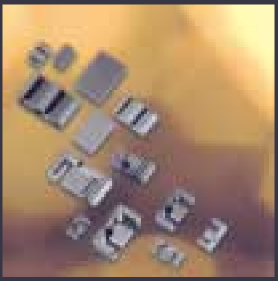


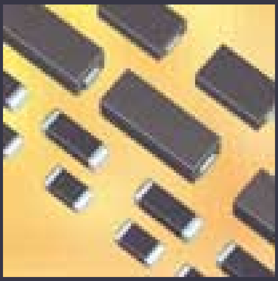

PRODUCT SELECTION GUIDE 2001

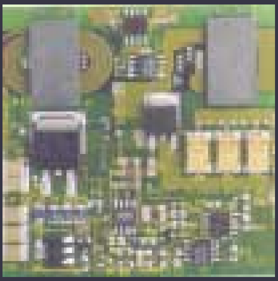
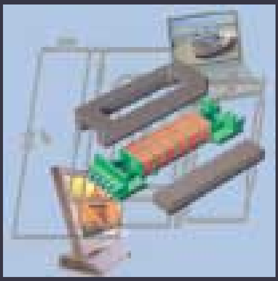




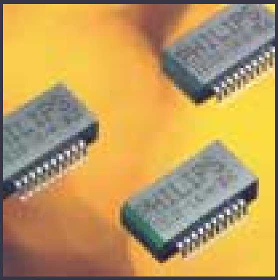










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Come to the Ferrite Source
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List of contents

page
General introduction 2
Application matrix 8

Power conversion and Signal processing
Materials and applications 10
Integrated Inductive Components (IIC) 20
Planar E cores 22
E cores 26
EFD cores 34
EP cores 36
EP/LP cores 38
EQ cores 40
ER cores 44
ETD cores 48
Frame and Bar cores 50
P cores 52
PH cores 55
P/I cores 56
PT cores 58
PQ cores 60
RM cores 62
RM/I cores 64
RM/ILP cores 66
U cores 68
I cores 70
UR cores 72
Ferrite toroids 74
Iron powder toroids 80

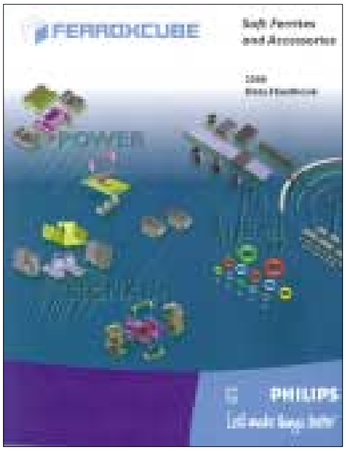
EMI-suppression
Materials and applications 82
Multilayer suppressors (MLS) 87
SMD beads and
Common-mode chokes(BDS, CMS) 88
Beads and Beads on wire (BD, BDW) 89
Cable shields (CST, CSA, CSC, CSU, CSF) 90
Bobbin cores (BC) 92
Multi hole cores (MHC, MHB, MHR) 93
Rods (ROD) 94
Tubes (TUB) 95
Wideband chokes (WBC) 96

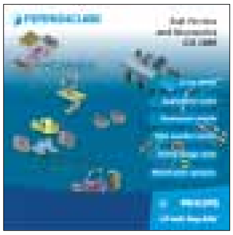
Specialty ferrites
Materials and applications 100
Machined ferrite cores 101
Toroids for particle accelerators 102

This Selection Guide offers an overview of the product ranges made by FERROXCUBE

It contains short-form data for quick selection by development engineers and offers an overview for purchasing, production and service departments. For information on availability and prices, please contact our Sales representatives.

Comprehensive data can be found in Data Handbook "Soft Ferrites and Accessories 2000" as well as on the CD-ROM.
For the latest info, please visit our web site on www.ferroxcube.com.





FERROXCUBE

Formerly a Philips Components company we now belong to the Yageo Corporation, one of the world's strongest suppliers of passive components.
Building on our Philips magnetic components heritage, FERROXCUBE can offer customers the highest level of support in the development of their new innovative designs.
Our competencies cover soft ferrite products and accessories.
All developed to meet today's demanding high-frequency, low-loss and environmental requirements.
We also offer extensive design-in support including application information and software to help equipment manufacturers optimize their new designs.
Contact us to find out!

FERROXCUBE, widely recognized as a leading supplier of ferrite components, has manufacturing operations, sales offices, and customer service centers all over the world. 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.

Innovation for tomorrow's applications

As a leading innovator in ferrite-ceramic technology, we supply one of the broadest ranges of high-quality, innovative products and place strong emphasis on miniaturization of magnetic functions. Our aim – to support today's digital electronics markets with products combining miniaturization with ever-greater functionality.

Business excellence

For us, the ferrite components business is more than supplying high-quality products. It's about striving for quality and excellence in everything we do, including customer support and service.

Committed to environmental care

Our commitment towards excellence applies also to the environment. We strive for highest standards of health and safety for everyone.

Advanced application support gives you the edge

Modern requirements for magnetic products are often so specific that only customized products will suffice. This means your supplier must be able to offer comprehensive design and application support.

Our application teams are always ready to answer enquiries from customers and to work with them in solving specific design problems.

To support their activities, we use our own software tools to optimize core shapes for new standard ranges and customized designs.

Innovative solutions in ferrite components

Our ferrite-based products, have been developed to support today's manufacturers throughout the industry in their drive for ever higher functionality, greater miniaturization, reduced power consumption and lower weight. What's more, our Innovation Centers, strategically located worldwide, are constantly developing solutions for designs with functions such as RF filtering and tuning, impedance matching, line termination, signal delay, coupling and safety isolation for today's and future generations of equipment.

As pioneers in interference suppression, we offer a broad range of ceramic-based solutions for both on-board and in-line EMI suppression. We are constantly working to develop ever more effective solutions for EMI suppression to support manufacturers in meeting current and future EMC (Electro-Magnetic Compatibility) requirements.

Innovative solutions we offer include:

- Low-profile planar cores offering exceptionally low build height in transformer designs and excellent thermal characteristics.
- Integrated Inductive Components (IICs) which integrate several inductive functions required of a circuit into a compact IC-like surface-mount package.
- Low-loss ferrite cores that allow exceptional levels of transformer miniaturization.
- New core shapes and a new ferrite material for DSL transformers featuring very low THD-levels.
- Ferrite EMI suppression products in a broad range of shapes and configurations meeting the diverse requirements of our customers
- Toroids in high-permeability (10 000) ferrite materials for highly-effective damping and filtering
- Multilayer suppressors offering the benefits of effective noise attenuation and miniaturization

We also assist customers with extensive application information and we constantly strive to work closely with them to provide the support they need to remain competitive in their markets.

Ordering information

The products in this guide are identified by type numbers. All physical and technical properties of the product are covered by these numbers. They are therefore recommended for both ordering and use on technical drawings and equipment parts lists. The 11-digit code, used in former editions of our data handbooks, also appears on Smallest Packaging Quantities (SPQ). These are packs which are ready for shipment to our customers. The information on the bar coded label consists of:

Technical information:

- Type number
- 11-digit code number
- Delivery and/or production batch numbers

Logistic information:

- 12-digit code number
- Quantity
- Country of origin
- Production week
- Production centre.

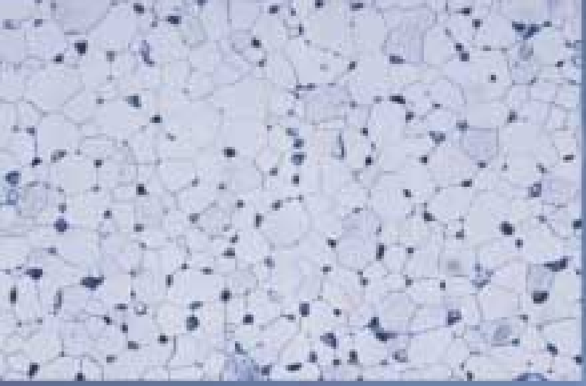
During all stages of the production process, data are collected and documented with reference to a unique batch number, which is printed on the packaging label. With this batch number it is always possible to trace the results of process steps afterwards and in the event of customer complaints, this number should always be quoted.

Products are available throughout their life cycle. A short definition of product status is given in the table. Besides the products listed in this catalog, we can also offer customized or application specific ferrite cores, bobbins and accessories.

Minimum shipment quantities, price and delivery details can be obtained from the Ferroxcube sales contacts in your country or from one of our franchised distributors.

PRODUCT STATUS DEFINITIONS

STATUS	INDICATION	DEFINITION
Prototype	prot	These are products that have been made as development samples for the purposes of technical evaluation only. The data for these types is provisional and is subject to change.
Design-in	des	These products are recommended for new design.
Preferred		These products are recommended for use in current designs and are available via our sales channels.
Support	sup	These products are **not** recommended for new designs and may not be available through all of our sales channels. Customers are advised to check for availability.



The nature of Soft Ferrites

Soft Ferrites are dark grey or black ceramic materials. They are very hard, brittle and chemically inert. Most modern magnetically soft ferrites have a cubic structure.

The most popular combinations are manganese and zinc (MnZn) or nickel and zinc (NiZn). These compounds exhibit good magnetic properties below a certain temperature called the Curie temperature (T_C). They can easily be magnetized (hence the name soft ferrites) and have a rather high intrinsic resistivity.
These materials can be used up to very high frequencies without laminating as is the normal requirement for magnetic metals.

NiZn ferrites exhibit a very high resistivity and are therefore most suitable for frequencies over 1 MHz, but MnZn ferrites exhibit higher permeabilities (μ_i) and saturation induction levels (B_S).

For certain special applications, single crystal ferrites can be produced but the majority of ferrites are manufactured as polycrystalline ceramics.

After sintering, the ferrite core has the required magnetic properties, and dimensions are typically within 2% of nominal because of spread in shrinkage. If this tolerance is too large or if some surfaces require a smooth finish (e.g. mating faces between core halves) a grinding operation is necessary. Usually diamond-coated wheels are used. For high permeability materials, very smooth, glossy polished pole faces are required. If an airgap is needed in the application, it is made by undercutting the appropriate pole face.

Environmental aspects of Soft Ferrites

Our range of soft ferrites has the general composition $MeFe_2O_4$ where Me represents one or several of the divalent transition metals such as manganese (Mn), zinc (Zn), nickel (Ni), or magnesium (Mg). To be more specific, all materials starting with digit 3 are manganese zinc ferrites based on the MnZn composition. Their general chemical formula is:
$Mn_{\delta}\ Zn(1-\delta)\ Fe_2\ O_4$

Materials starting with digit 4 are nickel zinc ferrites based on the NiZn composition. Their general chemical formula is:

$Ni_{\delta}\ Zn(1-\delta)\ Fe_2\ O_4$

General warning rules
With strong acids, the metals iron, manganese, nickel and zinc may be partially extracted.
In the event of fire, dust particles with metal oxides will be formed.
Disposal as industrial waste, depending on local rules and circumstances.

Need more information? Visit our web site on www.ferroxcube.com

Our new site reflects our new focus on supporting the fast growing digital-electronics markets with a truly global range of ferrite products, bobbins and accessories. Here you will find extensive data on our full product range, plus application information to support your design-in decisions.

The site has also been extensively revised, making navigation easier and faster than ever to be able to provide you with up-to-the-minute information on our latest developments.
It also provides direct links to the web-sites of our distributors.

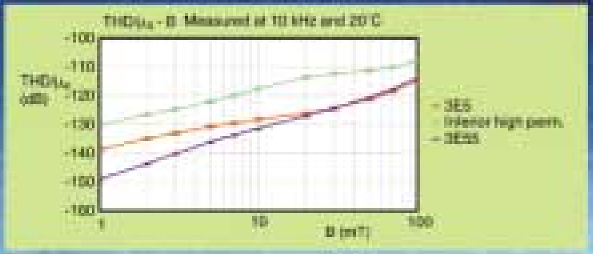
Our worldwide sales offices and distributors are happy to answer any questions you may have.

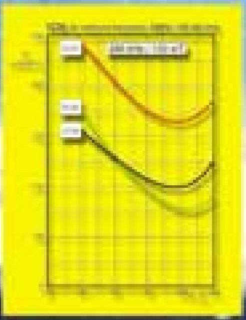
Leading in ferrite technology
Building on our Philips magnetic components heritage, FERROXCUBE can offer customers the highest level of support in the development of their new innovative designs.
Our competencies cover soft ferrite products and accessories. All developed to meet today's demanding high-frequency, low-loss and environmental requirements.

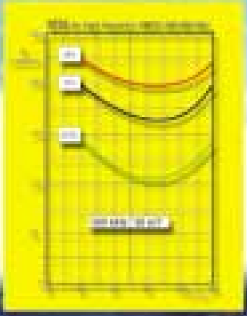
FERROXCUBE ferrites
supporting your design-in decisions

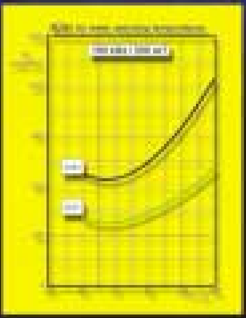
As a leading innovator in ferrite-ceramic technology, we offer a broad range of soft ferrite cores, accessories and EMI suppression products to support equipment manufacturers in their drive for greater miniaturization, reduced power consumption and lower electromagnetic interference.
We also offer extensive design-in support including application information and software to help equipment manufacturers optimize their new designs.
Contact us to find out!

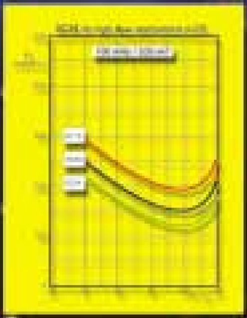
New products and Highlights

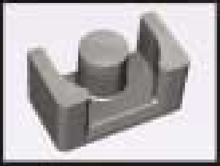












	Page
• Low THD ferrite 3E55	14
• Ultra low loss general purpose power ferrite 3C96	10
• Ultra low loss 500 kHz power ferrite 3F35	10
• Very low loss power ferrite with loss minimum at 60°C, 3C91	10
• Very low loss power ferrite for line output transformers (LOT) 3C34	10
• DC-bias ferrite 3E28	14
• High permeability ferrite 3E8	14
• High permeability ferrite 3E26	82
• Integrated Inductive Components (IIC)	20
• EQ cores	40
• Frame and Bar cores for LCD backlighting	50
• New core shapes EP6 and EP13/LP	36 38
• Toroids in 3E6 with a permeability of 10 000 up to 100 kHz	74

Application matrix

Application area Magnetic function	Telecommunication	Electronic Data Processing (EDP)	Sound and Vision	Lighting
Current transformers	3C81, 3C90, 3E5, 3E6, 3E27 Toroids	3C81, 3C90, 3E5, 3E6, 3E27 Toroids	3C81, 3C90, 3E5, 3E6, 3E27 U, Toroids	
Driver transformers	3C81, 3C90, 3C94, 3E27 Toroids, E, ER, EP, EFD, RM/I, P/I	3C81, 3C90, 3C94, 3E27 Toroids, E, ER, EP, EFD, RM/I, P/I	3C81, 3C90, 3C94, 3E27 Toroids, E, ER, EP, EFD, RM/I, P/I	3C81, 3C90, 3C94, 3E27, 3F4 Toroids, E, ER, EP, EFD, RM/I, P/I
EMI-suppression on PCB	3B1, 3S1, 3S4, 4A15, 4B1, 4S2, 4S4, 4S7 BDW, BDS, CMS, IIC, MLS, WBS, WBC	3B1, 3S1, 3S4, 4A15, 4B1, 4S2, 4S4, 4S7 BDW, BDS, CMS, IIC, MLS, WBS, WBC	3B1, 3S1, 3S4, 4A15, 4B1, 4S2, 4S4, 4S7 BDW, BDS, CMS, IIC, MLS, WBS, WBC	
EMI-suppression in power lines	2P, 3B1, 3C90, 3S1, 3S3, 3S4, 4A15, 4B1, 4S2 BC, BDW, BDS, IIC, WBS, WBC, CMS, MHC, Toroids	2P, 3B1, 3C90, 3S1, 3S3, 3S4, 4A15, 4B1, 4S2 BC, BDW, BDS, IIC, WBS, WBC, CMS, MHC, Toroids	2P, 3B1, 3C90, 3S1, 3S3, 3S4, 4A15, 4B1, 4S2 BC, BDW, BDS, IIC, WBS, WBC, CMS, MHC, Toroids	2P, 3B1, 3C90, 3S1, 3S3, 3S4, 4A15, 4B1, 4S2 BC, BDW, BDS, IIC, WBS, WBC, CMS, MHC, Toroids
EMI-suppression in mains filters	2P, 3C11, 3E25, 3E26, 3E27, 3E5, 3E6, 3S4, 4A11, 4A15, Toroids (T, TC, TL, TN, TX), U cores (U)	2P, 3C11, 3E25, 3E26, 3E27, 3E5, 3E6, 3S4, 4A11, 4A15, Toroids (T, TC, TL, TN, TX), U cores (U)	2P, 3C11, 3E25, 3E26, 3E27, 3E5, 3E6, 3S4, 4A11, 4A15, Toroids (T, TC, TL, TN, TX), U cores (U)	2P, 3C11, 3E25, 3E26, 3E27, 3E5, 3E6, 3S4, 4A11, 4A15 Toroids (T, TC, TL, TN, TX), U cores (U)
EMI-suppression on signal wires and cables	4C65, 4B1, 3B1, 4A11, 4A15, 3C11, 3E25, 3E5, 3C90, 3S1, 3S4, 4S2 BD, MHC, TUB, Cable shields, Toroids (T, TC, TL, TN, TX)	4C65, 4B1, 3B1, 4A11, 4A15, 3C11, 3E25, 3E5, 3C90, 3S1, 3S4, 4S2 BD, MHC, TUB, Cable shields, Toroids (T, TC, TL, TN, TX)	4C65, 4B1, 3B1, 4A11, 4A15, 3C11, 3E25, 3E5, 3C90, 3S1, 3S4, 4S2 BD, MHC, TUB, Cable shields, Toroids (T, TC, TL, TN, TX)	
EMI-absorbing powders and surfaces	2S10, 4S10, 4S50, PFP10 Tiles (PLT), Granules, Powders	2S10, 4S10, 4S50, PFP10 Tiles (PLT), Granules, Powders		
Filter inductors (signal)	3D3, 3H3 RM, P, PT			
Inductive delay lines	3E27, 3E5, 3E6, 3E7, 3E8 Toroids	3E27, 3E5, 3E6, 3E7, 3E8 Toroids	3E27, 3E5, 3E6, 3E7, 3E8 Toroids	
Line output transformers (LOT)		3C15, 3C30, 3C34, 3C81 UR	3C15, 3C30, 3C34, 3C81 UR	
Magnetic regulators	3R1 Toroids	3R1 Toroids	3R1 Toroids	
Power inductors	3C81, 3C90, 3F3, 3F4, 3C91, 3C30, 2P, 3C94, 3F35 Toroids, U, E, ETD, Planar E, ER, PQ, RM/I, RM/ILP, P/I, PT,PTS	3C81, 3C90, 3F3, 3F4, 3C91, 3C30, 2P, 3C94, 3F35 Toroids, U, E, ETD, Planar E, ER, PQ, RM/I, RM/ILP, P/I, PT,PTS	3C81, 3C90, 3F3, 3C91, 3C30, 2P Toroids, U, E, ETD, Planar E, ER	3C81, 3C90, 3F3, 3F4, 3C91, 3C30, 2P, 3C94, 3F35 Toroids, U, E, ETD, Planar E, ER, PQ
Power transformers	3C81, 3C90, 3C91, 3F3, 3F4, 4F1, 3C94, 3C96, 3F35 E, EC, EFD, ETD, ER, Planar E, PQ, RM/I, RM/ILP, P/I, PT, PTS, Toroids	3C81, 3C90, 3C91, 3F3, 3F4, 4F1, 3C94, 3C96, 3F35 E, EC, EFD, ETD, ER, Planar E, PQ, RM/I, RM/ILP, P/I, PT, PTS, Toroids	3C81, 3C90, 3C91, 3F3, 3C94, 3C96 E, EC, EFD, ETD, ER, Planar E	3C81, 3C90, 3C91, 3F3, 3F4, 4F1, 3C94, 3C96, 3F35 E, EC, EFD, ETD, ER, Planar E
Proximity switches	3H1, 3D3, 3B7 PH			
Tuning coils and antennas	4E1, 4D2, 4C65, 4B1, 3B1, 3C90 ROD, TUB		4E1, 4D2, 4C65, 4B1, 3B1, 3C90 ROD, TUB	
Wideband transformers	3E1, 3E4, 3E5, 3E6, 3E7, 3E27, 3C11, 3E25, 3E55, 3E28 RM/I, P/I, E, ER, EFD, EP, Toroids, MHB	3E1, 3E4, 3E5, 3E6, 3E7, 3E27, 3C11, 3E25, 3E55, 3E28 RM/I, P/I, E, ER, EFD, EP, Toroids	3E1, 3E4, 3E5, 3E6, 3E7, 3E27, 3C11, 3E25, 3E55, 3E28 RM/I, P/I, E, ER, EFD, EP, Toroids	

