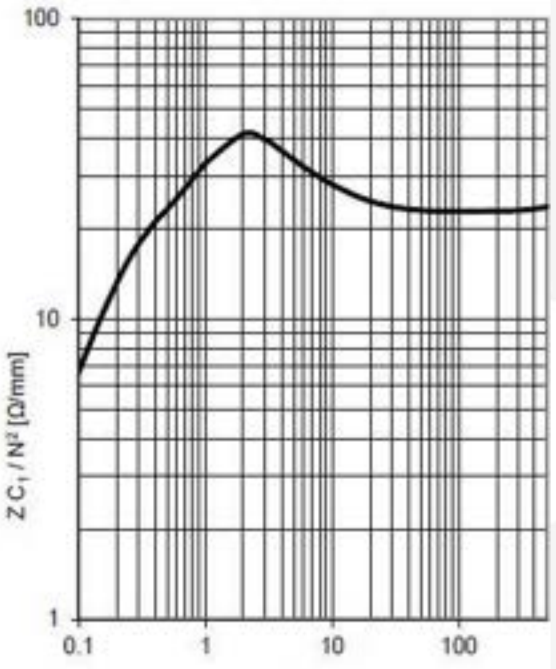


Fig.4 Normalized impedance as a function of frequency

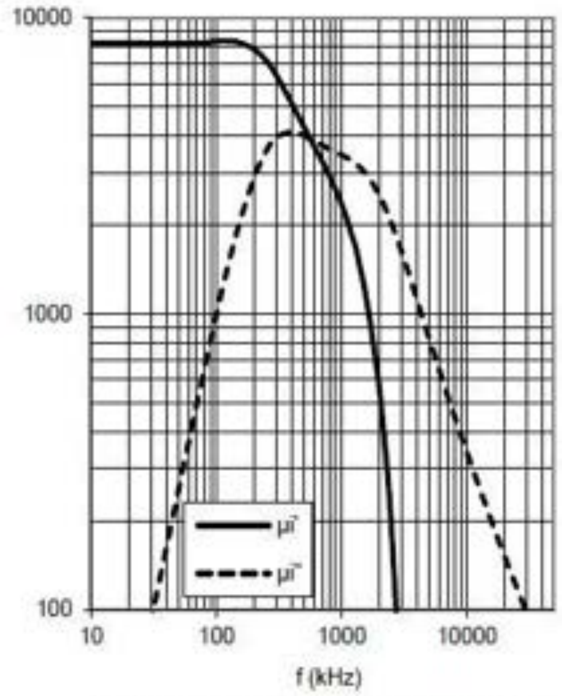


Fig.1 Complex permeability as a function of frequency

3N5 – Highest Impedance mediumF with Tc > 150°C

Medium permeability (5k)