Application matrix

Domestic Appliances	Automotive Electronics	Measurement, Control, Scientific and Medical	Electric Tools	EMC services and Equipment
	3C81, 3C90, 3E5, 3E6, 3E27 U, Toroids	3C81, 3C90, 3E5, 3E6, 3E27, 4C65 U, Toroids		
3C81, 3C90, 3C94, 3E27 Toroids, E, ER, EP, EFD, RM/I, P/I	3C81, 3C90, 3C94, 3E27 Toroids, E, ER, EP, EFD, RM/I, P/I	3C81, 3C90, 3C94, 3E27 Toroids, E, ER, EP, EFD, RM/I, P/I	3C81, 3C90, 3C94, 3E27 Toroids, E, ER, EP, EFD, RM/I, P/I	
	3B1, 3S1, 3S4, 4A15, 4B1, 4S2, 4S4, 4S7 BDW, BDS, CMS, IIC, MLS, WBS, WBC	3B1, 3S1, 3S4, 4A15, 4B1, 4S2, 4S4, 4S7 BDW, BDS, CMS, IIC, MLS, WBS, WBC		3B1, 3S1, 3S4, 4A15, 4B1, 4S2, 4S4, 4S7 BDW, BDS, CMS, IIC, MLS, WBS, WBC
2P, 3B1, 3C90, 3S1, 3S3, 3S4, 4A15, 4B1, 4S2 BC, BDW, BDS, IIC, WBS, WBC, CMS, ROD, TUB, MHC, Toroids	2P, 3B1, 3C90, 3S1, 3S3, 3S4, 4A15, 4B1, 4S2 BC, BDW, BDS, IIC, WBS, WBC, CMS, ROD, TUB, MHC, Toroids	2P, 3B1, 3C90, 3S1, 3S3, 3S4, 4A15, 4B1, 4S2 BC, BDW, BDS, IIC, WBS, WBC, CMS, ROD, MHC, Toroids	2P, 3B1, 3C90, 3S1, 3S3, 3S4, 4A15, 4B1, 4S2 BC, BDW, BDS, IIC, WBS, WBC, CMS, ROD, TUB, MHC, Toroids	2P, 3B1, 3C90, 3S1, 3S3, 3S4, 4A15, 4B1, 4S2 BC, BDW, BDS, IIC, WBS, WBC, CMS, Toroids
2P, 3C11, 3E25, 3E26, 3E27, 3E5, 3E6, 3S4, 4A11, 4A15, Toroids (T, TC, TL, TN, TX), U cores (U)		2P, 3C11, 3E25, 3E26, 3E27, 3E5, 3E6, 3S4, 4A11, 4A15 Toroids (T, TC, TL, TN, TX), U cores (U)	2P, 3C11, 3E25, 3E26, 3E27, 3E5, 3E6, 3S4, 4A11, 4A15 Toroids (T, TC, TL, TN, TX), U cores (U)	2P, 3C11, 3E25, 3E26, 3E27, 3E5, 3E6, 3S4, 4A11, 4A15 Toroids (T, TC, TL, TN, TX), U cores (U)
	4C65, 4B1, 3B1, 4A11, 4A15, 3C11, 3E25, 3E5, 3C90, 3S1, 3S4, 4S2 BD, MHC, TUB, Cable shields, Toroids (T, TC, TL, TN, TX)	4C65, 4B1, 3B1, 4A11, 4A15, 3C11, 3E25, 3E5, 3C90, 3S1, 3S4, 4S2 BD, MHC, TUB, Cable shields, Toroids (T, TC, TL, TN, TX)		4C65, 4B1, 3B1, 4A11, 4A15, 3C11, 3E25, 3E5, 3C90, 3S1, 3S4, 4S2 BD, MHC, TUB, Cable shields, Toroids (T, TC, TL, TN, TX)
	2S10, 4S10, 3C90 Granules, Powders	2S10, 4S10, 4S50, PFP10 Tiles (PLT), Granules, Powders		2S10, 4S10, 4S50, PFP10 Tiles (PLT), Granules, Powders
		3D3, 3H3 RM, P, PT		
		3E27, 3E5, 3E6, 3E7, 3E8 Toroids		
		3C15, 3C30, 3C34, 3C81 UR		
3R1 Toroids				
3C81, 3C90, 3C91, 3C30, 2P Toroids, U, E, ETD, Planar E, ER, PQ	3C81, 3C90, 3F3, 3C91, 3C30, 2P, 3C94, 3F35 Toroids, U, E, ETD, Planar E, ER, PQ	3C81, 3C90, 3F3, 3F4, 3C91, 3C30, 2P, 3C94, 3F35 Toroids, U, E, ETD, Planar E, ER, PQ, RM/I, RM/ILP, P/I, PT, PTS		
3C81, 3C90, 3C91, 3C94, 3C96, 3F3 E, EC, EFD, ETD, ER, Planar E, PQ	3C81, 3C90, 3C91, 3F3, 3C94, 3C96, 3F35 E, EC, EFD, ETD, ER, Planar E, PQ, RM/I, RM/ILP, Toroids	3C81, 3C90, 3C91, 3F3, 3F4, 4F1, 3C94, 3C96, 3F35 E, EC, EFD, ETD, ER, Planar E, PQ, RM/I, RM/ILP, P/I, PT, PTS, Toroids		
		3D3 PH		
	4B1, 3B1, 3C90 ROD, TUB	4E1, 4D2, 4C65, 4B1, 3B1, 3C90 ROD, TUB		
	3E1, 3E4, 3E5, 3E6, 3E7, 3E27, 3C11, 3E25, 3E55, 3E28 RM/I, P/I, E, ER, EFD, EP, Toroids	3E1, 3E4, 3E5, 3E6, 3E7, 3E27, 3C11, 3E25, 3E55, 3E28 RM/I, P/I, E, ER, EFD, EP, Toroids		3E1, 3E4, 3E5, 3E6, 3E7, 3E27, 3C11, 3E25, 3E55, 3E28 RM/I, P/I, E, ER, EFD, EP, Toroids

Materials and applications

property	test conditions				power transformers and power inductors												
symbol	**f (khz)**	**$\hat{B}$ or H**	**T (°C)**	**unit**	**3C15**	**3C30**	**3C34[1]**	**3C81**	**3C90**	**3C91[1]**	**3C94**	**3C96[1]**	**3F3**	**3F4**	**3F35**	**4F1**	**3R1**
μ_i (±20%)	≤ 10	≤ 0.1mT	25		1800	2100	2100	2700	2300	3000	2300	2000	2000	900	1400	≈ 80	800
B	10	250A/m	100	mT	≥ 350	≥ 370	≥ 370	≈ 330	≥ 340	≥ 330	≥ 340	≥ 370	≥ 330	≥ 300	≥ 330	≥ 100	≥ 285
		3000A/m	25		≈ 500	≈ 500	≈ 500	≈ 450	≈ 450	≈ 450	≈ 450	≈ 500	≈ 450	≈ 450	≈ 500	≈ 350	≈ 450
H_c	10		25	A/m	≈ 15	≈ 15	≈ 15	≈ 15	≈ 15	≈ 15	≈ 15	≈ 15	≈ 15	≈ 60	≈ 40	≈ 150	≈ 40
B_r	10		25	mT	≈ 200	≈ 180	≈ 180	≈ 110	≈ 170	≈ 110	≈ 170	≈ 170	≈ 150	≈ 150	≈ 200	≈ 200	≈ 340
Pv	25	200 mT	100	kW/m^3	≤ 140	≤ 80		≤ 185	≤ 80								
	100	100 mT			≤ 165	≤ 80	≤ 60		≤ 80	≈ 55[2]	≤ 60	≤ 45	≤ 80				
	100	200 mT				≈ 450	≤ 400		≈ 450	≈ 330[2]	≤ 400	≤ 330					
	200	100 mT					≈ 170										
	400	50 mT									≤ 170	≤ 140	≤ 150		≤ 80		
	500	50 mT													≤ 120		
	500	100 mT													≈ 800		
	1000	30 mT												≤ 200			
	3000	10 mT												≤ 320		≤ 200	
	10000	5 mT														≤ 200	
T_c				°C	≥ 190	≥ 240	≥ 240	≥ 210	≥ 220	≥ 220	≥ 220	≥ 240	≥ 200	≥ 220	≥ 240	≥ 260	≥ 230
ρ	DC			Ω m	≈ 1	≈ 2	≈ 5	≈ 1	≈ 5	≈ 5	≈ 5	≈ 5	≈ 2	≈ 10	≈ 10	≈ 10^5	≈ 10^3
density				kg/m^3	≈ 4800	≈ 4800	≈ 4800	≈ 4800	≈ 4800	≈ 4800	≈ 4800	≈ 4800	≈ 4750	≈ 4700	≈ 4750	≈ 4600	≈ 4700
ferrite type					MnZn	MnZn	MnZn	MnZn	MnZn	MnZn	MnZn	MnZn	MnZn	MnZn	MnZn	NiZn	MnZn

Properties measured on sintered, unground ring cores of dimensions ∅25 x ∅15 x 10 mm, which are not subjected to external stresses.

[1] preliminary specification [2] at 60 °C

Iron Powder Materials

property	test conditions				output chokes EMI-suppression				
symbol	**f (khz)**	**$\hat{B}$ or H**	**T (°C)**	**unit**	**2P40**	**2P50**	**2P65**	**2P80**	**2P90**
μ_i (±10%)	≤ 10	≤ 0.1mT	25		40	50	65	80	90
B	10	25.10^{3}A/m	25	mT	900	1000	1150	1400	1600
H_c	10		25	A/m	2000	1800	1500	1200	900
B_r	10		25	mT	250	300	350	400	450
T_{max}				°C	140	140	140	140	140
material					Fe	Fe	Fe	Fe	Fe

Properties measured on sintered, unground ring cores of dimensions ∅25 x ∅15 x 10 mm, which are not subjected to external stresses.

Products generally comply with the material specification. However deviations may occur due to shape, size and grinding operations etc. Specified product properties are given in the data sheets or product drawings.

Power transformers/inductors

Power conversion is a major application area for modern ferrites. The introduction of Switched Mode Power Supplies (SMPS) has stimulated the development of a number of new ferrites and core shapes for power transformers, ouput chokes and input filters.

Power transformers and inductors generally operate under loss or saturation limited conditions. This requires special power ferrites with high saturation levels and low losses.
The power handling capability of a transformer is determined by circuit topology, frequency, core geometry and ferrite material, available winding area, and by other factors which depend on the specific application.

Each of the core types was developed for a specific application, therefore they all have advantages and drawbacks. The choice of a core type for a specific design depends on the design considerations and sometimes on the personal preference of the designer. The tables give information about availability of core/grade combinations and an overview of core types as a function of power throughput. This may be useful to the designer for an initial selection.

Ferrite choice

frequency range	
< 100 kHz	3C81, 3C90, 3C91, 3C94, 3C96
< 400 kHz	3C94, 3C96
200-1000 kHz	3F4, 3F35
1-3 MHz	3F4, 4F1
> 3 MHz	4F1

Output chokes

Output chokes have to operate with a DC load which causes a bias magnetic field. In a closed ferrite circuit this can easily lead to saturation. Power ferrites such as 3C90 or 3F35 start saturating at field strengths of about 50 A/m. Permeability drops sharply and the inductor looses its effectivity.
There are two remedies against this effect:

- gapped ferrite cores
- a material with a low permeability and high saturation

The effect of an airgap in the circuit is that a much higher field strength is needed to saturate a core. For each operating condition an optimum airgap length can be found. In a design, the maximum output current (I) and the value of inductance (L) necessary to smooth the ripple current to the required level must be known. The product I^2L is a measure of the energy which is stored in the core during one half cycle.

Toroids made of compressed iron powder have a rather low permeability (max. 90) combined with a very high saturation level (up to 1500 mT). The permeability is low because the isolating coating on the iron particles acts as a so called distributed airgap. Therefore, 2P toroids can operate under bias fields of up to 2000 A/m.

Ferrite choice

frequency range	
< 500 kHz	2P.., 3C30, 3C90, 3C94
< 1 MHz	3C90, 3C94 3F35

Magnetic regulators

Saturable inductors can be used to regulate several independent outputs of an SMPS by blocking the secondary of the transformer during variable lenghts of time. The circuits required are both simple and economic and can easily be integrated. 3R1 ferrite material is a good alternative to amorphous metal, often used for these applications.
In technical performance 3R1 is comparable to amorphous metal, its price level is much lower.
The squareness of the B-H loop would be spoiled by any airgap in the magnetic circuit, so a toroid or IIC without partial gap is the recommended shape.

Ferrite choice
3R1

Line output transformers

Line output transformers (LOT) form a specific group of power transformers. They are used in TV sets and monitors to provide the voltage for the deflection coil and the high voltage for the picture tube. Traditionally the operating frequency is rather low (16 kHz) so a high throughput power density can only be achieved by means of a high flux density in the core. The high voltage output requires a special, resin potted winding. A large winding area is required and normally all windings are on one of the legs. A special U core type, with one round and one rectangular leg has become a standard for this application.
Switching frequency has recently increased to 32, 64 or 128 kHz for applications such as HDTV and special monitors.
For these applications, 3C30 and 3C34 with low losses up to 300 kHz in combination with high saturation levels are available.

Ferrite choice

frequency range	
16 kHz	3C30
32 kHz	3C30
64 kHz	3C30, 3C34
128 kHz	3C34

Materials and applications

Property	MnZn ferrite	NiZn ferrite	unit
Young's modulus	(90 – 150) x 10^3	(80 – 150) x 10^3	N/mm^2
Compressive strength	200 – 600	200 – 700	N/mm^2
Tensile strength	20 – 65	30 – 60	N/mm^2
Vickers hardness	600 – 700	800 – 900	N/mm^2
Coefficient of linear expansion	(10 – 12) x 10^{-6}	(7 – 8) x 10^{-6}	K^{-1}
Specific heat	700 – 800	≈ 750	Jkg^{-1} K^{-1}
Thermal conductivity	(3.5 – 5.0) x 10^{-3}	(3.5 – 5.0) x 10^{-3}	Jmm^{-1}s^{-1} K^{-1}

The above figures are the average values measured on a wide range of commercially available MnZn and NiZn materials

Current transformers

A current transformer is used to measure or detect a current without making contact. A common example is a ring core with a winding around a current carrying wire. The magnetic field around the wire creates a flux in the ring core which leads to an output voltage directly proportional to the current in the winding.

In effect the wire acts as a one-turn primary for the current transformer. This principle is often used to measure currents in power converters, or to detect current in an earth-leak safety switch.
A split toroid or two U-core halves are used in applications such as oscilloscope measuring probes.
The sensitivity of this type of transformer if largely controlled by the material permeability. So, depending on the current range, a high permeability grade is chosen.
For AC the highest occuring frequency determines the choice of the material.

Ferrite choice

frequency range	
< 100 kHz	*3E5, 3E6, 3E7*
< 500 kHz	*3E27*
< 1 MHz	*3B7, 3C81,3C90, 3F35*
< 10 MHz	*4C65*

Core shapes

Ring cores	*U cores*

Driver transformers

In many electronic circuits, small tansformers are used to drive or trigger transistors, thyristors of MOSFETS. It is a convenient way to provide galvanic isolation and synchronisation or reversal of drive pulses.

Sometimes these transformers operate under low- signal conditions but in most cases they have to operate at high flux density. MOSFET gates have high capacitances and therefore require high currents to switch fast.

The choice of ferrite depends on these drive conditions and operating frequency. For low power the high permeability grades are suitable, more severe conditions require power materials.

Ferrite choice

low - level drive	*3H3, 3B7, 3E1, 3E27*
high - level drive	*3C81, 3C90, 3F35*

Materials and applications

property	test conditions				filter inductors			wideband transformers								
symbol	**f (khz)**	**$\hat{B}$ or H**	**T (°C)**	**unit**	**3D3**	**3H3**	**3B7**	**3E1**	**3E4**	**3E27**	**3E28**	**3E5**	**3E55**	**3E6[1]**	**3E7[1]**	**3E8[1]**
μ_i (±20%)	< 10	< 0.1mT	25	-	750	2000	2300	3800	4700	6000	4000	10000	10000	12000	15000	18000
tan δ/μ_i	10	< 0.1mT	25	$(x10^{-6})$									≤ 10	≤ 10	≤ 10	≤ 10
	30					≤ 1.6						≤ 25	≤ 30	≤ 30	≤ 30	≤ 30
	100					≤ 2.5	≤ 5	≤ 20	≤ 20	≤ 15	≤ 5	≤ 75				
	300				≤ 10			≤ 150	≤ 150							
	500						≈ 25									
	1000				≤ 30		≈ 120									
	3000															
	10000															
η_B	10	1.5-3 mT	25	$10^{-3}T^{-1}$				≤ 1.2	≤ 1			≤ 1	≤ 0.2	≤ 1	≤ 1	≤ 1
	100				≤ 1.8	≤ 0.6										
α_F	< 10	< 0.1mT	5 to 25	$10^{-6}K^{-1}$		0.7 ± 0.3										
			25 to 55			0.7 ± 0.3										
			25 to 70		1.5 ± 1	0.7 ± 0.3	0 ± 0.6									
D_F	10	< 0.1mT	25	$(x10^{-6})$	≤ 12	≤ 3	≤ 3.5	≤ 5	≤ 5							
	100															
B	10	250A/m	100	mT	≈ 260	≈ 250	≈ 300	≈ 200	≈ 210	≈ 250	≈ 260	≈ 210	≈ 200[2]	≈ 210	≈ 210	≈ 150
		3000A/m	25		≈ 400	≈ 400	≈ 450	≈ 400	≈ 400	≈ 400	≈ 400	≈ 380	≈ 380	≈ 380	≈ 380	≈ 380
H_c	10		25	A/m	≈ 75	≈ 15	≈ 15	≈ 12	≈ 10	≈ 5	≈ 5	≈ 5	≈ 5	≈ 4	≈ 4	≈ 4
B_r	10		25	mT	≈ 150	≈ 70	≈ 150	≈ 100	≈ 100	≈ 100	≈ 100	≈ 80	≈ 150	≈ 100	≈ 100	≈ 100
T_c			25	°C	≥ 200	≥ 160	≥ 170	≥ 125	≥ 125	≥ 150	≥ 145	≥ 125	≥ 100	≥ 130	≥ 130	≥ 100
ρ	DC			Ω m	≈ 2	≈ 2	≈ 1	≈ 1	≈ 1	≈ 0.5	≈ 1	≈ 0.5	≈ 0.1	≈ 0.1	≈ 0.1	≈ 0.1
density				kg/m^3	≈ 4700	≈ 4700	≈ 4800	≈ 4800	≈ 4800	≈ 4800	≈ 4800	≈ 4900	≈ 5000	≈ 4900	≈ 4900	≈ 5000
ferrite type					MnZn	MnZn	MnZn	MnZn	MnZn	MnZn	MnZn	MnZn	MnZn	MnZn	MnZn	MnZn

Properties measured on sintered, unground ring cores of dimensions ∅25 x ∅15 x 10 mm which are not subjected to external stresses.

[1] Measured on sintered, unground ring cores of dimensions ∅14 x ∅9 x 5 mm which are not subjected to external stresses.

[2] at 80°**C**

Products generally comply with the material specification. However deviations may occur due to shape, size and grinding operations etc.
Specified product properties are given in the data sheets or product drawings.

Filter inductors (signal)

Ferrite filter inductors are used in combination with high quality capacitors in very stable and selective filters. The following design parameters are important for high quality filter inductors:

- low losses, high Q
- precise inductance
- high stability over periods of time
- fixed temperature dependence

The quality factor (Q) of a filter inductor should generally be as high as possible. For this reason filter materials such as 3H3 and 3D3 have low magnetic losses in their frequency ranges.

These materials also have controlled temperature factors (α_F) to compensate the negative temperature coefficients of the filter capacitors. The drift of permeability with time D_F (desaccomodation factor) is kept as low as possible in these filter materials. A recent application is in low-pass filters for ADSL. Since there is bias current, 3C81 or 3C90 are used because of their higher saturation level.

Ferrite choice

frequency range	
< 300 kHz	3H3, 3C81, 3C90
300 kHz - 2 MHz	3D3

Wideband transformers

Pulse and signal transformers, also known as wideband transformers, are frequently used in communications systems and digital networks such as ISDN and DSL. They provide impedance matching and galvanic isolation and transform signal amplitudes. Signal power levels are usually low. To transmit analog signals or digital pulses with little distortion, good wideband characteristics are needed.

The principal functions of the transformer core are to provide optimum coupling between the windings, and a high inductance under pulse conditions.

To achieve this, high permeability ferrite materials such as 3E27, 3E4, 3E5, 3E6, 3E7 and 3E8 are used. When there is a DC component in the signal it is often better to take a lower permeability grade such as 3E1 or the special DC-bias material 3E28. For DSL transformers Total Harmonic Distortion (THD) is a critical factor. The new low THD ferrite material 3E55 helps to solve many design problems.The trend is towards smaller and lower profile pulse transformers. With the increasing integration of digital electronics, magnetic components are becoming the biggest components on the PCB.

Increasing the material permeability and using closed magnetic cores, like toroids, are two ways to achieve miniaturization.

However, other cores are also widely used but with polished pole faces to eliminate the effect of the gap between core halves as much as possible.

Ferrite choice

without DC	3E4, 3E27, 3E5, 3E55, 3E6, 3E7, 3E8
with DC	3H3 3E55, 3E28

Inductive delay lines

In many electronic devices it is necessary to delay pulses for a short, well defined time (some nano- or microseconds). One method of doing this is to pass the pulses through an inductor-capacitor network.

The inductance delays the rise of the current until the ferrite core saturates.

The delay time is determined by the saturation flux in the ferrite core and the applied voltage.

Requirements for the material are:

- high pulse permeability
- high saturation flux density

The main application area is in data processing. As the inductor should be as compact as possible, small toroids are mostly used to avoid the degrading effect of the parasitic airgap.

Ferrite choice

3E27, 3E5, 3E6, 3E7, 3E8

Proximity switches

Magnetic proximity switches generally consist of a PH core half and a winding on a coil former. This inductor is part of a tuned oscillator circuit. A magnetic flux protrudes in front of the core. When a conductive object moves into this stray flux, eddy currents start to flow in it, lowering the quality factor (Q) of the circuit. When this decreases below a critical level, the oscillator stops and the object is detected. There are applications throughout industry in all sorts of production equipment to detect positions of moving parts. The ferrite used should have a low loss level at the frequency of the oscillator. (e.g. 1 MHz), therefore an appropriate filter material like 3D3 performs well.

As temperature stability must be resonably good, materials with controlled temperature behaviour are chosen. However, since the magnetic circuit is open this is not very critical. For a good detection range the Q of the circuit should be as high as possible. This Q-factor is controlled mainly by the resistance of the winding. Magnetic losses in the ferrite generally contribute less then 10% because of the open circuit.

Ferrite choice

frequency range	
< 2 MHz	3D3

Bobbins & Accessories

Our bobbins and our clips…
…your basis for perfect windings

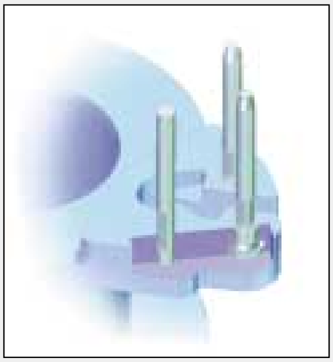
The components you use can affect the quality of your products. Every individual part of an assembly may influence the reliability or performance, so choosing the best is not just important, it's essential – particularly with critical wound components. The cores, bobbin and windings depend on the integrity of each other to operate as an effective functional component.

Ferroxcube makes ferrite cores to meet exacting requirements. And to ensure a perfect winding every time, the Bobbins & Accessories Group manufactures and supplies precision bobbins and support products. The bobbins are designed for perfect windings and zero-defect mounting on and in printed circuit boards. The materials and surface treatments we use withstand the insertion forces and high temperatures of assembly and soldering. We have a full range of multifunctional bobbins and accessories for surface-mount and through-hole wound components.

In addition to our bobbins, we have an extensive range of mounting clips. Our clips, both for through-hole and surface-mount wound components, provide a clean and easy way of assembling the individual parts to a functional component. The materials and surface treatments used in our clips are carefully selected and ensure an even clamping force over the lifetime of the component. As well as providing industry-standard clipping solutions, we have a range of specific clips, where the function of a multiple part clip has been replaced by a single clip. So, providing you with the best assemblyfriendly and cost-effective solution where possible.

Our design expertise…
…your key to a total solution

Our standard product ranges cover most applications, but we can also design a part to meet your specific requirements. Our engineers have unparalleled experience in designing and engineering products in record time, drawing on the extensive production technology and materials engineering expertise available within Philips. Utilizing the latest full 3D CAD system we are ensuring the shortest possible time to market.



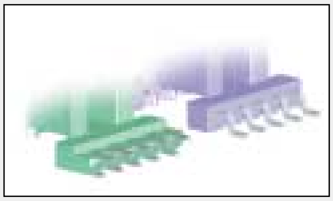
Our technological competence…
…your access to quality products

We have developed and refined different production processes to enable us to make bobbins with their own specific characteristics and properties. There are two printed circuit board mounting technologies (through-hole and surface-mount), and for each we have two separate production techniques.

Pin through-hole technology (mounted in the PCB)

- In-moulded pins – specially shaped pins are inserted in the mould prior to injection, so that when the material flows around them, 100 per cent fixation is guaranteed. This in turn, ensures excellent positioning and fixation in the PCB. The pins have a square-shaped base to prevent the wire slipping during wrapping.

- Post-inserted pins – a two-step production process involving the insertion of the pins after the plastic part has been moulded. Depending on the application, round- or square-section wires are used for the pins. This is the more cost-effective through-hole bobbin manufacturing technique.



Surface-Mount Device technology (mounted on the PCB)

- Gullwing-shaped pins – another 'in-moulding' process similar to that described above but employing a leadframe. Once the moulding has taken place, the redundant leadframe metal is cut off, leaving the gullwing pins protruding from the bobbin.
- C-shaped pins – a 'C-shaped' pin makes the bobbin easier to wind, so our SMD bobbins are usually made this way. C-pins are also thicker and wider than most gullwing pins, and therefore stronger.

Design innovation

Metal pick-and-place caps for SMD bobbins, for example, combine both the fixing and pick-and-place functions in a single clamp. This reduces the total number of parts from three to one. The C-shaped pin construction has mechanical advantages too, as it separates the wire termination function from electrical connection, and so ensuring excellent coplanarity.

Our choice of materials…
...your assurance of conformity

When selecting materials for our products, the design, production process, electrical- and mechanical requirements are important factors. But above all, we aim for optimum performance at an acceptable price. Many materials are used, ranging from industry-standard polyamide (PA) to the more exotic liquid crystal polymers (LCP) and thermosetting phenolic materials (PF).

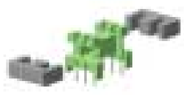
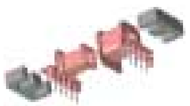
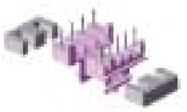
Meeting today's standards

- Underwriter Laboratories (UL) compliance – all polymeric materials used in our bobbins and accessories are tested and in full compliance with UL.
- Environmental acceptance – as part of our ISO 14001 certification, all materials are screened and shown to be free from banned substances according to agreed Philips standards.

Matching materials to special requirements

- Smaller surface-mount bobbins – are made from high-performance thermoplastic LCP.
- Larger bobbins – are made from thermosetting materials because thick winding wires require extra mechanical stability at high soldering temperatures.
- Square section pins – help reduce the number of wrappings needed to secure copper wires to the pins.

Bobbins & Accessories

Core Type	Pin Through-Hole (PTH)	Surface-Mount Device (SMD)	Specials
E (EF)	 Sizes: E13, 16, 20, 30, 32, 42, 55, 65 Clips and Clasps available for most products	 Sizes: E5.3, 6.3, 8.8, 13, 16 Multi-section, Caps and Clips available	 Sizes: E16, 20 High insulation two pieces male/ female bobbins
EFD	 Sizes: EFD15, 20, 25, 30 15 and 20 L-pin, low build height	 Sizes: EFD10, 12, 15, 20 One piece pick and place metal Covers/ Clamps, C-pin design	
ETD	 Sizes: ETD29, 34, 39, 44, 49, 54, 59 Complete range in-moulded pins. Clips available		 Sizes: ETD34 Two pieces male/female high insulation factor in-moulded pins
EP	 Sizes: EP6, 7, 10, 13, 17, 20 All phenolic parts, both single Clips and Clasps/ Springs available	 Sizes: EP7, 10, 13 Single Clips, C-pins phenolic version	
ER		 ER9.5, 11, 14.5 Gullwing pin type in high performance thermoplastic. Clamps available	
RM	 Sizes: RM4, 5, 6, 7, 8, 10, 12, 14 Clips available, both in-moulded and post-inserted pin versions	 Sizes: RM4, 5, 6 Both phenolic and thermoplastic types, multi-section, low profile Clips available	 Sizes: RM4, 5, 6, 8, 10, 14 In-moulded L-pin version for easy winding
P + PQ	 Sizes: P11, 14, 18, 22, 26, 30, 36, 42 Multi-section, complete range of Bobbins, Tag-plates, Springs, Containers. High stability assembled product.		 Sizes: PQ20, 26, 32, 35 L-pin post-inserted versions in high performance thermo-plastic material
Special Products		 Sizes: T9 Cover and Tagplate, C-pin version	 Custom Designs for all core types
Special Products	 Sizes: E16, 20 High insulating and coupling factor. Robust design in phenolic material.	 Sizes: FRM 9,10,12,15 C-pin version in high performance thermo-plastic material.	 Sizes: E14, 18, 22 Range of Clamps available


PHILIPS
IIC10-14/4-3E6

Integrated Inductive Components (IIC)

The IIC design

For the majority of today's designs it is desirable to have low profile inductive components. This allows designers not only to make low profile equipment, but also to place the component anywhere on the PC board without need to adapt the equipment housing. This is especially true when the inductive component matches the height of other components on the board, for instance ICs.

A possible way to reach this goal is demonstrated in the new Integrated Inductive Component (IIC). This consists of a rectangular ferrite sleeve with a copper lead frame inserted. The lead frame is moulded with a high-tech resin to secure the leads and insulate them from the ferrite core.

After insertion the leads are bent into a 'gull wing' shape to form contact pads as with most surface-mount ICs.

The finished product looks like an IC from the outside (SOT).

It can be handled by standard pick-and-place equipment and soldered on the board along with other ICs .

The leads in the moulding form one half of a winding which is completed by a track on the PC board. In this way, depending on the board layout, core material and configuration, several magnetic functions can be realized.

IIC with partial airgap

This product type has a partial airgap to improve energy storage capability. Its performance has all the characteristics of a stepped choke. Possible magnetic functions are:

- power inductor
- output choke
- EMI-choke with bias

Power inductors are used in modern high-frequency DC/DC buck/boost converters or resonant converters.

Because operating frequencies are usually high (≥ 200 kHz), inductors with a lower number of turns can be used.

This makes IIC10 suitable for these applications. The curves of L as a function of DC bias show the effect of its partial airgap. For most applications, high saturation flux density and low power losses are key requirements. Therefore 3C30 is the ideal material here. However for very high frequencies (≥ 500 kHz), 3F35 or 3F4 would be a better choice.

EMI-chokes often suffer from saturation when used without current compensation in lines with DC or AC bias currents. The partial airgap avoids complete saturation to a large extend. The suppression effect remains at an acceptable level for high current levels.

IIC without partial airgap

This design is suitable for the following magnetic functions:

- power transformer
- common-mode choke

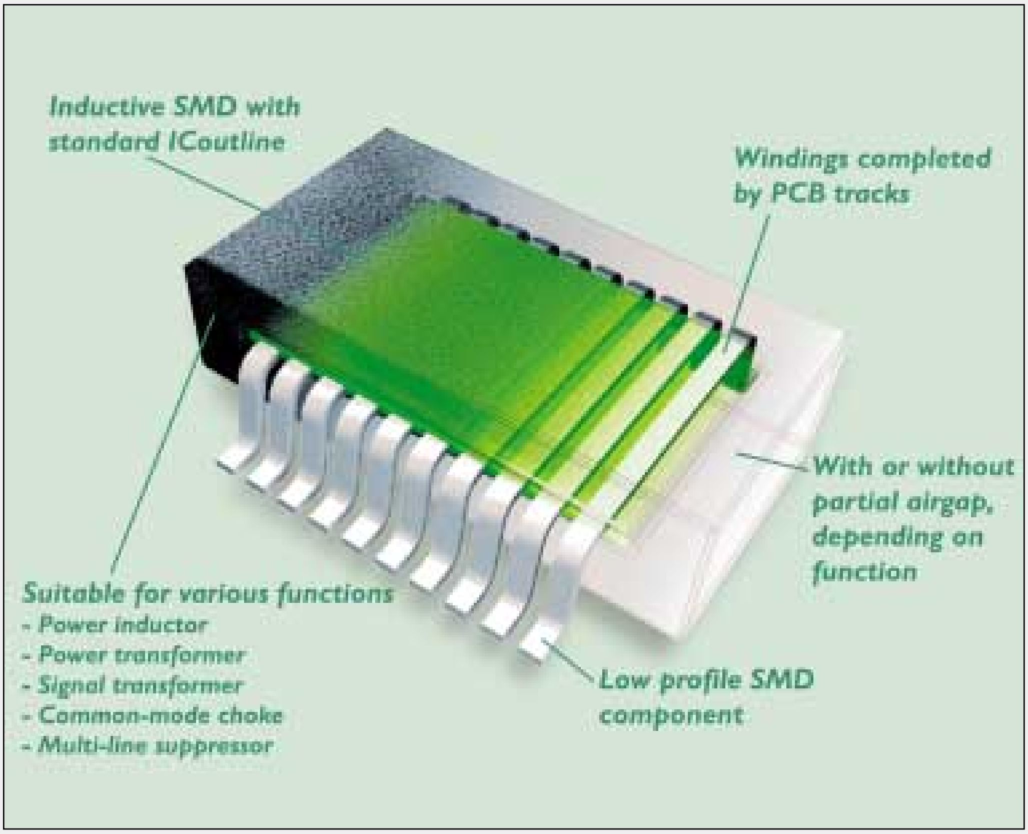
The IIC can be used as a low profile power transformer in high-frequency DC/DC converters, especially those working with low voltage and power levels.

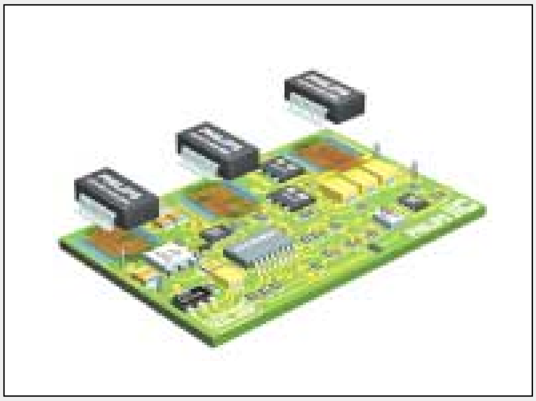
Although isolation voltage is specified at 500 V, the IIC10 should not be used in AC/DC applications as a safety isolation transformer. The short distance between the leads makes it unsuitable for that function.

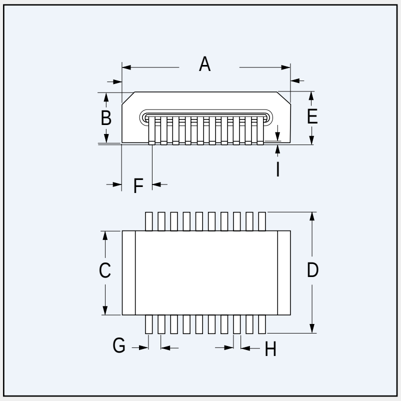
Made in our top-quality 3S4 suppression material or the high-permeability 3E6, the design is ideal for common- mode choke in signal or supply lines, especially if these carry large currents. The sturdy lead frame will take almost any current surge without damage.

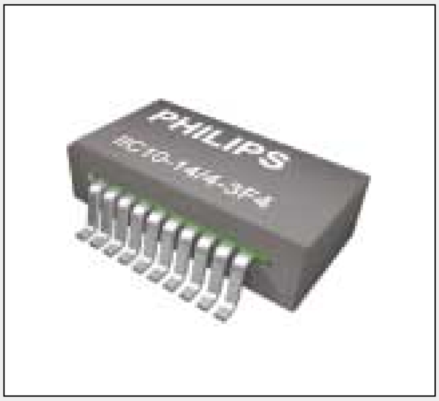
Features and Benefits:

- Inductive surface-mount component that looks like a standard IC outline (SOT).
- Windings are completed by PC board tracks.
- Automatic placement and soldering together with other ICs on the board.
- Suitable for reflow soldering.
- Wide range of magnetic functions can be realized with the same product, depending on track layout.
- Superior physical properties.
- Available in standard EIA and EIAJ tape-and-reel.
- Operating temperature -55 ˚C to +150 ˚C.









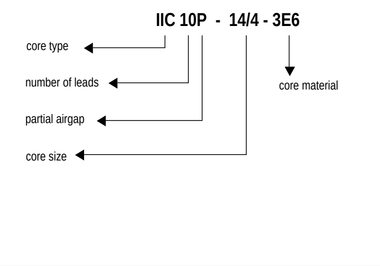
	Core type	IIC10-14/4 IIC10P-14/4
effective core parameters	core factor Σ l/A(mm^{-1})	2.47
	eff. volume V_e (mm^3)	338
	eff. length l_e (mm)	28.9
	eff. area A_e (mm^2)	11.7
	min. area A_{min} (mm^2)	11.7
	mass of core set (g)	≈ 1.85
dimensions (mm)	A	14.4 ± 0.2
	B	4 ± 0.08
	C	7.2 ± 0.15
	D	10.45 max
	E	4.38 max
	F	2.7 ± 0.2
	G	1.0
	H	0.6 max
	I	0.3

IICs without partial airgap

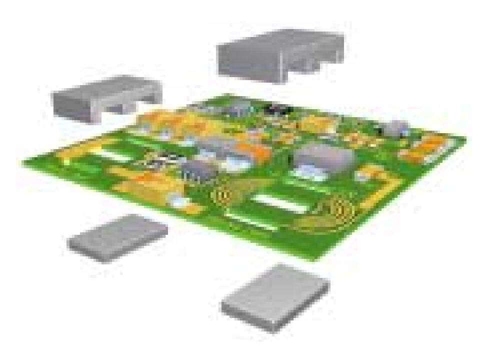
type number	A_L (nH) at B 0.1 mT, f 10 kHz, T = 25°C	A_L (nH) at B 0.1 mT, f 500 kHz, T = 25°C	A_L (nH) at B 0.1 mT, f 1 MHz, T = 25°C	IZI_{typ} (Ω) at 100 MHz for 1 turn, T = 25°C	E.T (V. µs) f = 100 kHz H = 800 A/m I_{reset} = 70 mA T = 100°C
IIC10-14/4-3E6	6000 ± 30%	-	-	-	-
IIC10-14/4-3F4	-	-	450 ± 25%	-	-
IIC10-14/4-3F35	-	700 ± 25%	-	-	-
IIC10-14/4-3R1	-	-	-	-	≥ 33
IIC10-14/4-3S4	-	-	-	≈ 35	-

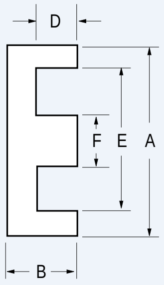
IICs with partial airgap

type number	L (µH) for 10 turns no bias current f = 100 kHz, T = 25°C	L (µH) for 10 turns no bias current f = 500 kHz, T = 25°C	L (µH) for 10 turns no bias current f = 1 MHz, T = 25°C	L (µH) for 10 turns with bias current 1A f = 100 kHz, T = 25°C	L (µH) for 10 turns with bias current 1A f = 500 kHz, T = 25°C	L (µH) for 10 turns with bias current 1A f = 1 MHz, T = 25°C
IIC10P-14/4-3C30	92 ± 25%	-	-	≥ 5	-	-
IIC10P-14/4-3F4	-	-	45 ± 25%	-	-	≥ 5
IIC10P-14/4-3F35	-	70 ± 25%	-	-	≥ 5	-



Planar E cores





E core (E)

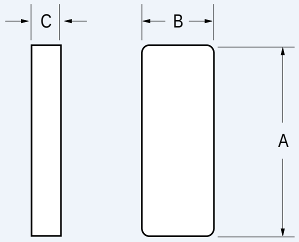


plate (PLT)

Planar magnetics offer an attractive alternative to conventional core shapes when a low profile of magnetic devices is required. Basically this is a construction method of inductive components whose windings are fabricated using printed circuit tracks or copper stampings separated by insulating sheets or constructed from multilayer circuit boards. These windings are placed in low profile ferrite EE- or E-PLT combinations. Planar devices can be constructed as stand alone components or 'integrated' into a multilayer mother board with slots for the ferrite E-core.

Principal advantages of planar magnetics are:

- Low profile construction
- Low leakage inductance
- Excellent repeatability of parasitic properties
- Ease of construction and assembly
- Cost effective
- Greater reliability
- Excellent thermal characteristics, easy to heatsink.

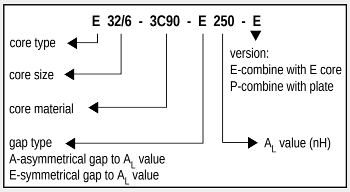
The Philips range of planar E cores are all made from press tooling. This gives the advantage of radiused corners and edges. It also means that clamp recesses can be incorporated.