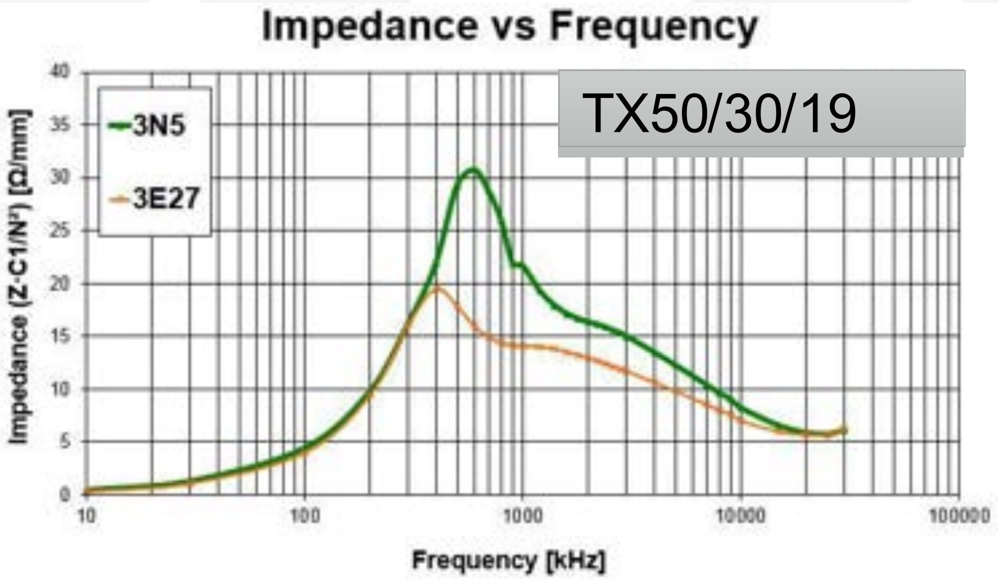
Broad frequency range Tc

> 150 °C

Full range of sizes including toroids, cable shields and shapes (E, U…)

SYMBOL	CONDITIONS	VALUE	UNIT
µi	25°C; 10kHz; 0.25mT	≈ 6000	
B	25°C; 10kHz; 1200A/m 100°C; 10kHz; 1200A/m	≈ 460 ≈ 300	mT
ZC_1/N^2	25°C; 1MHz; 0.25mT 25°C; 3MHz; 0.25mT	≈ 22 ≈ 41	Ω/mm
ρDC	25°C	≈ 0.5	Ωm
Tc		≥ 150	°C
density		≈ 4850	kg/m3

Measurd on T14/9/5



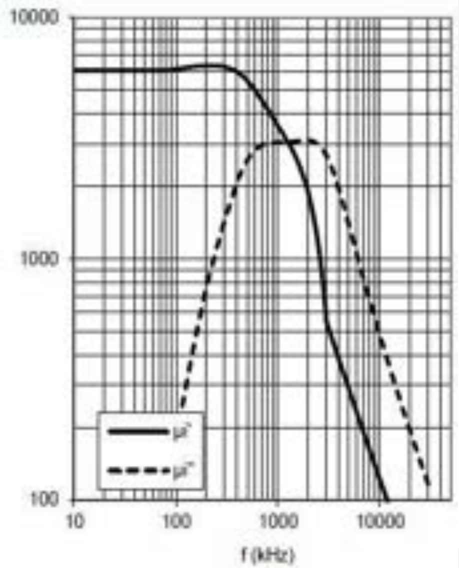


Fig.1 Complex permeability as a function of frequency

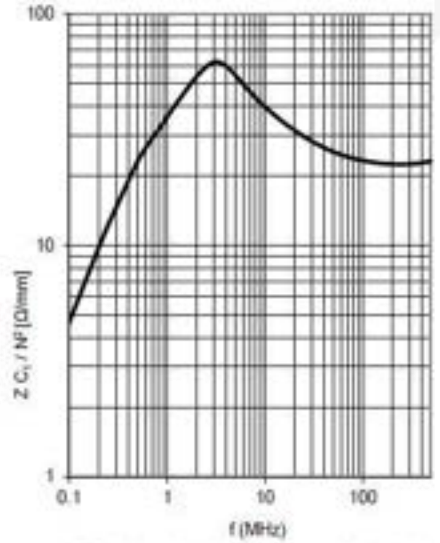


Fig.4 Normalized impedance as a function of frequency

3N4 – Highest Impedance medium F with Tc > 200°C

YAGEO GROUP
YAGEO Ferroxcube

Medium permeability

Broad frequency range (1-10 MHz)

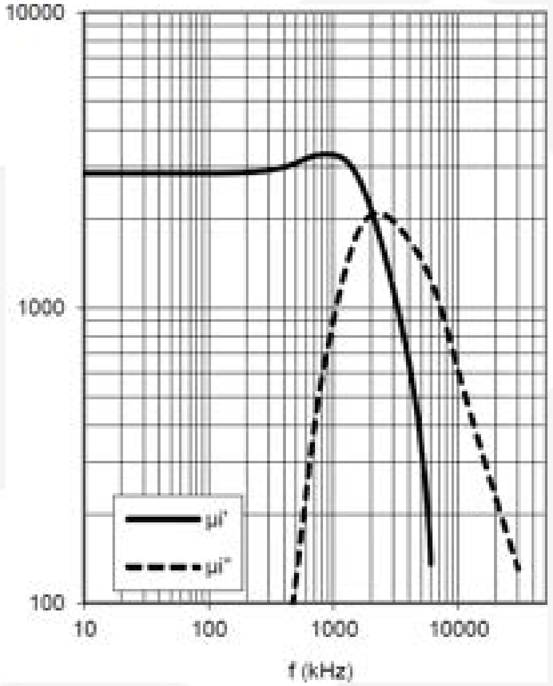
Tc > 200 °C

Full range of sizes including toroids, cable shields and shapes (E, U…)