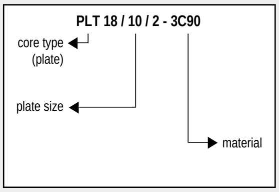
Core type	dimensions (mm)						effective core parameters					
	A	B	C	D	E	F	core factor Σ l/A (mm^{-1})	eff. volume V_e (mm^3)	eff. length l_e (mm)	eff. area A_e (mm^2)	min. area A_{min} (mm^2)	mass of core half (g)
E14/3.5/5 (E-E combination)	14 ± 0.3	3.5 ± 0.1	5 ± 0.1	2 ± 0.1	11 ± 0.25	3 ± 0.05	1.43	300	20.7	14.5	14.5	≈ 0.6
PLT14/5/1.5 (E-PLT combination)	14 ± 0.3	5 ± 0.1	1.5 ± 0.05	-	-	-	1.16	240	16.7	14.5	14.5	≈ 0.5
E18/4/10 (E-E combination)	18 ± 0.35	4 ± 0.1	10 ± 0.2	2 ± 0.1	14 ± 0.3	4 ± 0.1	0.616	960	24.3	39.5	39.5	≈ 2.4
PLT18/10/2 (E-PLT combination)	18 ± 0.35	10 ± 0.2	2 ± 0.05	-	-	-	0.514	800	20.3	39.5	39.5	≈ 1.7
E22/6/16 (E-E combination)	21.8 ± 0.4	5.7 ± 0.1	15.8 ± 0.3	3.2 ± 0.1	16.8 ± 0.4	5 ± 0.1	0.414	2550	32.5	78.5	78.5	≈ 6.5
PLT22/16/2.5 (E-PLT combination)	21.8 ± 0.4	15.8 ± 0.3	2.5 ± 0.05	-	-	-	0.332	2040	26.1	78.5	78.5	≈ 4
E32/6/20 (E-E combination)	31.75 ± 0.64	6.35 ± 0.13	20.32 ± 0.41	3.18 ± 0.13	24.9 min	6.35 ± 0.13	0.323	5380	41.7	129	129	13
PLT32/20/3 (E-PLT combination)	31.75 ± 0.64	20.32 ± 0.41	3.18 ± 0.13	-	-	-	0.278	4560	35.9	129	129	10
E38/8/25 (E-E combination)	38.1 ± 0.76	8.26 ± 0.13	25.4 ± 0.51	4.45 ± 0.13	30.23 min	7.62 ± 0.15	0.272	10200	52.6	194	194	≈ 25
PLT38/25/4 (E-PLT combination)	38.1 ± 0.76	25.4 ± 0.51	3.81 ± 0.13	-	-	-	0.226	8460	43.7	194	194	≈ 18
E43/10/28 (E-E combination)	43.2 ± 0.9	9.5 ± 0.13	27.9 ± 0.6	5.4 ± 0.13	34.7 min	8.1 ± 0.2	0.276	13900	61.7	225	225	≈ 35
PLT43/28/4 (E-PLT combination)	43.2 ± 0.9	27.9 ± 0.6	4.1 ± 0.13	-	-	-	0.226	11500	50.8	225	225	≈ 24
E58/11/38 (E-E combination)	58.4 ± 1.2	10.5 ± 0.13	38.1 ± 0.8	6.5 ± 0.13	50 min	8.1 ± 0.2	0.268	24600	81.2	305	305	≈ 62
PLT58/38/4 (E-PLT combination)	58.4 ± 1.2	38.1 ± 0.8	4.1 ± 0.13	-	-	-	0.224	20800	68.3	305	305	≈ 44
E64/10/50 (E-E combination)	63.8 ± 1.3	10.2 ± 0.13	50.3 ± 1	5.1 ± 0.13	53.6 ± 1.1	10.2 ± 0.2	0.156	40700	79.7	511	511	≈ 100
PLT64/50/5 (E-PLT combination)	63.8 ± 1.3	50.3 ± 1	5.08 ± 0.13	-	-	-	0.136	35500	69.	511	511	≈ 78

Planar E cores

Core type		E14/3.5/5	E18/4/10	E22/6/16	E32/6/20	E38/8/25	E43/10/28	E58/11/38	E64/10/50
Matching plates		PLT14/5/1.5	PLT18/10/2	PLT22/16/2.5	PLT32/20/3	PLT38/25/4	PLT43/28/4	PLT58/38/4	PLT64/50/5
core HALVES for use in combination with an ungapped E core or plate	3C90	A63 - E A63 - P A100 - E A100 - P A160 - E A160 - P 1280 / 1500	A100 - E A100 - P A160 - E A160 - P A250 - E A250 - P A315 - E A315 - P 3200 / 3680	A160 - E A160 - P A250 - E A250 - P A315 - E A315 - P A400 - E A400 - P A630 - E A630 - P 5150 / 6150	E160 - E A160 - P E250 - E A250 - P A315 - E A315 - P A400 - E A400 - P A630 - E A630 - P 6425 / 7350	E250 - E A250 - P E315 - E A315 - P E400 - E A400 - P A630 - E A630 - P A1000 - E A1000 - P 7940 / 9290	E250 - E A250 - P E315 - E A315 - P E400 - E A400 - P A630 - E A630 - P A1000 - E A1000 - P 8030 / 9250	E315 - E A315 - P E400 - E A400 - P E630 - E A630 - P A1000 - E A1000 - P A1600 - E A1600 - P 8480 / 9970	E630 - E A630 - P E1000 - E A1000 - P A1600 - E A1600 - P A2500 - E A2500 - P A3150 - E A3150 - P 14640/16540
	3C94 des	A63 - E A63 - P A100 - E A100 - P A160 - E A160 - P 1280 / 1500	A100 - E A100 - P A160 - E A160 - P A250 - E A250 - P A315 - E A315 - P 3200 / 3680	A160 - E A160 - P A250 - E A250 - P A315 - E A315 - P A400 - E A400 - P A630 - E A630 - P 5150 / 6150	E160 - E A160 - P E250 - E A250 - P A315 - E A315 - P A400 - E A400 - P A630 - E A630 - P 6425 / 7350				
	3C96 prot	1200 / 1350	2900 / 3250	4600 / 5450	6425 / 7350				
	3F3	A63 - E A63 - P A100 - E A100 - P A160 - E A160 - P 1100 / 1300	A100 - E A100 - P A160 - E A160 - P A250 - E A250 - P A315 - E A315 - P 2700 / 3100	A160 - E A160 - P A250 - E A250 - P A315 - E A315 - P A400 - E A400 - P A630 - E A630 - P 4300 / 5000	E160 - E A160 - P E250 - E A250 - P A315 - E A315 - P A400 - E A400 - P A630 - E A630 - P 5900 / 6780	E250 - E A250 - P E315 - E A315 - P E400 - E A400 - P A630 - E A630 - P A1000 - E A1000 - P 7250 / 8500	E250 - E A250 - P E315 - E A315 - P E400 - E A400 - P A630 - E A630 - P A1000 - E A1000 - P 7310 / 8700	E315 - E A315 - P E400 - E A400 - P E630 - E A630 - P A1000 - E A1000 - P A1600 - E A1600 - P 7710 / 9070	E630 - E A630 - P E1000 - E A1000 - P A1600 - E A1600 - P A2500 - E A2500 - P A3150 - E A3150 - P 13300/15050
	3F35 prot	900 / 1050	2200 / 2500	3500 / 4100					
	3F4 des	A63 - E A63 - P A100 - E A100 - P A160 - E A160 - P 650/780	A100 - E A100 - P A160 - E A160 - P A250 - E A250 - P A315 - E A315 - P 1550 / 1800	A160 - E A160 - P A250 - E A250 - P A315 - E A315 - P A400 - E A400 - P A630 - E A630 - P 2400 / 2900	E160 - E A160 - P E250 - E A250 - P A315 - E A315 - P A400 - E A400 - P A630 - E A630 - P 3200 / 3700	E250 - E A250 - P E315 - E A315 - P E400 - E A400 - P A630 - E A630 - P A1000 - E A1000 - P 3880 /4600	E250 - E A250 - P E315 - E A315 - P E400 - E A400 - P A630 - E A630 - P A1000 - E A1000 - P 3870 / 4660	E315 - E A315 - P E400 - E A400 - P E630 - E A630 - P A1000 - E A1000 - P A1600 - E A1600 - P 4030 / 4780	E630 - E A630 - P E1000 - E A1000 - P A1600 - E A1600 - P A2500 - E A2500 - P A3150 - E A3150 - P 6960 / 7920
high µ halves	3E6	5600/6400	13500/15500	22000/26000					

E160 - E	gapped core half with symmetrical gap (E). A_L = 160 nH measured in combination with an Equal-gapped E core half.
A25 - E	gapped core half with asymmetrical gap (A). A_L = 25 nH in combination with an ungapped E core half.
A25 - P	gapped core half with asymmetrical gap (A). A_L = 25 nH in combination with a plate.
1100/1300	ungapped core half. A_L = 1100/1300 nH measured in combination with an ungapped half / plate.

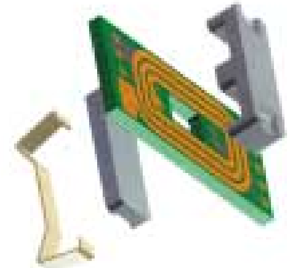


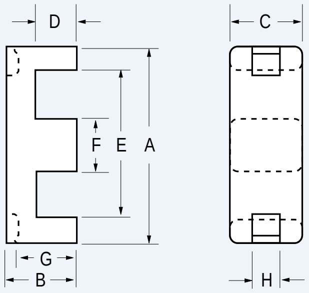


A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

A_L tolerance: ± 3% | ± 5% | ± 8% | ± 10% | ± 25% | + 40% – 30%

Planar E cores with recess





E core with recess (E/R)

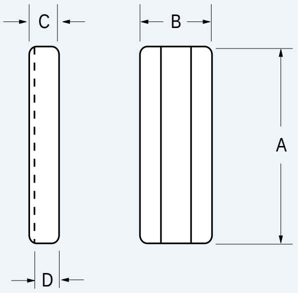


plate with slot (PLT/S)

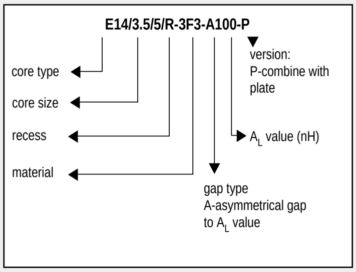
For those customers not in favor of glueing we developed a new range of planar E cores with matching plates and metal clamps. These cores can easily be mounted together with the PCB winding without the use of any glue. The E cores have recesses (E/R) to prevent the clamp from slipping off. The plates have slots (PLT/S) to limit any sideways movement during vibrations or shocks.
This clamping method is only available for E-PLT-combinations, not for EE-combinations. It is particularly suitable for the cores in high permeability materials like 3E6. Any glue on the mating faces would potentially degradel the high A_L value of these core assemblies. Planar cores in high μ material 3E6 are recommended for use in common mode input filters or in wideband transformers.

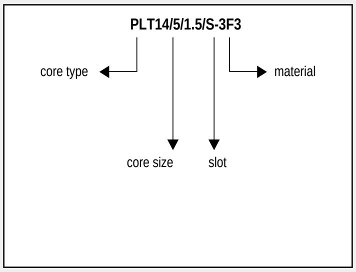
Summary:
- no glue necessary
- plate with slot to prevent sideways movement
- no A_L reduction of high permeability cores due to glue on the mating faces

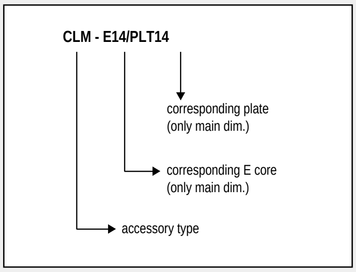
	Core type	E14/3.5/5/R	PLT14/5/1.5/S (E-PLT combination)	E18/4/10/R	PLT18/10/2/S (E-PLT combination)	E22/6/16/R	PLT22/16/2.5/S (E-PLT combination)
effective core parameters	core factor Σ l/A(mm^{-1})	-	1.15	-	0.498	-	0.324
	eff. volume V_e (mm^3)	-	230	-	830	-	2100
	eff. length l_e (mm)	-	16.4	-	20.3	-	26.1
	eff. area A_e (mm^2)	-	14.2	-	40.8	-	80.4
	min. area A_{min} (mm^2)	-	10.9	-	35.9	-	72.6
	mass of core half (g)	≈ 0.6	≈ 0.5	≈ 2.4	≈ 1.7	≈ 6.5	≈ 4
dimensions (mm)	A	14 ± 0.3	14 ± 0.3	18 ± 0.35	18 ± 0.35	21.8 ± 0.4	21.8 ± 0.4
	B	3.5 ± 0.1	5 ± 0.1	4 ± 0.1	10 ± 0.2	5.7 ± 0.1	15.8 ± 0.3
	C	5 ± 0.1	1.8 ± 0.05	10 ± 0.2	2.4 ± 0.05	15.8 ± 0.3	2.9 ± 0.05
	D	2 ± 0.1	1.5 ± 0.1	2 ± 0.1	2 ± 0.1	3.2 ± 0.1	2.5 ± 0.1
	E	11 ± 0.25	-	14 ± 0.3	-	16.8 ± 0.4	-
	F	3 ± 0.05	-	4 ± 0.1	-	5 ± 0.1	-
	G	2.8 ± 0.15	-	3.3 ± 0.15	-	4.7 ± 0.15	-
	H	2.5 + 0.2	-	2.5 + 0.2	-	2.8 + 0.2	-
mounting parts	CLM		■		■		■

Planar E cores with recess

Core type		E14/3.5/5/R	E18/4/10/R	E22/6/16/R
Matching plates		PLT14/5/1.5/S	PLT18/10/2/S	PLT22/16/2.5/S
core **HALVES** for use in combination with a plate	**3C90**	A63-P	A100-P	A160-P
		A100-P	A160-P	A250-P
		A160-P	A250-P	A315-P
		1500	A315-P	A400-P
			3680	A630-P
				6150
	3C94 des	A63-P	A100-P	A160-P
		A100-P	A160-P	A250-P
		A160-P	A250-P	A315-P
		1500	A315-P	A400-P
			3680	A630-P
				6150
	3C96 prot	1350	3250	5450
	3F3	A63-P	A100-P	A160-P
		A100-P	A160-P	A250-P
		A160-P	A250-P	A315-P
		1300	A315-P	A400-P
			3100	A630-P
				5000
	3F35 prot	1050	2500	4100
	3F4 des	A63-P	A100-P	A160-P
		A100-P	A160-P	A250-P
		A160-P	A250-P	A315-P
		780	A315-P	A400-P
			1800	A630-P
				2900
high μ core **HALVES** for use in combination with a plate	**3E6**	6400	15500	26000







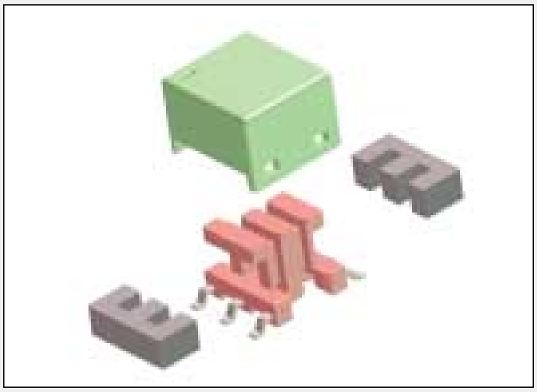
E/R = E core with recess
PLT/S = Plate with slot

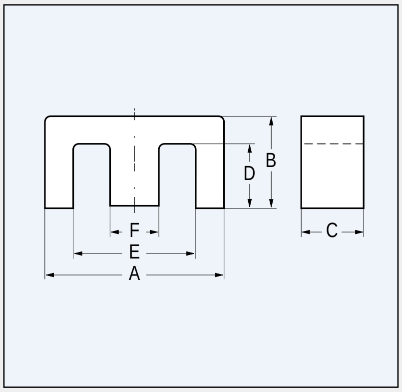
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

A_L tolerance: ± 3% ± 5% ± 8% ± 25% $^{+40\%}_{-30\%}$

A63-P — gapped core half with asymmetrical gap (A), A_L = 63 nH measured in combination with a plate.
1280 — ungapped core half, A_L = 1280 nH measured in combination with a plate.

E cores





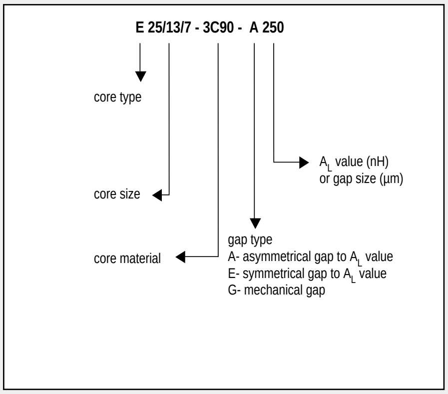
The shape of E cores is derived from the classical iron sheet lamination cores. For the original E range in fact the dimensions of the existing lamination range were taken so that already commercially available coil formers and mounting hardware could be used. The former EF range has been optimized for the use of ferrite as a core material. Cross sections were rearranged resulting in a homogenious magnetic flux density in the core and more space for the windings. Main use is as power transformer or choke in SMPS. E cores have a simple shape and can therefore be produced more economically than more complicated cores.

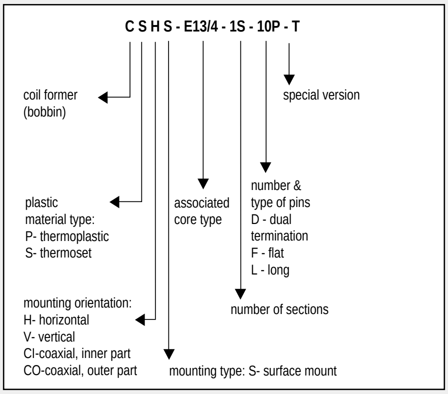
A drawback is the rectangular cross-section of the centre pole which makes it more difficult to wind, especially with heavy wires. Also the structure of the core is rather open resulting in stray flux sometines causing interference problems.

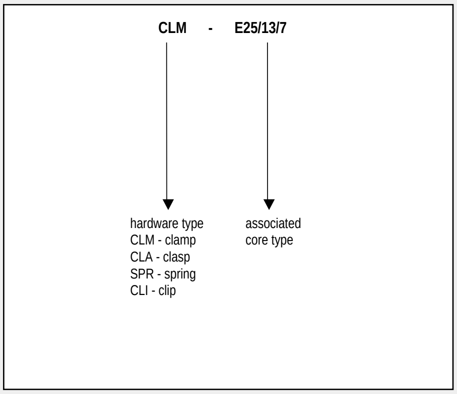
Summary:

- simple, economic shape
- square cross-section, not easy for heavy wires
- large effective ferrite area
- low magnetic self shielding

	Core type (old core description)	**E5.3/2.7/2**	**E6.3/2.9/2**	**E8.8/4.1/2**	**E13/6/3**	**E13/6/6** (814E250)	**E13/7/4** (EF12.6)	**E16/8/5** (EF16)
effective core parameters	**core factor $\Sigma l/A$ (mm^{-1})**	4.70	3.67	3.13	2.74	1.37	2.39	1.87
	eff. volume V_e (mm^3)	33.3	40.6	78	281	559	369	750
	eff. length l_e (mm)	12.5	12.2	15.6	27.8	27.7	29.7	37.6
	eff. area A_e (mm^2)	2.66	3.3	5.0	10.1	20.2	12.4	20.1
	min. area A_{min} (mm^2)	2.63	2.6	3.6	10.1	20.2	12.2	19.3
	mass of core half (g)	≈ 0.08	≈ 0.12	≈ 0.25	≈ 0.7	≈ 1.4	≈ 0.9	≈ 2.0
dimensions (mm)	**A**	5.25 ± 0.1	6.3 – 0.25	9 ± 0.4	12.7 ± 0.25	12.7 ± 0.25	12.6 + 0.5 / –0.4	16 + 0.7 / –0.5
	B	2.65 ± 0.05	2.9 – 0.1	4.1 – 0.2	5.7 ± 0.13	5.7 ± 0.13	6.5 – 0.2	8.2 – 0.3
	C	2.0 – 0.1	2.0 – 0.1	2.0 – 0.2	3.18 ± 0.13	6.4 ± 0.13	3.7 – 0.3	4.7 – 0.4
	D	1.9 + 0.15	1.85 + 0.1	2.03 + 0.32	4.1 ± 0.13	4.1 ± 0.13	4.5 + 0.3	5.7 + 0.4
	E	3.8 + 0.2	3.6 + 0.2	5.2 ± 0.13	9.5 ± 0.25	9.5 ± 0.25	8.9 + 0.6	11.3 + 0.6
	F	1.4 – 0.1	1.4 – 0.1	1.9 ± 0.12	3.2 ± 0.13	3.2 ± 0.13	3.7 – 0.3	4.7 – 0.3
coil formers	**CP**					1S		
	CPH						1S - 6P	1S - 6P
	CPHS	1S - 4P 1S - 6P 2S - 4P 2S - 6P	1S - 4P 1S - 6P 2S - 4P 2S - 6P					
	CPV							
	CSH							1S-9P
	CSHS						1S - 10P	
mounting parts	**CLM**	■						
	CLA							
	CLI	■						
	SPR							
	COV	■	■				■	

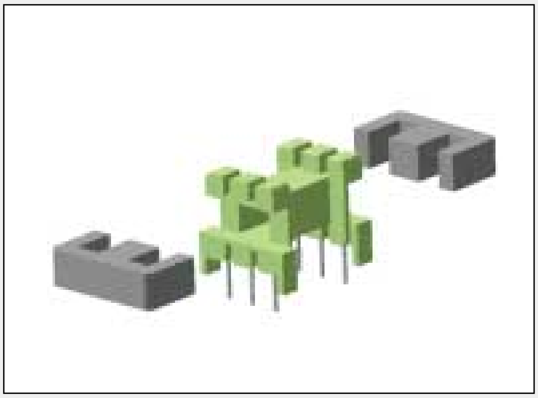


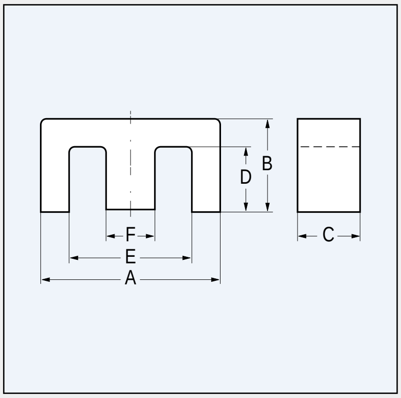


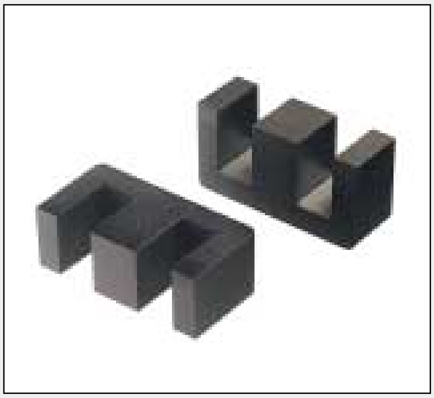


	Core type (old core description)	E19/8/5 (813E187)	E19/8/9 (813E343)	E20/10/5	E20/10/6 (EF20)	E22/16/10	E25/10/6 (812E250)	E25/13/7 (EF25)	E25/13/11	E30/15/7
effective core parameters	core factor Σ l/A(mm^{-1})	1.77	0.960	1.37	1.45	0.695	1.24	1.11	0.733	1.12
	eff. volume V_e (mm^3)	900	1650	1340	1490	5143	1930	2990	4500	4000
	eff. length l_e (mm)	39.9	39.9	42.8	46.0	59.8	49.0	58.5	57.5	67.0
	eff. area A_e (mm^2)	22.6	41.3	31.2	32.0	86	39.5	52.0	78.4	60.0
	min. area A_{min} (mm^2)	22.1	41.1	25.2	32.0	80	37.0	52.0	78.4	49.0
	mass of core half (g)	≈ 2.3	≈ 4	≈ 4	≈ 3.7	≈ 14	≈ 4.8	≈ 8	≈ 11	≈ 11
dimensions (mm)	A	19.1 ± 0.4	19.05 ± 0.38	20.7-1.1	20+0.8 /-0.6	22 ± 0.5	25.4 ± 0.6	25 + 0.8/-0.7	25 + 0.8/-0.7	30.8 – 1.4
	B	8.1 ± 0.13	8.05 ± 0.13	10 ± 0.2	10.2 – 0.4	15.75 ± 0.5	9.65 ± 0.2	12.8 – 0.5	12.8 – 0.5	15 ± 0.2
	C	4.7 ± 0.13	8.71 ± 0.13	5.3 – 0.4	5.9 – 0.5	10 ± 0.25	6.35 ± 0.25	7.5 – 0.5	11 – 0.5	7.3 – 0.5
	D	5.7 ± 0.13	5.69 ± 0.13	6.3 + 0.4	7 + 0.4	9.75 ± 0.25	6.4 min	8.7 + 0.5	8.7 + 0.5	9.7 + 0.5
	E	14.3 ± 0.3	14.33 ± 0.3	12.8 + 0.8	14.1 + 0.8	13 min	18.8 min	17.5 + 1.0	17.5 + 1.0	19.5 + 1.0
	F	4.7 ± 0.13	4.75 ± 0.13	5.2 – 0.4	5.9 – 0.4	8 ± 0.25	6.35 ± 0.25	7.5 ± 0.5	7.5 ± 0.5	7.2 - 0.5
coil formers	CP	1S	1S	1S			1S			1S
	CPH	1S - 8PD		1S - 8P	1S - 8P		1S - 10P	1S - 10P		
	CPCI				1S - 5P					
	CPCO				1S - 5P					
	CPHS									
	CPV			1S - 6P				1S - 6P		
	CSH			1S - 8P						1S - 10P
mounting parts	CLM						■			
	CLA			■						■
	CLI							■		
	SPR			■						■

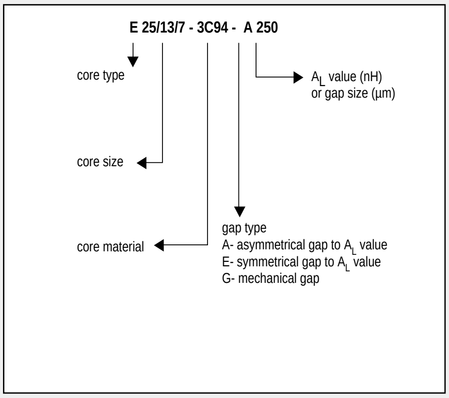
E cores

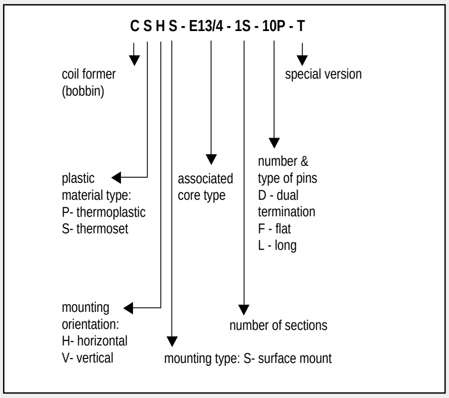


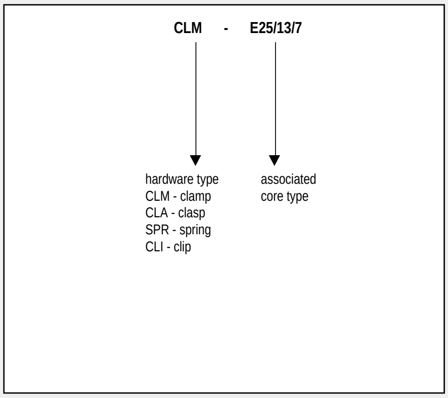




	Core type (old core description)	E31/13/9	E32/16/9 (EF32)	E34/14/9 (E375)	E36/21/12	E41/17/12 (E21)	E42/21/15	E42/21/20	E42/33/20
effective core parameters	core factor Σ l/A(mm^{-1})	0.740	0.894	0.850	0.762	0.517	0.548	0.417	0.614
	eff. volume V_e (mm^3)	5150	6180	5590	12160	11500	17300	22700	34200
	eff. length l_e (mm)	61.9	74	69.3	96	77.0	97.0	97.0	145
	eff. area A_e (mm^2)	83.2	83	80.7	126	149	178	233	236
	min. area A_{min} (mm^2)	83.2	83	80.7	121	142	175	233	234
	mass of core half (g)	≈ 13	≈ 16	≈ 14	≈ 31	≈ 30	≈ 44	≈ 56	≈ 82
dimensions (mm)	A	30.9 ± 0.5	32 + 0.9/-0.7	34.3 ± 0.6	36 ± 0.7	40.6 ± 0.65	43 – 1.7	43 – 1.7	42 + 1/ – 0.7
	B	13.4 ± 0.15	16.4 – 0.4	14.1 ± 0.15	21.75 – 0.4	16.6 ± 0.2	21 ± 0.2	21 ± 0.2	32.8 – 0.4
	C	9.4 ± 0.3	9.5 - 0.7	9.3 ± 0.25	12 – 0.6	12.4 ± 0.3	15.2 – 0.6	20 – 0.8	20 – 0.8
	D	8.6 min	11.2 + 0.6	9.8 ± 0.13	15.75 + 0.6	10.4 min	14.8 + 0.6	14.8 + 0.6	26 + 1
	E	21.9 min	22.7 + 1.2	25.5 min	24.5 + 1.2	28.6 min	29.5 + 1.4	29.5 + 1.4	29.5 + 1.4
	F	9.4 ± 0.25	9.5 – 0.6	9.3 ± 0.2	10.2 – 0.5	12.45 ± 0.25	12.2 – 0.5	12.2 – 0.5	12.2 – 0.5
coil formers	CP			1S		1S	1S	1S	
	CPH		1S - 12P	1S - 12PD		1S - 12PD	1S-10PD-A 1S-10P	1S - 12PD	
	CPHS								
	CPV								
	CSH								
mounting parts	CLM								
	CLA						■		
	CLI								
	SPR						■		







	Core type (old core description)	**E47/20/16**	**E50/27/15**	**E55/28/21**	**E55/28/25**	**E56/24/19** (E75)	**E65/32/27**	**E71/33/32**	**E80/38/20**
effective core parameters	**core factor** Σ **I/A(mm^{-1})**	0.380	0.530	0.350	0.239	0.320	0.274	0.218	0.470
	eff. volume **V_e (mm^3)**	20800	26900	44000	52000	36000	79000	102000	72300
	eff. length **l_e (mm)**	88.9	120	124	123	107	147	149	184
	eff. area **A_e (mm^2)**	234	225	353	420	337	540	683	392
	min. area **A_{min} (mm^2)**	226	213	345	411	337	530	676	392
	mass of core half (g)	≈ 53	≈ 68	≈ 108	≈ 130	≈ 90	≈ 205	≈ 260	≈ 180
dimensions (mm)	**A**	46.9 ± 0.8	50 ± 1	56.2 – 2.1	56.2 – 2.1	56.1 ± 1	65.0+1.5/-1.2	70.5 ± 1	80 ± 1.6
	B	19.6 ± 0.2	27.2 ± 0.2	27.5 ± 0.3	27.5 ± 0.3	23.6 ± 0.25	32.8 – 0.6	33.2 – 0.5	38.1 ± 0.3
	C	15.6 ± 0.25	14.6 ± 0.4	21.0 – 0.8	25 – 0.8	18.8 ± 0.25	27.4 – 0.8	32 – 0.8	19.8 ± 0.4
	D	12.1 min	18.6 ± 0.13	18.5 + 0.8	18.5 + 0.8	14.6 ± 0.13	22.2 + 0.8	21.9 + 0.7	28.2 ± 0.3
	E	32.4 ± 0.65	34.1 min	37.5 + 1.5	37.5 + 1.5	38.1 min	44.2 + 1.8	48 + 1.5	59.1 min
	F	15.6 ± 0.25	14.6 ± 0.4	17.2 – 0.5	17.2 – 0.5	18.8 ± 0.25	20 – 0.7	22 – 0.7	19.8 ± 0.4
coil formers	**CP**	1S		1S - A 1S		1S	1S		
	CPH	1S - 12PD		1S - 14P		1S - 12PD			
	CPHS								
	CPV								
	CSH								
mounting parts	**CLM**								
	CLA			■			■		
	CLI								
	SPR			■			■		

E cores

	Core type (old core description)	**E5.3/2.7/2**	**E6.3/2.9/2**	**E8.8/4.1/2**	**E13/6/3**	**E13/6/6** (814E250)	**E13/7/4** (EF12.6)	**E16/8/5** (EF16)	**E19/8/5** (813E187)	**E19/8/9** (813E343)
core **HALVES** for general purpose transformers and power applications	**3C81**					A63 A100 A160 A250 A315 1950			E63 E100 A160 A250 A315 1500	E63 E100 A160 A250 A315 2740
	3C90				A63 A100 A160 A250 A315 730	A63 A100 A160 A250 A315 1470	A63 A100 A160 A250 A315 800	A63 A100 A160 A250 A315 1100	E63 E100 A160 A250 A315 1170	E63 E100 A160 A250 A315 2150
	3C94	300 des	400 des	530 prot		1470	800	1100	1170	2150
	3C96	275 prot	380 prot	480 prot		1250 prot	700 prot	980 prot	995 prot	1830 prot
	3F3	265	360	460 prot		A63 A100 A160 A250 A315 1250 des	A63 A100 A160 A250 A315 700	A63 A100 A160 A250 A315 980	E63 E100 A160 A250 A315 995 des	E63 E100 A160 A250 A315 1830 des
	3F35	225 prot	300 prot	380 prot		1000 prot	560 prot	760 prot	810 prot	1490 prot
	3F4	165 des	225 des	280 prot						
high μ **HALVES**	**3C11**									
	3E1		700 sup				1200	1800		
	3E25					2600 sup	1500 sup	2200 sup	2300 sup	4250 sup
	3E26									
	3E27				1300	2600	1500	2200	2300	4250
	3E5	1400	1700							
	3E6	1600	2100	2500 prot						

E63	gapped core half with symmetrical gap (E). A_L = 63 nH measured in combination with an Equal-gapped core half.
A315	gapped core half with asymmetrical gap (A). A_L = 315 nH measured in combination with a non-gapped core half.
1950	ungapped core half. A_L = 1950 nH measured in combination with another ungapped core half.

A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

A_L tolerance: ± 5% | ± 8% | ± 10% | ± 15% | ± 20% | ± 25% | + 30% − 20% | + 40% − 30%

	Core type (old core description)	E20/10/5	E20/10/6 (EF20)	E22/16/10	E25/10/6	E25/13/7 (EF25)	E25/13/11	E30/15/7	E31/13/9
core HALVES for general purpose transformers and power applications	3C81				E63 A100 A160 A250 A315 2340	E63 A100 A160 A250 A315 2460		E100 A160 A250 A315 A400 A630 2500	E100 E160 A250 A315 A400 A630 3735
	3C90	A63 A100 A160 A250 A315 1500	A63 A100 A160 A250 A315 1450	A63 A100 A160 A250 A315 3090	E63 A100 A160 A250 A315 1600	E63 A100 A160 A250 A315 1900	E63 E100 A160 A250 A315 2800	E100 A160 A250 A315 A400 A630 1900	E100 E160 A250 A315 A400 A630 2970
	3C94	1500 **des**	1380 **des**		1600 **des**	1900 **des**	2800 **des**	2000 **des**	2970
	3C96	1400 **prot**	1350 **prot**		1470 **prot**	1650 **prot**	2700 **prot**	1600 **prot**	2650 **prot**
	3F3	A63 A100 A160 A250 A315 1400	A63 A100 A160 A250 A315 1350		E63 A100 A160 A250 A315 1470	E63 A100 A160 A250 A315 1650	E63 E100 A160 A250 A315 2700	E100 A160 A250 A315 A400 A630 1600	E100 A160 A250 A315 A400 A630 2650
	3F35	1060 **prot**	1000 **prot**		1150 **prot**	1250 **prot**	2000 **prot**	1250 **prot**	1950 **prot**
	3F4								
high µ HALVES	3C11	2600	2600		2600	3100		3300	
	3E25	2800 **des**	2700 **des**		3000 **des**	4000		4100 **sup**	6790 **sup**
	3E26								
	3E27	2800	2700		3200	4000		4100	6790

E63 — gapped core half with symmetrical gap (E). A_L = 63 nH measured in combination with an Equal-gapped core half.
A315 — gapped core half with asymmetrical gap (A). A_L = 315 nH measured in combination with a non-gapped core half.
1350 — ungapped core half. A_L = 1350 nH measured in combination with another ungapped core half.

A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

A_L tolerance: ± 5% | ± 8% | ± 10% | ± 15% | ± 20% | ± 25% | + 30% − 20% | + 40% − 30%

E cores

	Core type (old core description)	E32/16/9 (EF32)	E34/14/9 (E375)	E35/18/10	E36/21/12	E41/17/12	E42/21/15	E42/21/20	E42/33/20
core HALVES for general purpose transformers and power applications	**3C81**		E100 E160 A250 A315 A400 A630 3200			E100 E160 E250 A315 A400 A630 5370	E100 E160 E250 A315 A400 A630 5300	E100 E160 E250 E315 A400 A630 6950	
	3C90	E100 E160 A250 A315 A400 A630 2500	E100 E160 A250 A315 A400 A630 2440	E100 E160 A250 A315 A400 A630 2500	E100 E160 A250 A315 A400 A630 2650	E100 E160 E250 A315 A400 A630 4100	E100 E160 E250 A315 A400 A630 3900	E100 E160 E250 E315 A400 A630 5000	E100 E160 E250 A315 A400 A630 4000
	3C94	2500 des	2440			4100 des	4100 des	5200 des	4000 des
	3C96	2300 prot	2125 prot						
	3F3	E100 E160 A250 A315 A400 A630 2300	E100 E160 A250 A315 A400 A630 2125			E100 E160 E250 A315 A400 A630 3575	E100 E160 E250 A315 A400 A630 3600	E100 E160 E250 E315 A400 A630 4600	E100 E160 E250 A315 A400 A630 3700
	3F35	1700 prot	1680 prot						
	3F4								
high μ HALVES	**3C11**	4000					8000		
	3E25	5000 des	4695 sup			9400 sup	8000 sup	10500 sup	
	3E27	5000	4695			9400	8000	10500	

E63 — gapped core half with symmetrical gap (E). A_L = 63 nH measured in combination with an Equal-gapped core half.

A315 — gapped core half with asymmetrical gap (A). A_L = 315 nH measured in combination with a non-gapped core half.

2200 — ungapped core half. A_L = 2200 nH measured in combination with another ungapped core half.

A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

A_L tolerance: ± 5% | ± 8% | ± 10% | ± 15% | ± 20% | ± 25% | + 30% − 20% | + 40% − 30%

Core type (old core description)		E47/20/16	E50/27/15	E55/28/21	E55/28/25	E56/24/19 (E75)	E65/32/27	E71/33/32	E80/38/20
core HALVES for general purpose transformers and power applications	**3C81**	E100	E100	E100		E100			E100
		E160	E160	E160		E160			E160
		E250	E250	E250		E250			E250
		E315	E315	E315		E315			E315
		E400	E400	E400		E400			E400
		A630	A630	E630		E630			E630
		7540	5500	8625		9500			6730
	3C90	E100	E100	E100	E100	E100	E100	E100	E100
		E160	E160	E160	E160	E160	E160	E160	E160
		E250	E250	E250	E250	E250	E250	E250	E250
		E315	E315	E315	E315	E315	E315	E315	E315
		E400	E400	E400	E400	E400	E400	E400	E400
		A630	A630	E630	E630	E630	E630	E630	E630
		5500	4355	6300	8000	6900	8600	10800	5070
	3C94								
	3F3	E100		E100	E100		E100	E100	E100
		E160		E160	E160		E160	E160	E160
		E250		E250	E250		E250	E250	E250
		E315		E315	E315		E315	E315	E315
		E400		E400	E400		E400	E400	E400
		A630		E630	E630		E630	E630	E630
		5100		5700	7400		7300	10000	4590
	3F35								
	3F4								
high µ HALVES	**3C11**			12800			16700		
	3E25	11475 **sup**		14000 **des**		14580 **sup**			
	3E27	11475		15400		14580			

E63 — gapped core half with symmetrical gap (E). A_L = 63 nH measured in combination with an Equal-gapped core half.

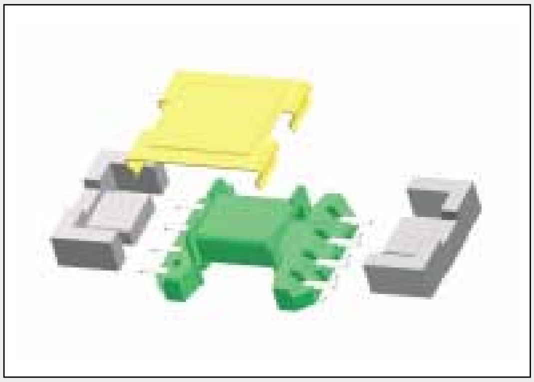
A315 — gapped core half with asymmetrical gap (A). A_L = 315 nH measured in combination with a non-gapped core half.

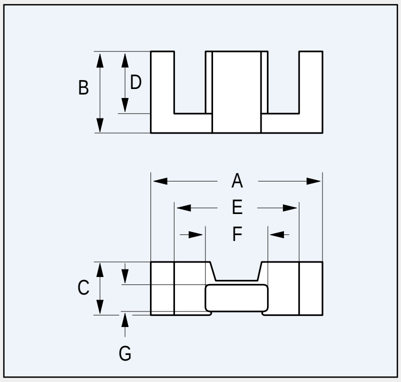
5100 — ungapped core half. A_L = 5100 nH measured in combination with another ungapped core half.

A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

A_L tolerance: ± 5% | ± 8% | ± 10% | ± 15% | ± 20% | ± 25% | + 30% − 20% | + 40% − 30%

EFD cores





Economic Flat Design (EFD) power transformer cores offer a significant advance in circuit miniaturization. Their low build height and high throughput power-density make them ideally suited to applications where space is at a premium.

Throughput power of a ferrite core transformer is essentially proportional to its volume. So the transformer is one of the main limitations in a DC-DC converter's size. Now, with the introduction of the EFD system, a significant reduction in transformer core height has been achieved.

EFD transformer cores combine both extreme flatness with a very high throughput power-density for frequencies up to 1 MHz and higher.

Every transformer, based on the EFD range, has a lower building height than any other existing low-profile design with the same magnetic volume. This is achieved by placing the centre pole of the core always in the centre of the finished transformer, thus making maximum use of the winding area.