High Bsat, suitable for strong CM noise

SYMBOL	CONDITIONS	VALUE	UNIT
μi	25ºC; 10kHz; 0.25mT	≈ 2500	
B	25ºC; 10kHz; 1200A/m	≈ 530	mT
	100ºC; 10kHz; 1200A/m	≈ 410	
ZC_1/N^2	25ºC; 3MHz; 0.25mT	≈ 42	Ω/mm
	25ºC; 5MHz; 0.25mT	≈ 47	
ρDC	25ºC	≈ 10	Ωm
Tc		≥ 200	ºC
density		≈ 4800	kg/m3

Measurd on T14/9/5



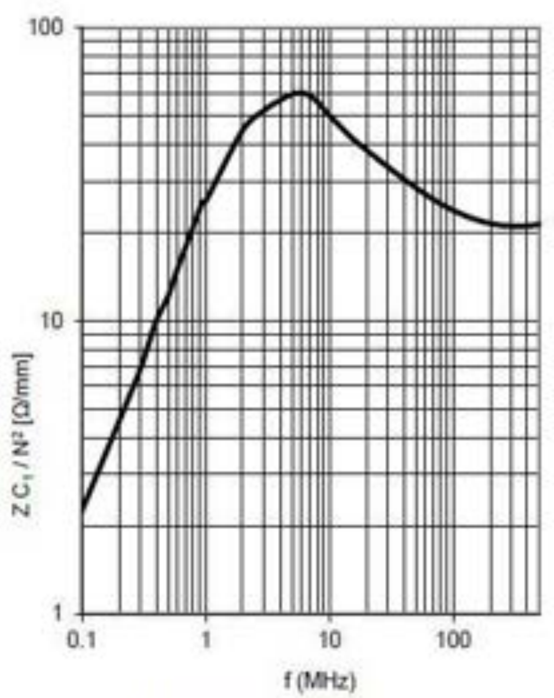


Fig.4 Normalized impedance as a function of frequency

3N3 – Highest Impedance medium F with Tc > 200°C

Low permeability

Broad frequency range (1-10 MHz)

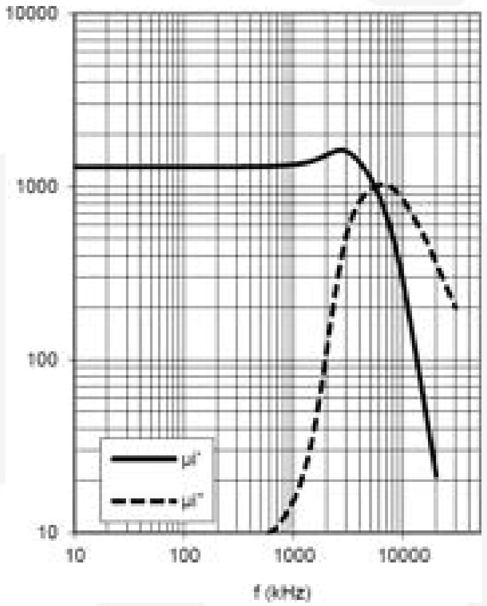
Tc > 200 °C

Full range of sizes including toroids, cable shields and shapes (E, U...)

High Bsat, suitable for strong CM noise

SYMBOL	CONDITIONS	VALUE	UNIT
μi	25°C; 10kHz; 0.25mT	≈ 1250	
B	25°C; 10kHz; 1200A/m 100°C; 10kHz; 1200A/m	≈ 520 ≈ 420	mT
ZC_1/N^2	25°C; 5MHz; 0.25mT 25°C; 10MHz; 0.25mT	≈ 40 ≈ 50	Ω/mm
ρDC	25°C	≈ 15	Ωm
Tc		≥ 200	°C
density		≈ 4750	kg/m3

Measurd on T14/9/5



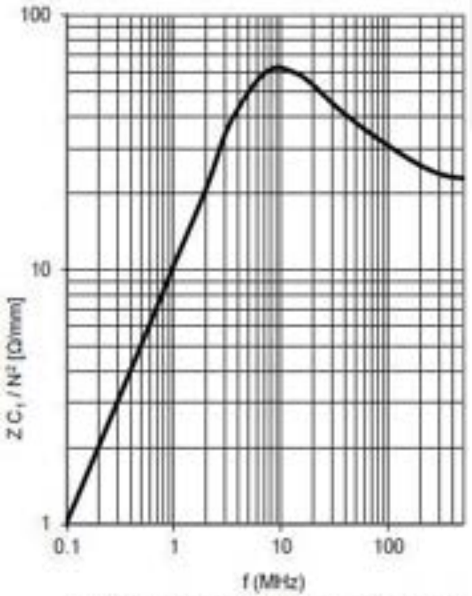


Fig.4 Normalized impedance as a function of frequency

3N2 – Full bandwidth filtering

Full bandwidth filtering thanks to relatively high permeability (3k) for low frequency suppression and high frequency impedance beyond 100 MHz

Low remanence, stable permeability and impedance after magnetization

Tc> 150°C

New!

SYMBOL	CONDITIONS	VALUE	UNIT
μ_i	25°C; 10kHz; 0.25mT	≈ 3000	
$\mu_{i\,remanence}$	25°C; 10kHz; 0.25mT	≈ 3000	
B	25°C; 10kHz; 1200A/m	≈ 410	mT
	100°C; 10kHz; 1200A/m	≈ 260	
$Z\,C_1/N^2$	25°C; 3MHz; 0.25mT	≈ 35	Ω/mm
	25°C; 30MHz; 0.25mT	≈ 61	
	25°C; 100MHz; 0.25mT	≈ 71	
ρDC	25°C	≈ 10^3	Ωm
Tc		≥ 150	°C
density		≈ 4800	kg/m3