Summary:

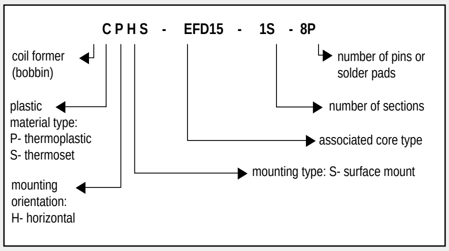
- very low build height
- very high throughput power density
- complete range of accessories including SMD coil formers
- available from several sources

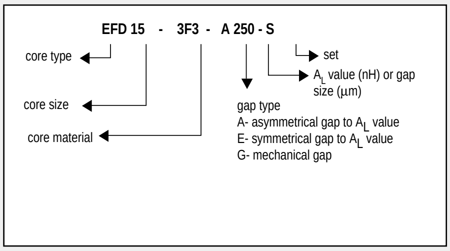
	Core type	EFD10	EFD12	EFD15	EFD20	EFD25	EFD30
effective core parameters	core factor Σ l/A(mm^{-1})	3.29	2.50	2.27	1.52	1.00	0.98
	eff. volume V_e (mm^3)	171	325	510	1460	3300	4700
	eff. length l_e (mm)	23.7	28.5	34.0	47.0	57.0	68.0
	eff. area A_e (mm^2)	7.2	11.4	15.0	31.0	58.0	69.0
	min. area A_{min} (mm^2)	6.5	10.7	12.2	29.0	55.0	66.0
	mass of core half (g)	≈ 0.45	≈ 0.9	≈ 1.4	≈ 3.5	≈ 8	≈ 12
dimensions (mm)	A	10.5 ± 0.3	12.5 ± 0.3	15 ± 0.4	20 ± 0.55	25 ± 0.65	30 ± 0.8
	B	5.2 ± 0.1	6.2 ± 0.1	7.5 ± 0.15	10 ± 0.15	12.5 ± 0.15	15 ± 0.15
	C	2.7 ± 0.1	3.5 ± 0.1	4.65 ± 0.15	6.65 ± 0.15	9.1 ± 0.2	9.1 ± 0.2
	D	3.75 ± 0.15	4.55 ± 0.15	5.5 ± 0.25	7.7 ± 0.25	9.3 ± 0.25	11.2 ± 0.3
	E	7.65 ± 0.25	9 ± 0.25	11 ± 0.35	15.4 ± 0.5	18.7 ± 0.6	22.4 ± 0.75
	F	4.55 ± 0.15	5.4 ± 0.15	5.3 ± 0.15	8.9 ± 0.2	11.4 ± 0.2	14.6 ± 0.25
	G	1.45 ± 0.05	2 ± 0.1	2.4 ± 0.1	3.6 ± 0.15	5.2 ± 0.15	4.9 ± 0.15
coil formers	CPHS	1S - 8P	1S - 8P	1S - 8P 1S - 10P	1S-10P		
	CSHS		1S - 8P	1S - 8P	1S - 10P		
	CPH			1S - 8P	1S - 10P		
	CSH			1S - 8P	1S - 8P	1S - 10P	1S - 12P
mounting parts	CLI			■	■	■	■
	CLM	■	■	■	■		

EFD cores

	Core type	EFD10 SETS	EFD12 SETS	EFD15 SETS	EFD20 HALVES	EFD25 HALVES	EFD30 HALVES
cores for general purpose transformers and power applications	**3C90**	A25-S A40-S A63-S 585-S	A40-S A63-S A100-S 825-S	A63-S A100-S A160-S 950-S	E63 A100 A160 A250 A315 1300	A160 A250 A315 A400 A630 2200	A160 A250 A315 A400 A630 2100
	3C94 des	A25-S A40-S A63-S 585-S	A40-S A63-S A100-S 825-S	A63-S A100-S A160-S 950-S	E63 A100 A160 A250 A315 1300	A160 A250 A315 A400 A630 2200	A160 A250 A315 A400 A630 2100
	3C96 prot	525-S	750-S	850-S	1200	2000	1900
	3F3	A25-S A40-S A63-S 500-S	A40-S A63-S A100-S 700-S	A63-S A100-S A160-S 780-S	E63 A100 A160 A250 A315 1200	A160 A250 A315 A400 A630 2000	A160 A250 A315 A400 A630 1900
	3F35 prot	400-S	550-S	630-S	920	1500	1450
	3F4 des	A25-S A40-S A63-S 280-S	A40-S A63-S A100-S 380-S	A63-S A100-S A160-S 400-S	E63 A100 A160 A250 A315 650	E63 A100 A160 A250 A315 1000	A160 A250 A315 A400 A630 1050
high µ cores	**3E4** des	1400-S	1900-S	2000-S			
	3E5 des	2000-S	2800-S	3600-S			

E63-S — gapped core set with symmetrical gap (E). A_L = 63 nH.
A315-S — gapped core set with asymmetrical gap (A). A_L = 315 nH.
1200 — ungapped core half. A_L = 500 nH measured in combination with another ungapped core half.

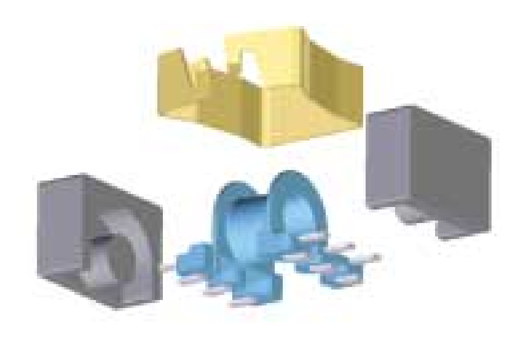


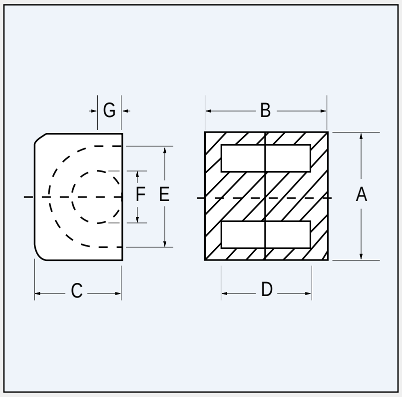


A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

A_L tolerance: ± 3% | ± 5% | ± 8% | ± 10% | ± 25% | + 40% − 30%

EP cores





The EP core range was specially designed for wideband transformer applications. The shape of the assembly is almost cubical, allowing high packing densities on the PCB. The winding except the bottom is completely surrounded by ferrite. Shielding from neighbouring cores is therefore excellent. The bobbins have two rows of pins allowing easy design of multiple output transformers. Cores are available in high permeability materials for wide band transformers and in power materials for small power transformers.

Summary:
- cubical design for dense packing
- excellent magnetic shielding
- easy design of multiple output transformers

Core type		EP6	EP7	EP10	EP13	EP17	EP20
effective core parameters	**core factor Σ l/A(mm^{-1})**	3.40	1.45	1.70	1.24	0.870	0.520
	eff. volume V_e (mm^3)	30.1	165	215	472	999	3230
	eff. length l_e (mm)	10.1	15.5	19.3	24.2	29.5	41.1
	eff. area A_e (mm^2)	2.97	10.7	11.3	19.5	33.7	78.7
	min. area A_{min} (mm^2)	2.27	8.55	8.55	14.9	25.5	60.8
	mass of core set (g)	≈ 0.5	≈ 0.8	≈ 1.1	≈ 2.4	≈ 5	≈ 16
dimensions (mm)	**A**	6 ± 0.15	9.4 – 0.4	11.5 ± 0.3	12.8 – 0.6	18 ± 0.4	24 ± 0.5
	B	6 ± 0.1	7.5 – 0.2	10.2 ± 0.2	13 – 0.3	16.8 ± 0.2	21.4 ± 0.2
	C	3.8 ± 0.1	6.5 – 0.3	7.6 ± 0.2	9 – 0.4	11 ± 0.25	15 ± 0.35
	D	4.4 ± 0.15	5 + 0.4	7.85 - 0.4	9 + 0.4	11.4 ± 0.3	14.4 ± 0.3
	E	4.4 ± 0.15	7.2 + 0.4	9.4 ± 0.2	9.7 + 0.6	12 ± 0.4	16.5 ± 0.4
	F	1.7± 0.1	3.4 – 0.2	3.3 ± 0.15	4.5 – 0.3	5.7 ± 0.18	8.8 ± 0.25
	G	0.8± 0.1	1.7 ± 0.1	1.8 ± 0.13	2.4 ± 0.1	3.3 ± 0.2	4.5 ± 0.2
coil formers	**CSH**		1S - 4P 1S - 6P 1S - 6P - B 2S - 4P - TA 2S - 6P - T	1S - 8P 2S - 8P	1S - 10P 2S - 10P	1S - 8P 2S - 8P	1S - 10P 2S - 10P
	CSHS	1S - 6P	1S - 5P 1S - 6P	1S - 8P-T	1S - 10P-T		
	CPH			1S - 8P-T			
	CPHS		1S - 6P	1S - 8P-T 2S - 8P	1S - 10P		
mounting parts	**CLI**	■	■	■	■		
	CLI/P		■				
	CLA		■	■	■	■	■
	SPR		■	■	■	■	■

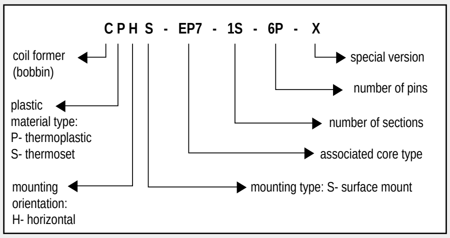
	Core type	EP6 prot	EP7	EP10	EP13	EP17	EP20
core SETS for general purpose transformers and power applications	**3D3**	A40 A63 A100 530	A40 A63 A100 530	A40 A63 A100 470	A63 A100 A160 670		
	3H3	A40 A63 A100 A160 A250 1120	A40 A63 A100 A160 A250 1120	A40 A63 A100 A160 1025	A63 A100 A160 1475		
	3C81	E25 A40 A63 A100 A160 ≥ 875	E25 A40 A63 A100 A160 ≥ 875	E25 A40 A63 A100 A160 ≥ 900	E40 A63 A100 A160 A250 ≥ 1250	E63 A100 A160 A250 A315 ≥ 1950	E160 A250 A315 A400 A630 ≥ 3450
	3C90	E25 A40 A63 A100 A160 1200	E25 A40 A63 A100 A160 1200	E25 A40 A63 A100 A160 1140	E40 A63 A100 A160 A250 1650	E63 A100 A160 A250 A315 2485	E160 A250 A315 A400 A630 4435
	3C91 prot	≥ 875	≥ 875	≥ 900	≥ 1250	≥ 1950	≥ 3450
	3C94 des	E25 A40 A63 A100 A160 1200	E25 A40 A63 A100 A160 1200	E25 A40 A63 A100 A160 1140	E40 A63 A100 A160 A250 1650	E63 A100 A160 A250 A315 2485	E160 A250 A315 A400 A630 4435
	3C96 prot	1120	1120	1025	1475		
	3F3	E25 A40 A63 A100 A160 1000	E25 A40 A63 A100 A160 1000	E25 A40 A63 A100 A160 1000	E40 A63 A100 A160 A250 1325	E63 A100 A160 A250 A315 2000	E160 A250 A315 A400 A630 3550
	3F35 prot	850	850	800	1100		
	3F4 des	A100 A160 600	A100 A160 600	A63 A100 A160 560	A160 A250 A315 780		
	3E1		2100 sup	2000 sup	2600 sup		
	3E27		≥ 2500	≥ 2500	≥ 3400	≥ 5300	
	3E4			3200 sup	4400 sup		≥ 8700 sup
	3E5		5200	4800	7000	≥ 8000	
	3E6	2100	5800	6900	8500		≥ 13500
	3E55 prot	E16 A25 A40 A63 1900			A100 A160 A250 A400 A630 7000		

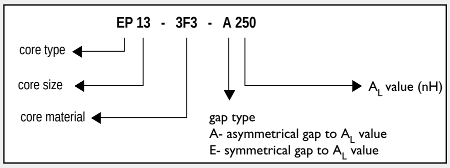
E63	gapped core set with A_L = 63 nH, symmetrical gap (E).
A315	gapped core set with A_L = 315 nH, asymmetrical gap (A).
1200	ungapped core set, A_L = 1200 nH.

A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

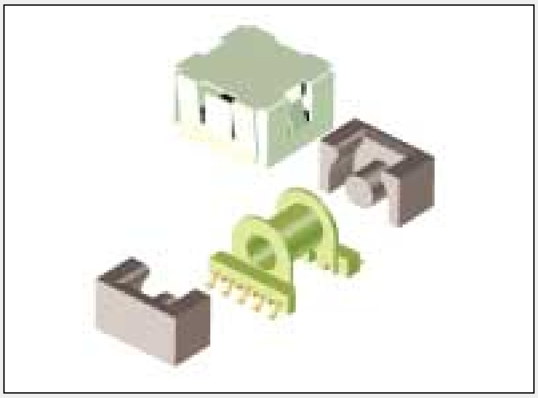
A_L tolerance:

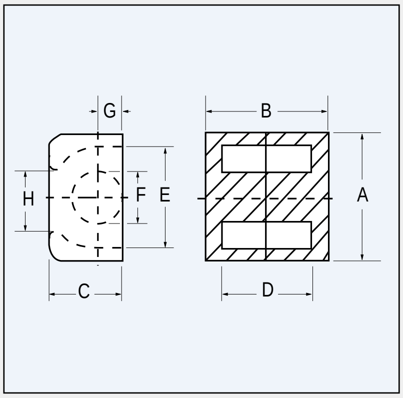
± 3%	± 5%	± 8%	± 12%	± 15%	± 25%	+ 30% − 20%	+ 40% − 30%





EP/LP cores



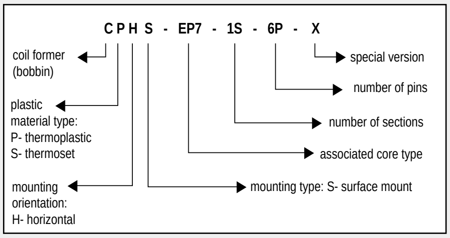


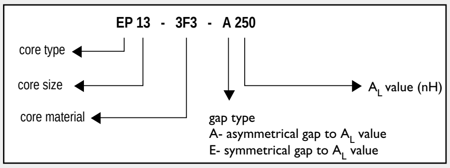
The EP/LP core range was specially designed for wideband transformer applications where low build hight is a must. The board area occupied by the assembly is almost a square, allowing high packing densities on the PCB. The bobbins have two rows of pins allowing easy design of multiple output transformers. Cores are available in high permeability materials, including the new low THD material 3E55, for wide band transformers and in power materials for small power transformers.

Summary:

- square design for dense packing
- lower build hight than EP
- easy design of multiple output transformers

Core type		EP13/LP
effective core parameters	**core factor** Σ **l/A(mm^{-1})**	1.42
	eff. volume V_e **(mm^3)**	501
	eff. length l_e **(mm)**	26.7
	eff. area A_e **(mm^2)**	18.8
	min. area A_{min} **(mm^2)**	14.9
	mass of core set (g)	≈
dimensions (mm)	**A**	12.8 – 0.6
	B	13 – 0.3
	C	7.18 ± 0.2
	D	9 + 0.4
	E	9.7 + 0.6
	F	4.5 – 0.3
	G	2.4 ± 0.1
		6.8 ± 0.15
coil formers	**CSH**	1S - 10P 2S - 10P
	CSHS	1S - 10P-T
	CPH	
	CPHS	1S - 10P
mounting parts	**CLI**	■
	CLI/P	
	CLA	■
	SPR	■





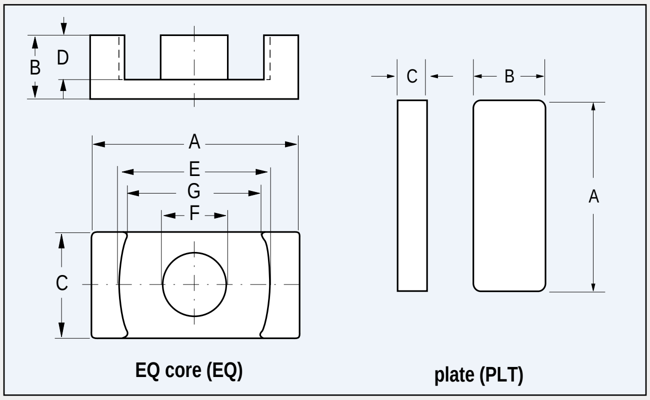
	Core type	EP13/LP
core SETS for general purpose transformers and power applications	3D3	
	3H3	
	3C81	
	3C90	
	3C91 prot	
	3C94 des	
	3C96 prot	
	3F3	
	3F35 prot	
	3F4 des	
	3E1	
	3E27	
	3E4	
	3E5	
	3E6	
	3E55 prot	A100
		A160
		A250
		A315
		A400
		A630
		6000

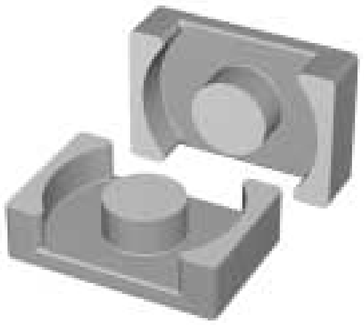
E63	gapped core set with A_L = 63 nH, symmetrical gap (E).
A315	gapped core set with A_L = 315 nH, asymmetrical gap (A).
1200	ungapped core set, A_L = 1200 nH.

A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

A_L tolerance: ± 3% ± 5% ± 8% ± 10% ± 12% ± 15% ± 25% + 30% − 20% + 40% − 30%

EQ cores





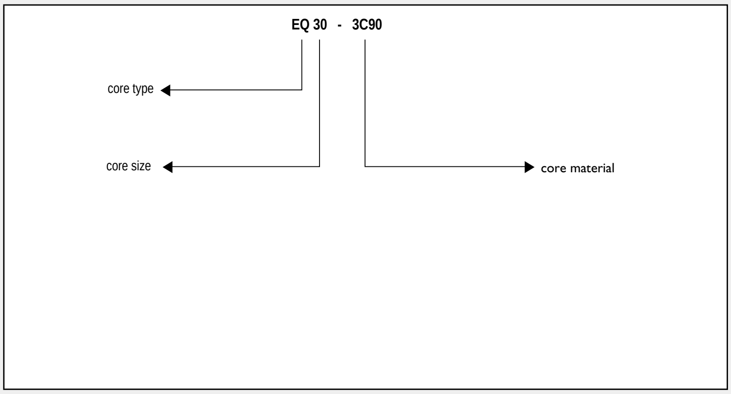
The EQ core design is derived from the ER and PQ. The range is optimized for use in compact AC/DC notebook adapters and DC/DC converters.
For instance, the EQ30 has the capability to handle a power range of 50 to 70 W (flyback topology) in an enclosed casing of a notebook adapter or 100 to 150 W in low profile DC/DC converter .
The advantages of EQ cores are a simple core shape, round centre pole, high A_e value , a large winding window, low profile and a large surface area for heat dissipation.

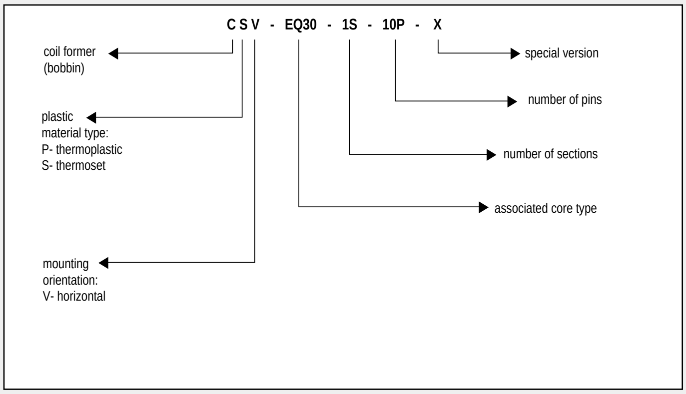
Summary :

- Simple core shape
- Round centre pole
- High Ae value
- Large winding window
- Low profile
- Large surface area for heat dissipation

	Core type	EQ13	PLT13/9/1 (EQ/PLT combination)	EQ20/R 1)	PLT20/14/2/S 2) (EQ/PLT combination)
effective core parameters	**core factor** **Σ l/A(mm^{-1})**	0.911	0.803	0.563	0.420
	eff. volume **V_e (mm^3)**	348	315	1960	1500
	eff. length **l_e (mm)**	17.5	15.9	33.2	25.1
	eff. area **A_e (mm^2)**	19.9	19.8	59	59.8
	min. area **A_{min} (mm^2)**	19.2	19.2	55	55
	mass of core set (g)	≈ 0.9	≈ 0.6	≈ 5.5	≈ 3
dimensions (mm)	**A**	12.8 ± 0.3	12.8 ± 0.3	20 ± 0.35	20 ± 0.35
	B	2.85 ± 0.075	8.7 ± 0.25	6.3 ± 0.1	14 ± 0.3
	C	8.7 ± 0.25	1.1 ± 0.1	14 ± 0.3	2.3 ± 0.05
	D	1.75 ± 0.125	-	4.1 ± 0.15	-
	E	11.2 ± 0.3	-	18 ± 0.35	-
	F	5 ± 0.15	-	8.8 ± 0.15	-
	G	9.05 ± 0.3	-	12.86 ± 0.35	-
coil formers	**CSV**				

1) Core has clip recesses
2) Plate has a slot to accomodate a mounting clip.
(Similar to Planar E cores with recess.)





Core type		EQ25	EQ25/LP	PLT25/18/2 (EQ/LP/PLT combination)	EQ30	PLT30/20/3 (EQ/PLT combination)
effective core parameters	core factor Σ l/A(mm^{-1})	0.414	-	0.294	0.426	0.292
	eff. volume V_e (mm^3)	4145	-	2370	4970	3400
	eff. length l_e (mm)	41.4	-	26.4	46	31.5
	eff. area A_e (mm^2)	100	-	89.7	108	108
	min. area A_{min} (mm^2)	95	-	82.8	95	95
	mass of core set (g)	≈ 12	≈ 8.5	≈ 5	≈ 13.5	≈ 8
dimensions (mm)	A	25 ± 0.4	25 ± 0.4	25 ± 0.4	30 ± 0.4	30 ± 0.4
	B	8 ± 0.1	5.6 ± 0.05	18 ± 0.3	8 ± 0.15	20 ± 0.3
	C	18 ± 0.3	18 ± 0.3	2.3 ± 0.05	20 ± 0.3	2.7 ± 0.1
	D	5.15 ± 0.15	3.2 ± 0.15	-	5.3 ± 0.2	-
	E	22 ± 0.4	22 ± 0.4	-	26 ± 0.4	-
	F	11 ± 0.2	11 ± 0.2	-	11 ± 0.2	-
	G	14.5 min	14.5 min	-	19.45 ± 0.4	-
coil formers	CSV				1S - 10P	

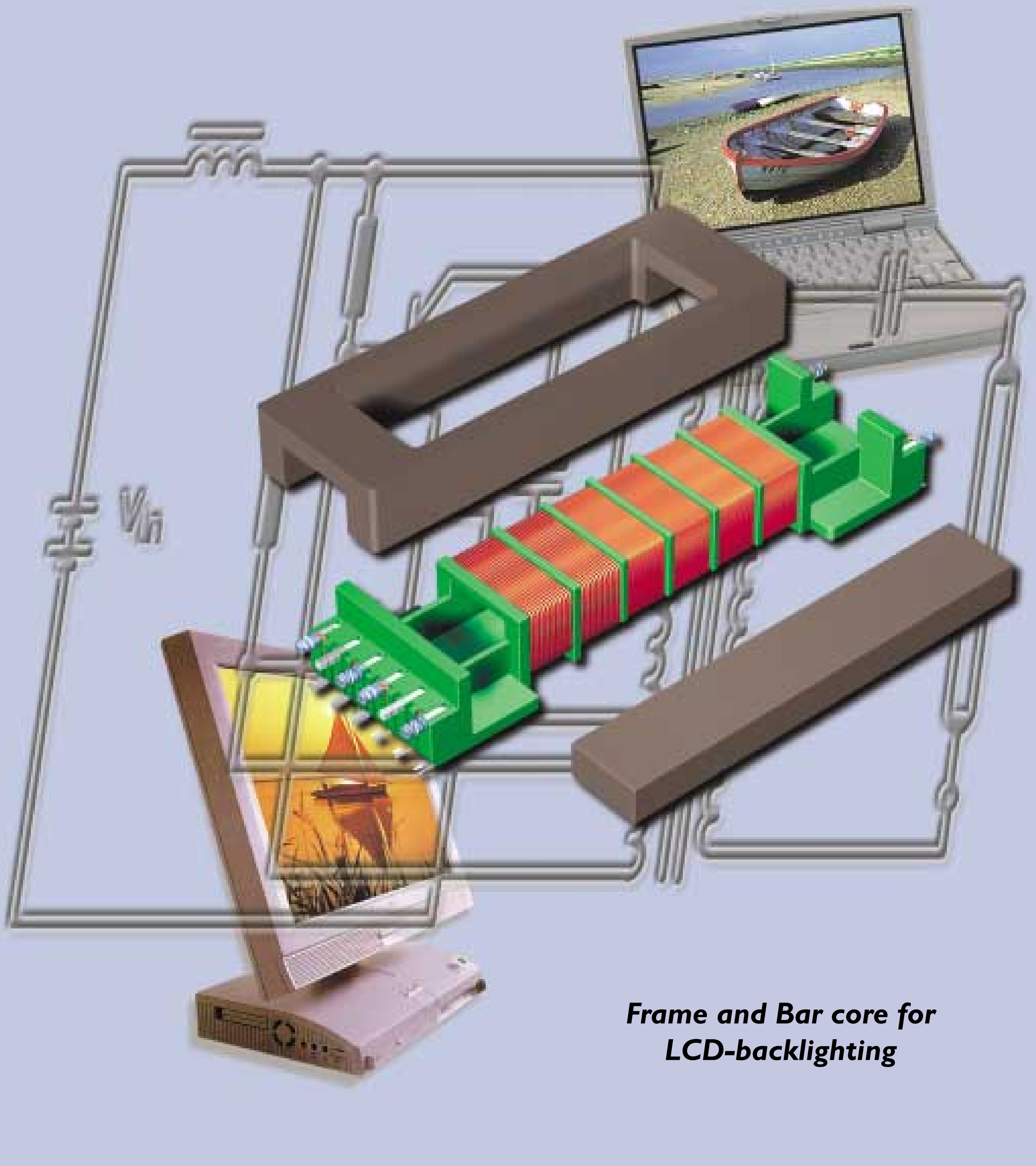
EQ cores

Core type		EQ13	EQ13 + PLT13/9/1	EQ20/R	EQ20/R + PLT20/14/2/S	EQ25	EQ25/LP + PLT25/18/2	EQ30	EQ30 + PLT30/20/3
core HALVES for power applications	**3C90**	1700	1800						
	3C94 **des**	1700	1800	3500	4750	4800	6100	4300	6550
	3C96 **prot**	1600	1700	3150	4350	4400	5600	3900	6000
	3F3				4350		5600	3900	6000
	3F35 **prot**	1300	1350	2400	3300	3350	4350		

4300	ungapped core half, A_L = 4300 measured in combination with another ungapped core half

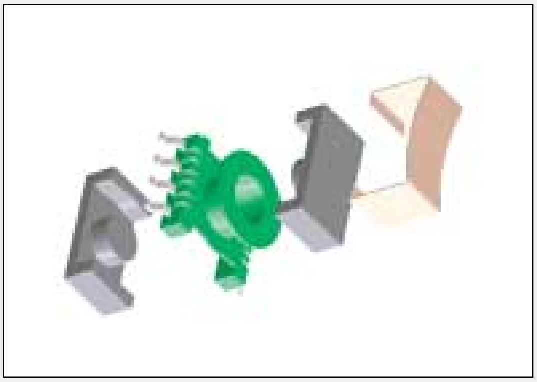
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, f ≤ 10 kHz, T = 25°C

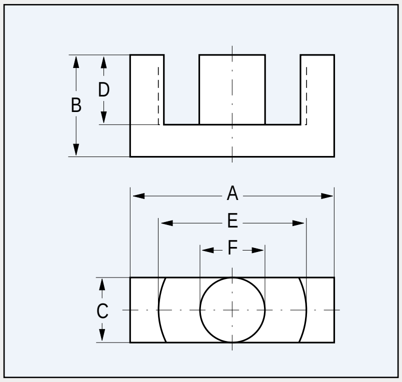
A_L tolerance: ± 25%



Frame and Bar core for LCD-backlighting

ER cores



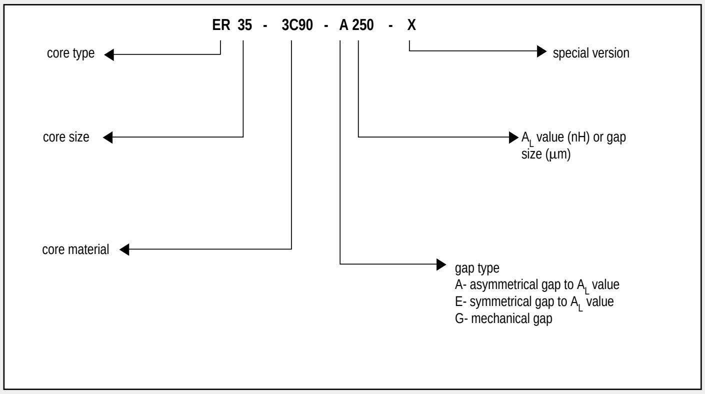


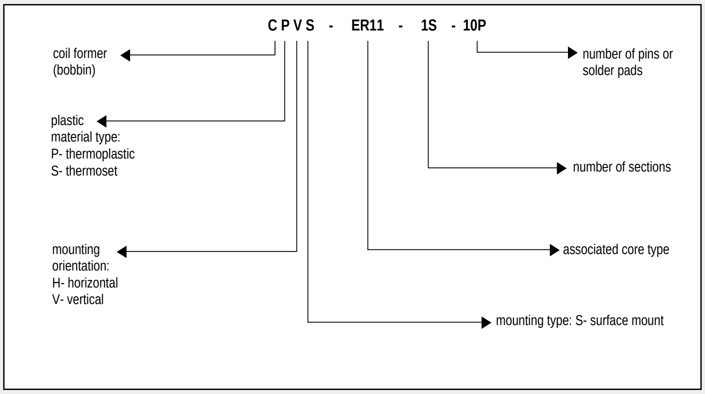
The ER core design is derived from the original E core and, like ETD and EC cores, has a round centre pole and outer legs with a radius to accomodate round coil formers. These cores are mainly used for power transformers. The round centre pole allows the use of thicker wires while the shorter turn length keeps the copper losses low.
The smaller sizes, ER 9.5, ER11 and ER 14.5, are very suitable to build small SMD power and signal tranformers. For both sizes matching SMD coil formers and clips are available.

Summary:

- round centre pole
- outer legs with a radius
- for the smaller sizes, SMD coilformers and clamps are available
- moderate shielding

	Core type	**ER9.5**	**ER11**	**ER14.5**	**ER28**	**ER28L**	**ER35**
effective core parameters	**core factor Σ l/A(mm^{-1})**	1.67	1.23	1.08	0.786	0.928	0.849
	eff. volume V_e (mm^3)	120	174	333	5260	6140	9710
	eff. length l_e (mm)	14.2	14.7	19.0	64.0	75.5	90.8
	eff. area A_e (mm^2)	8.47	11.9	17.6	81.4	81.4	107
	min. area A_{min} (mm^2)	7.6	10.3	17.3	77.0	77.0	100
	mass of core half (g)	≈ 0.35	≈ 0.5	≈ 0.9	≈ 14	≈ 16	≈ 23
dimensions (mm)	**A**	9.5 – 0.3	11 – 0.35	14.5 ± 0.2	28.55 ± 0.55	28.55 ± 0.55	35 ± 0.65
	B	2.45 ± 0.05	2.45 ± 0.05	2.95 ± 0.05	14 ± 0.2	16.9 ± 0.25	20.7 ± 0.2
	C	5 – 0.2	6 – 0.2	6.8 – 0.2	11.4 ± 0.35	11.4 ± 0.35	11.4 ± 0.35
	D	1.6 + 0.15	1.5 + 0.15	1.55 + 0.2	9.75 ± 0.4	12.65 ± 0.4	14.75 ± 0.35
	E	7.5 + 0.25	8.7 + 0.3	11.8 ± 0.2	21.75 ± 0.5	21.75 ± 0.5	26.15 ± 0.55
	F	3.5 – 0.2	4.25 – 0.25	4.8 – 0.2	9.9 ± 0.25	9.9 ± 0.25	11.3 ± 0.25
coil formers	**CPVS**	1S - 8P	1S - 10P 1S - 12P	1S - 10P			
	CSVS		1S - 12P				
mounting parts	**CLM**	■	■	■			





	Core type	ER35W	ER40	ER42	ER42A	ER48	ER54
effective core parameters	core factor Σ l/A(mm^{-1})	0.900	0.658	0.509	0.582	0.392	0.370
	eff. volume V_e (mm^3)	9548	14600	19200	16800	25500	23000
	eff. length l_e (mm)	92.7	98	98.8	99	100	91.8
	eff. area A_e (mm^2)	103	149	194	170	255	250
	min. area A_{min} (mm^2)	100	139	189	170	248	240
	mass of core half (g)	≈ 27	≈ 37	≈ 48	≈ 47	≈ 64	≈ 61
dimensions (mm)	A	35 ± 0.65	40 ± 0.7	42 ± 0.75	42 + 1.0 / – 0.7	48 ± 1	53.5 ± 1
	B	20.9 ± 0.2	22.4 ± 0.2	22.4 ± 0.2	21.8 ± 0.4	21.1 – 0.4	18.3 ± 0.2
	C	11.3 ± 0.35	13.4 ± 0.35	15.6 ± 0.4	15.6 ± 0.4	21 + 0.3 / -0.5	17.95 ± 0.35
	D	15 ± 0.2	15.45 ± 0.35	15.45 ± 0.35	15.6 + 0.7	14.7 + 0.7	11.1 ± 0.3
	E	27.1 ± 0.7	29.6 ± 0.6	30.05 ± 0.65	30.4 + 1.2	38 + 0.5 / – 0.8	40.65 ± 0.85
	F	11.3 ± 0.25	13.3 ± 0.25	15.5 ± 0.3	15 – 0.6	18 ± 0.3	17.9 ± 0.4
coil formers	CPVS						
mounting parts	CLM						

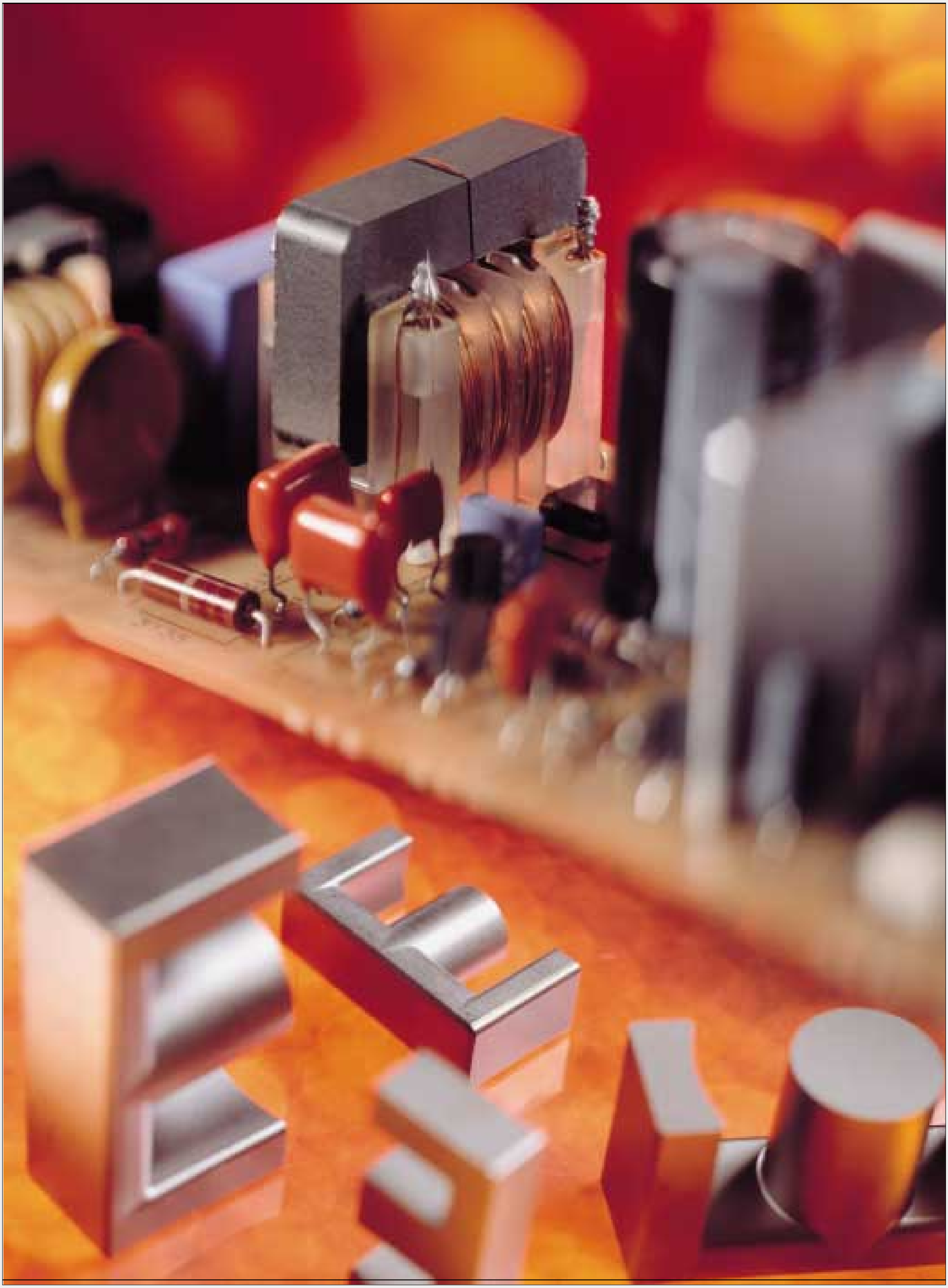
ER cores

	Core type	ER9.5 SETS **des**	ER11 SETS **des**	ER14.5 SETS **des**	ER28 HALVES	ER28L HALVES	ER35 HALVES	ER35W HALVES	ER40 HALVES	ER42 HALVES	ER42A HALVES	ER48 HALVES	ER54 HALVES
cores for general purpose transformers and power applications	**3C90**				2900	2500	2800	3000	3600	4600	4000	5700	6100
	3C94 **des**	A63-S A100-S A160-S 1000-S	A100-S A160-S A250-S 1400-S	A100-S A160-S A250-S 1650-S	2900	2500	2800		3600	4600	4000	5700	6100
	3C96 **prot**	900	1250	1500									
	3F3	A63-S A100-S A160-S 850-S	A100-S A160-S A250-S 1200-S	A100-S A160-S A250-S 1400-S									
	3F35 **prot**	700	1000	1150									
	3F4 **des**	A40-S A63-S A100-S 525-S	A63-S A100-S A160-S 725-S	A100-S A160-S A250-S 850-S									
	3E5	3600-S	5000-S										
	3E6	4800-S	6700-S	7900-S									

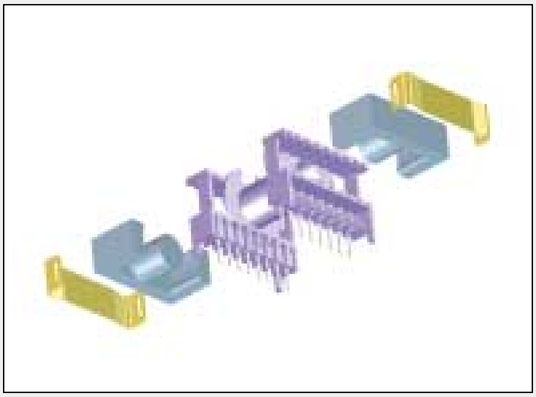
2400 — ungapped core half, A_L = 2400 nH measured in combination with another ungapped core half.
4800-S — ungapped core set, A_L = 4800 nH.

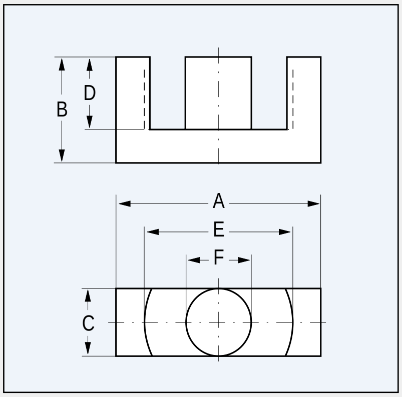
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

A_L tolerance: ± 3% ± 5% ± 8% ± 10% ± 25% + 40% – 30%



ETD cores





The ETD core design is a further development of E cores. They are optimized for use in SMPS transformers with switching frequencies between 50 and 200 kHz. The designation ETD (Economic Transformer Design) implies that this design achieves maximum throughput power related to volume and weight of the total transformer. Shielding is somewhat improved compared with E cores. The matching coil formers are suitable for many winding types and can be handled on automatic equipment. Clips are easy to mount and the range is available from several major suppliers.