Measured on T14/9/5

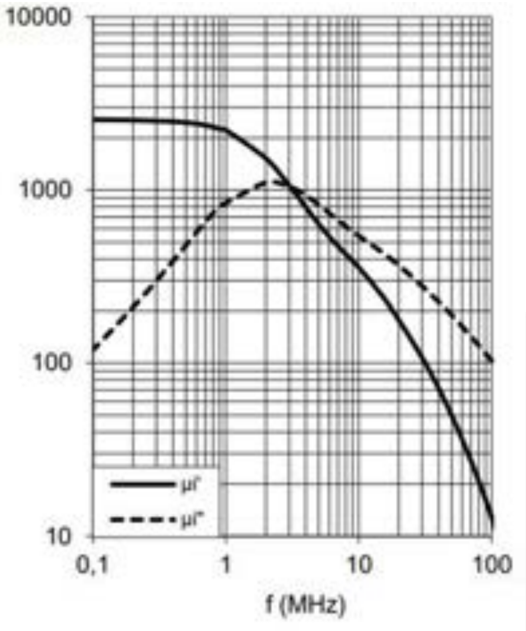


Fig.1 Complex permeability as a function of frequency

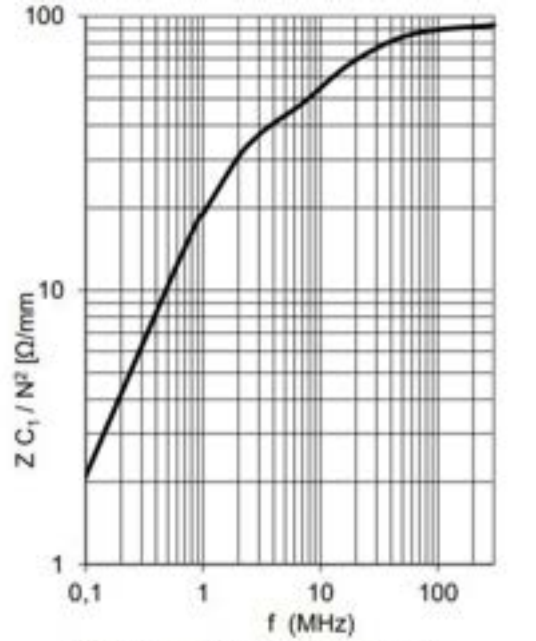


Fig.4 Normalized impedance as a function of frequency

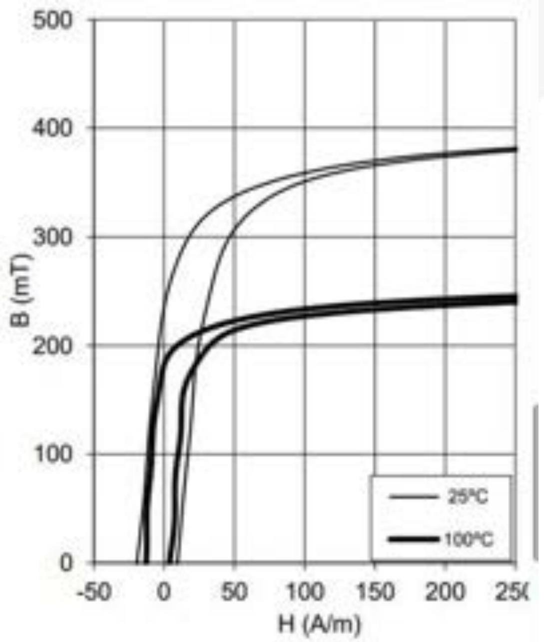


Fig.3 Typical BH loop

3N1T

High resistivity MnZn, alternative to NiZn

High Bsat and high Tc

Ideal for common mode chokes for 30 to 100 MHz

3N1T SPECIFICATION

An EMI-suppression material for conducted and radiated emissions up to 300 MHz with a maximum impedance in the frequency range 30 to 100 MHz.

SYMBOL	CONDITIONS	VALUE	UNIT
μi	25°C; 10kHz; 0.25mT	≈ 1100	
B	25°C; 10kHz; 1200A/m	≈ 450	mT
	100°C; 10kHz; 1200A/m	≈ 350	
ZC_1/N^2	25°C; 10MHz; 0.25mT	≈ 25	Ω/mm
	25°C; 100MHz; 0.25mT	≈ 56	
Pv	100°C; 100kHz; 100mT	≈ 350	kW/m³
ρDC	25°C	≈ 10³	Ωm
Tc		≥ 200	°C
density		≈ 4800	kg/m3

Measured on T14/9/5

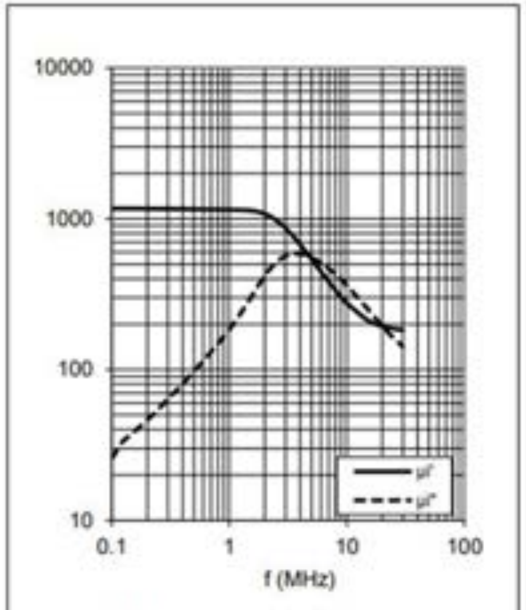


Fig.1 Complex permeability as a function of frequency

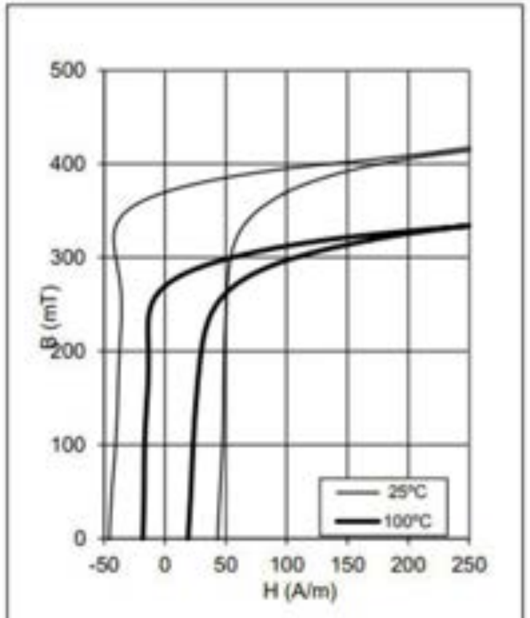


Fig.3 Typical BH loop

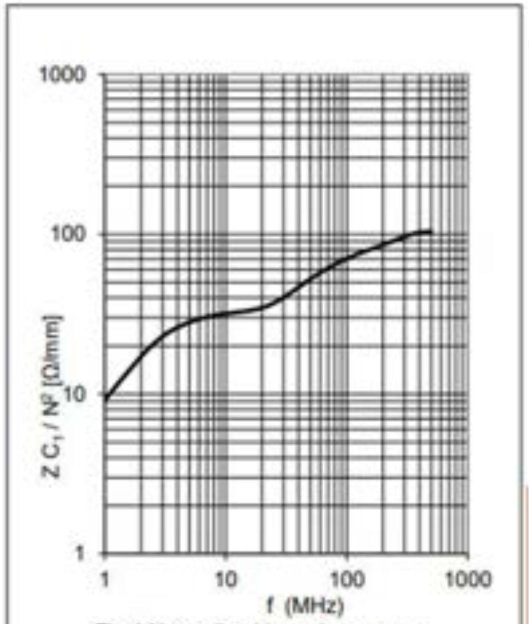


Fig.4 Normalized impedance as a function of frequency at 25°C

3N1 – 3N2 – 3N1T – 3N2T

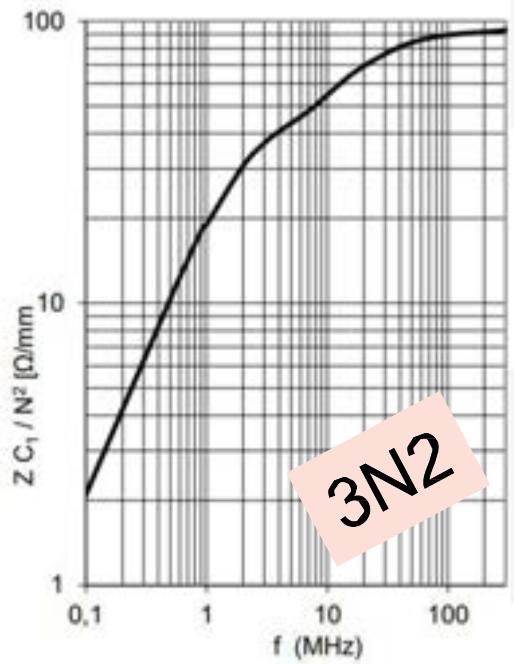
Tc > 150

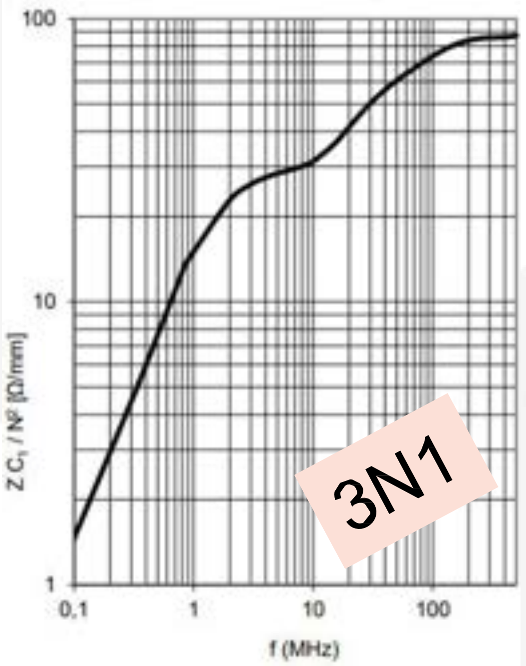
3N2:

- High impedance 0.1 to 30 MHz
- High permeability μ=3000

3N1:

- Cost effective





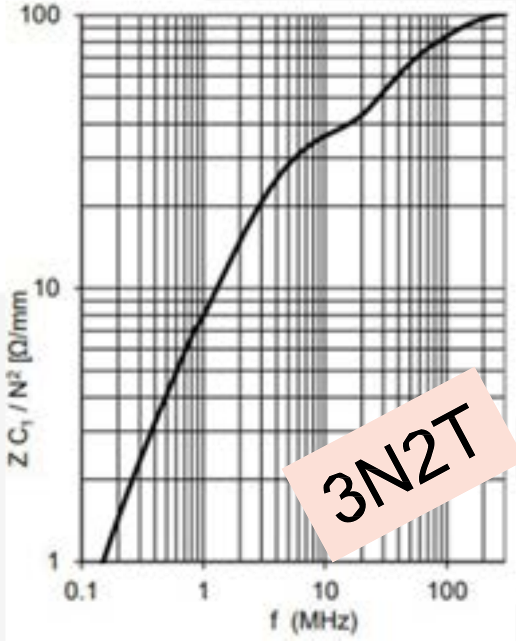
Tc > 200

3N2T:

- High impedance 0.1 to 30 MHz
- Better temperature stability

3N1T: only for large volume

- Cost effective



3N series – Impedance table

SYMBOL	Conditions	3N10 VALUE	3N5 VALUE	3N4 VALUE	3N3 VALUE	3N1 VALUE	UNIT
μi	25°C; 10kHz; 0.25mT	≈ 8000	≈ 6000	≈ 2500	≈ 1250	≈ 1800	-
B	25°C; 10kHz; 1200A/m	≈ 460	≈ 460	≈ 530	≈ 520	≈ 420	mT
	100°C; 10kHz; 1200A/m	≈ 270	≈ 300	≈ 410	≈ 420	≈ 280	
$Zc1/n^2$	25°C; 0.1MHz; 0.25mT	≈ 5	≈ 3	≈ 2	≈ 1	≈ 1	Ω/mm
	25°C; 0.3MHz; 0.25mT	**≈ 14**	≈ 8	≈ 6	≈ 2	≈ 4	
	25°C; 0.5MHz; 0.25mT	≈ 19	≈ 14	≈ 10	≈ 4	≈ 6	
	25°C; 1MHz; 0.25mT	**≈ 26**	**≈ 22**	≈ 20	≈ 7	≈ 12	
	25°C; 3MHz; 0.25mT	≈ 32	**≈ 41**	**≈ 42**	≈ 27	≈ 21	
	25°C; 5MHz; 0.25mT	≈ 27	≈ 45	**≈ 47**	**≈ 40**	≈ 23	
	25°C; 10MHz; 0.25mT	≈ 23	≈ 33	≈ 40	**≈ 50**	≈ 25	
	25°C; 30MHz; 0.25mT	≈ 19	≈ 23	≈ 27	≈ 36	**≈ 40**	
	25°C; 100MHz; 0.25mT	≈ 18	≈ 19	≈ 19	≈ 25	**≈ 59**	
	25°C; 300MHz; 0.25mT	≈ 18	≈ 18	≈ 17	≈ 19	≈ 69	
ρ	DC; 25°C	≈ 0.5	≈ 0.5	≈ 10	≈ 15	$\approx 10^3$	Ωm
Tc		≥ 130	≥ 150	≥ 200	≥ 200	≥ 150	°C
Density		≈ 5000	≈ 4850	≈ 4800	≈ 4750	≈ 4800	kg/m^3

Measured on
T14/9/5