Summary:

- optimized shape for AC/DC SMPS transformers up to 200 kHz
- lowest weight and volume for throughput power
- efficient mounting parts
- moderate shielding

Core type		ETD29	ETD34	ETD39	ETD44	ETD49	ETD54	ETD59
effective core parameters	**core factor Σ l/A(mm^{-1})**	0.947	0.810	0.737	0.589	0.534	0.454	0.378
	eff. volume V_e (mm^3)	5470	7640	11500	17800	24000	35500	51500
	eff. length l_e (mm)	72	78.6	92.2	103	114	127	139
	eff. area A_e (mm^2)	76	97.1	125	173	211	280	368
	min. area A_{min} (mm^2)	71	91.6	123	172	209	280	368
	mass of core half (g)	≈ 14	≈ 20	≈ 30	≈ 47	≈ 62	≈ 90	≈ 130
dimensions (mm)	**A**	30.6 – 1.6	35 – 1.6	40 – 1.8	45 – 2	49.8 – 2.2	54.5 ± 1.3	59.8 ± 1.3
	B	15.8 ± 0.2	17.3 ± 0.2	19.8 ± 0.2	22.3 ± 0.2	24.7 ± 0.2	27.6 ± 0.2	31.0 ± 0.2
	C	9.8 – 0.6	11.1 – 0.6	12.8 – 0.6	15.2 – 0.6	16.7 – 0.6	18.9 ± 0.4	21.65 ± 0.45
	D	11 ± 0.3	11.8 + 0.6	14.2 + 0.8	16.1 + 0.8	17.7 + 0.8	20.2 ± 0.4	22.5 ± 0.4
	E	22 + 1.4	25.6 + 1.4	29.3 + 1.6	32.5 + 1.6	36.1 + 1.8	41.2 ± 1.1	44.7 ± 1.1
	F	9.8 – 0.6	11.1 – 0.6	12.8 – 0.6	15.2 – 0.6	16.7 – 0.6	18.9 ± 0.4	21.65 ± 0.45
coil formers	**CPH**	1S-13P	1S - 14P	1S - 16P	1S - 18P	1S - 20P	1S - 22P	1S - 24P
	CPV	1S-12P			1S-18P			
	CSV		1S-12P			1S-22P		
	CSCI		1S - 7P					
	CSCO		1S - 7P					
clips	**CLI**	■	■	■	■	■	■	■

ETD cores

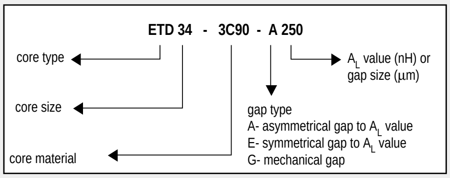
	Core type	ETD29	ETD34	ETD39	ETD44	ETD49	ETD54	ETD59
core **HALVES** for power applications	**3C90**	2350	2700	3000	3800	4200	5000	6000
	3C94 des	2350	2700					
	3C96 prot	2200	2500					
	3F3	2200	2500	2800	3500	3900	4600	5600
	3F35 prot	1600	1850					

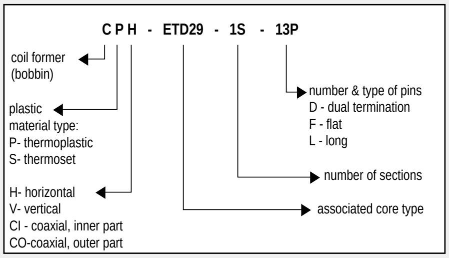
2000

ungapped core half. A_L = 2000 nH measured in combination with another ungapped core half.

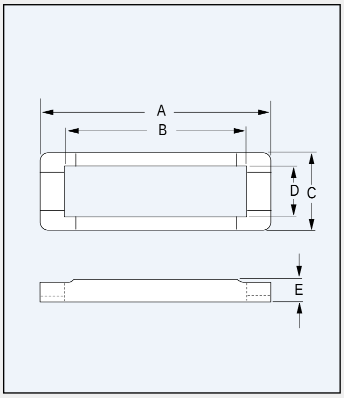
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

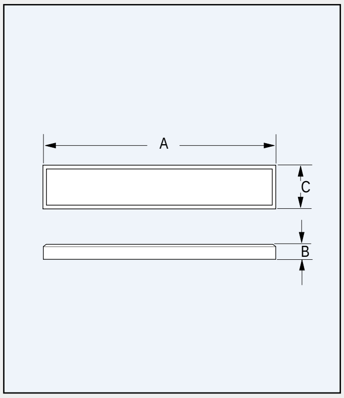
A_L tolerance: ± 25%

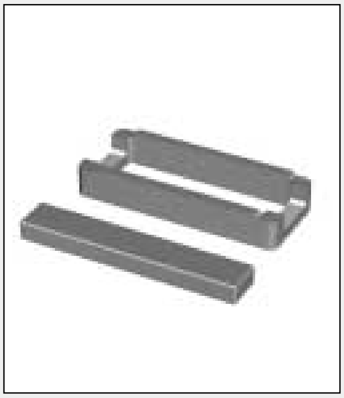




Frame and Bar cores







Cores with a design similar to Frame and Bar cores have been available from Philips under the name of H cores, since 1971. They were mainly applied as signal transformers in Telecom applications. The new Frame and Bar cores have been modified to a slim and elongated rectangular shape in order to meet the dimension requirements of a flat LCD panel. The elongated rectangular shape is also optimized to accommodate the large number of turns required to generate the high ignition voltage (1400 Vrms) for a backlight discharge lamp. Besides this, the Frame and Bar core is also easy to assemble into a transformer and has been adopted as a standard core for the LCD backlight inverter transformer.
A backlight inverter is an electronic DC to AC circuit that drives a Cold Cathode Fluorescent Lamp (CCFL) for the backlighting of a notebook LCD display or LCD monitor .

Summary :

- Narrow design
- Easy to assemble
- Large winding space to accommodate a high number of turns

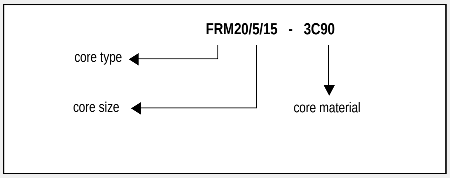
	Core type	FRM 20/5/15	FRM 21/4/12	FRM 24/3.9/10	FRM 27/3.8/9	BAR 20/3/5.5	BAR 22/2/6	BAR 25/2.2/4	BAR 28/3.8/2.3
effective core parameters	**core factor** Σ **l/A(mm^{-1})**	3.29	5.06	5.65	5.56	3.29	5.06	5.65	5.56
	eff. volume V_e **(mm^3)**	655	312	370	504	655	312	370	504
	eff. length l_e **(mm)**	46	40	45.8	52.1	46	40	45.8	50
	eff. area A_e **(mm^2)**	14	7.9	8.1	9.7	14	7.9	8.1	9.0
	min. area A_{min} **(mm^2)**	7.4	5.7	6	8.7	7.4	5.7	6	8.7
	mass of core half (g)	≈ 2.1	≈ 1.5	≈ 1.3	≈ 1.6	≈ 1.5	≈ 1	≈ 1.2	≈ 1.2
dimensions (mm)	**A**	19.7 ± 0.3	21 ± 0.2	23.8 ± 0.3	26.7 ± 0.7	19.9 ± 0.3	21.8 ± 0.3	24.7 ± 0.3	28 ± 0.5
	B	15.6 ± 0.3	16.2 ± 0.3	19.2 ± 0.3	19.7 ± 0.6	2.85 ± 0.05	1.8 ± 0.1	2.15 ± 0.05	3.8 ± 0.1
	C	14.8 ± 0.3	11.8 ± 0.25	9.8 ± 0.2	9.0 ± 0.3	5.45 ± 0.15	5.5 ± 0.2	4.4 ± 0.2	2.3 ± 0.1
	D	11.4 ± 0.25	8.9 ± 0.2	7.3 ± 0.2	6.5 ± 0.2				
	E	4.6 ± 0.1	4.0 ± 0.1	3.85 ± 0.1	3.8 ± 0.2				
coil formers	**CPHS**	■	■	■	■				
mounting parts	**COV**	■							

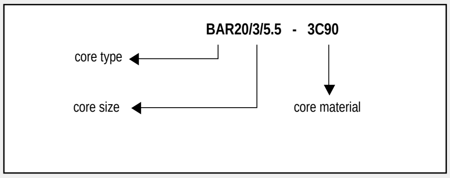
Core type		FRM20/5/15	FRM21/4/12	FRM24/3.9/10	FRM27/3.8/9
Matching cores		BAR20/3/5.5	BAR22/2/6	BAR25/2.2/4	BAR28/3.8/2.3
core SETS for power applications	**3C90**	500	400	370	350
	3C91 prot	600	470	440	420

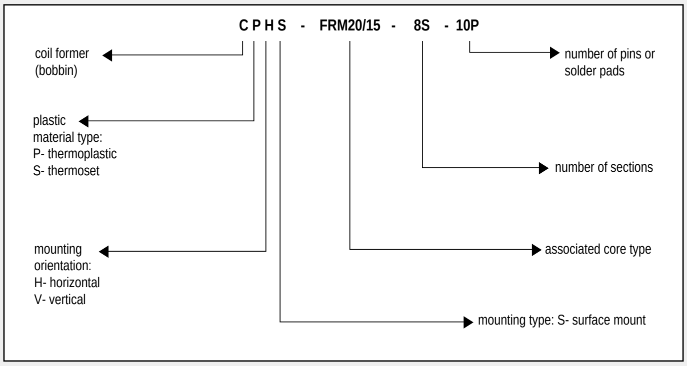
500 — ungapped core set. $A_L = 500$

A_L value (nH) measured at $\hat{B} \le 0.1$ mT, $f \le 10$ kHz, T = 25°C

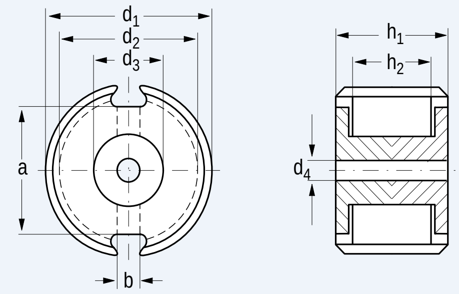
A_L tolerance: ± 25%







P cores

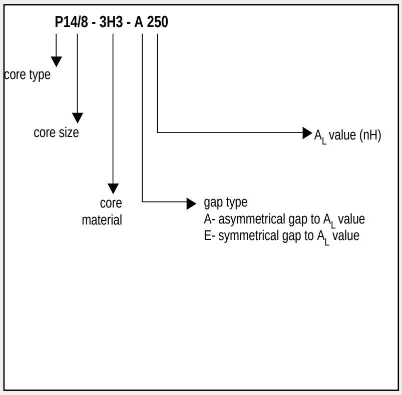


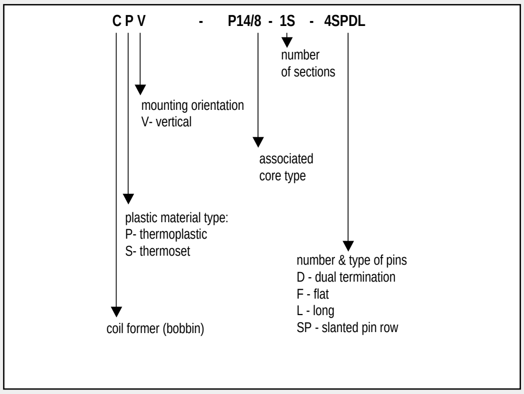
The P core is the earliest design for telecom filter inductors. As with RM-cores there is a complete, standardized range (IEC 133). The cores are available in a range of A_L-values from many suppliers. The core surrounds the winding almost completely so magnetic shielding is outstanding. The slots in the core are rather narrow which complicates assembly and mounting. A complete range of accessories is available, but most are not optimized for easy automatic handling.

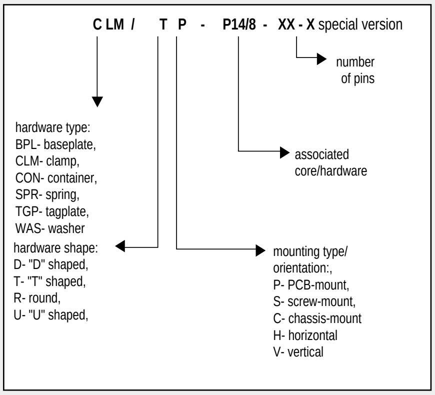
Summary:

- excellent magnetic shielding
- complete range of sizes and material grades
- not easy to assemble and mount
- difficult to get leads out
- mains insulation difficult

	Core type	**P9/5**	**P11/7**	**P14/8**	**P18/11**
effective core parameters	**core factor Σ l/A(mm^{-1})**	1.24	0.956	0.789	0.597
	eff. volume V_e (mm^3)	126	251	495	1120
	eff. length l_e (mm)	12.5	15.5	19.8	25.8
	eff. area A_e (mm^2)	10.1	16.2	25.1	43.3
	min. area A_{min} (mm^2)	7.9	13.2	19.8	36.0
	mass of core set (g)	≈ 0.8	≈ 1.8	≈ 3.2	≈ 6.0
dimensions (mm)	**a**	6.5 ± 0.25	6.8 ± 0.25	9.5 ± 0.3	13.4 ± 0.3
	b	2 ± 0.2	2.2 ± 0.3	2.7 + 1.2	3.8 ± 0.6
	d1	9.3 – 0.3	11.3 – 0.4	14.3 – 0.5	18.4 – 0.8
	d2	7.5 + 0.25	9 + 0.4	11.6 + 0.4	14.9 + 0.5
	d3	3.9 – 0.2	4.7 – 0.2	6 – 0.2	7.6 – 0.3
	d4	2.1 ± 0.1	2.1 ± 0.1	3.1 ± 0.1	3.1 ± 0.1
	h1	5.4 – 0.3	6.5 + 0.1 / – 0.2	8.4 + 0.1 / – 0.2	10.6 ± 0.1
	h2	3.6 + 0.3	4.4 + 0.3	5.6 + 0.4	7.2 + 0.4
coil formers	**CP**	1S	1S 2S - A 3S - A	1S 2S 3S - A	1S 2S 3S
	CPV			1S - 4SPD 1S - 4SPDL 2S - 4SPD 2S - 4SPDL 1S - 6PD 1S - 6PDL 2S - 6PD 2S - 6PDL	1S - 6PD 1S - 6PDL 2S - 6PD 2S - 6PDL 3S - 6PD 3S - 6PDL
mounting parts	**TGP**		4P	6P	8P
	CON		■	■	■
	SPR		■	■	■
	CLM/TP	■	■	■	■
	CLM/TS				
	WAS-CLM/TP			■	■
	WAS-CLM/TS				







Core type		P22/13	P26/16
effective core parameters	core factor Σ l/A(mm^{-1})	0.497	0.400
	eff. volume V_e (mm^3)	2000	3530
	eff. length l_e (mm)	31.5	37.6
	eff. area A_e (mm^2)	63.4	93.9
	min. area A_{min} (mm^2)	50.9	77.4
	mass of core set (g)	≈ 12	≈ 20
dimensions (mm)	a	15 ± 0.4	18 ± 0.4
	b	3.8 ± 0.6	3.8 ± 0.6
	d1	22 – 0.8	25.5 ± 0.5
	d2	17.9 + 0.6	21.2 + 0.8
	d3	9.4 – 0.3	11.5 – 0.4
	d4	4.4 + 0.3	5.4 + 0.2
	h1	13.4 ± 0.2	16 ± 0.2
	h2	9.2 + 0.4	11 + 0.4
coil formers	CP	1S 2S 3S	1S 2S 3S
	CPV	1S - 6PD 1S - 6PDL 2S - 6PD 2S - 6PDL 3S - 6PD 3S - 6PDL	1S - 6PD 1S - 6PDL 2S - 6PD 2S - 6PDL 3S - 6PD 3S - 6PDL
mounting parts	TGP	8P	8P
	CON	■	■
	SPR	■	■
	CLM/TP		■
	CLM/TS	■	
	WAS-CLM/TP		
	WAS-CLM/TS	■	

P cores

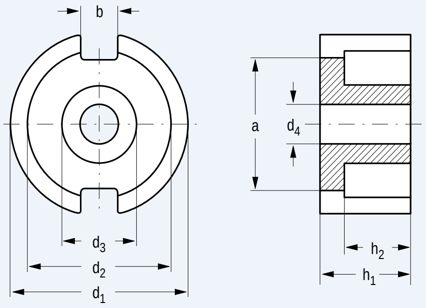
Core type		P9/5	P11/7	P14/8	P18/11	P22/13	P26/16
core SETS for signal filter applications	**3D3** sup	E40 E63 630	E16 E25 E40 E63 A100 800	E40 E63 E100 1000	E63 E100 E160 1400	E40 E63 E100 E160 1700	E100 E160 E250 2150
	3H3 sup		A160 A250 1650	A160 A250 A315 A400 2150	E160 A250 A315 A400 A630 3100	E160 E250 A315 A400 A630 3900	E160 E250 E315 E400 A630 5000
high μ SETS	**3E1** sup			3700	5400	6900	9000
	3E27			5750	7500	9250	12000
	3E4 sup		4100	5300	7550	9450	12100

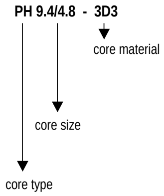
E63 — gapped core set with A_L = 63 nH, symmetrical gap (E).
A315 — gapped core set with A_L = 315 nH, asymmetrical gap (A).
1960 — ungapped core set, A_L = 1960 nH.

A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, $T = 25°C$

A_L tolerance: ± 3% | ± 5% | ± 8% | ± 10% | ± 25% | + 40% − 30%

PH cores





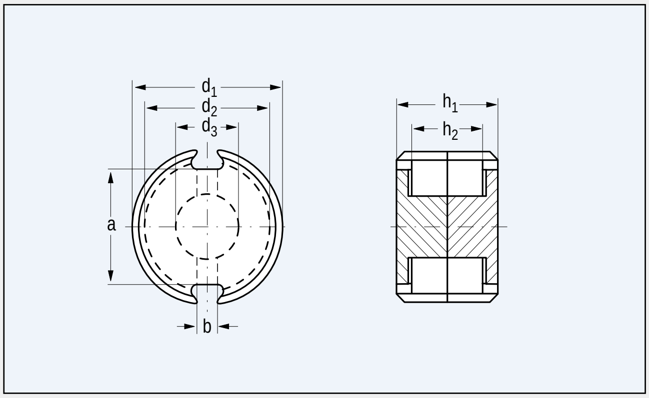
The PH core range consists of potcore halves specially designed for use in proximity switches. Their shape is derived from the IEC standard P-core range. Outside diameters are adapted to fit standardized sizes of proximity switch housings. Since the cores are used as halves, their height is increased to accommodate the winding.
A complete range of coil formers is available.

Summary:

- range of standard sizes
- higher shape than normal P core halves to accommodate windings

Core type		PH5.6/3.6-3D3	PH7.4/3.9-3D3	PH9.4/4.8-3D3
dimensions (mm)	a	4 ± 0.2	5.7 ± 0.4	6.5 ± 0.3
	b	1.5 ± 0.15	1.6 + 0.3	2 ± 0.2
	d1	5.75 – 0.35	7.4 – 0.3	9.4 – 0.4
	d2	4.5 + 0.35	5.8 + 0.25	7.5 + 0.35
	d3	2.5 – 0.1	3 – 0.12	3.9 – 0.2
	d4	0.95 + 0.1	1.38 + 0.1	2 + 0.1
	h1	3.6 – 0.25	3.95 – 0.3	4.8 – 0.4
	h2	2.8 + 0.25	2.8 + 0.2	3.55 + 0.3

P/I cores



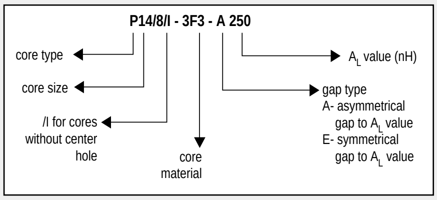
P cores with solid centre poles have approximately a 15% higher effective area than the corresponding P cores with central hole. This makes them more suitable for applications where high flux densities are used. This will be the case in power conversion where the P core is still popular mainly because of its excellent magnetic shielding. This helps to avoid EMI problems, especially at higher switching frequencies.

remark: for coil formers and mounting parts see P cores.

Core type		P11/7/I	P14/8/I	P18/11/I	P22/13/I	P26/16/I
effective core parameters	core factor Σ l/A(mm^{-1})	0.860	0.700	0.560	0.450	0.360
	eff. volume V_e (mm^3)	309	628	1270	2460	4370
	eff. length l_e (mm)	16.3	21.0	26.7	33.3	39.6
	eff. area A_e (mm^2)	19.0	29.9	47.5	73.4	110
	min. area A_{min} (mm^2)	13.7	23.6	37.4	58.1	87.0
	mass of core set (g)	≈ 1.9	≈ 3.5	≈ 7	≈ 13	≈ 21
dimensions (mm)	a	6.8 ± 0.25	9.5 ± 0.3	13.4 ± 0.3	15 ± 0.4	18 ± 0.4
	b	2.2 ± 0.3	3.3 ± 0.6	3.8 ± 0.6	3.8 ± 0.6	3.8 ± 0.6
	d1	11.1 ± 0.2	14.05 ± 0.25	17.9 ± 0.3	21.5 ± 0.3	25.5 ± 0.5
	d2	9.2 ± 0.2	11.8 ± 0.2	15.1 ± 0.25	18.2 ± 0.3	21.6 ± 0.4
	d3	4.6 ± 0.1	5.9 ± 0.1	7.4 ± 0.15	9.2 ± 0.15	11.3 ± 0.2
	h1	6.6 ± 0.15	8.4 ± 0.15	10.6 ± 0.15	13.4 ± 0.2	16.2 ± 0.2
	h2	4.6 ± 0.15	5.8 ± 0.2	7.4 ± 0.2	9.4 ± 0.2	11.2 ± 0.2

Core type		P11/7/I	P14/8/I	P18/11/I	P22/13/I	P26/16/I
core **SETS** for general purpose transformers and power applications	**3C81**	A63	A100	A160	A250	E250
		A100	A160	A250	A315	A315
		A160	A250	A315	A400	A400
		A250	A315	A400	A630	A630
		A315	A400	A630	A1000	A1000
		2100	2900	4200	5330	7000
	3C90	A63	A100	A160	A250	E250
		A100	A160	A250	A315	A315
		A160	A250	A315	A400	A400
		A250	A315	A400	A630	A630
		A315	A400	A630	A1000	A1000
		2010	2695	3660	4785	6230
	3C91 prot	2100	2900	4200	5330	7000
	3F3	A63	A100	A160	A250	E250
		A100	A160	A250	A315	A315
		A160	A250	A315	A400	A400
		A250	A315	A400	A630	A630
		A315	A400	A630	A1000	A1000
		1750	2400	3110	4070	5250

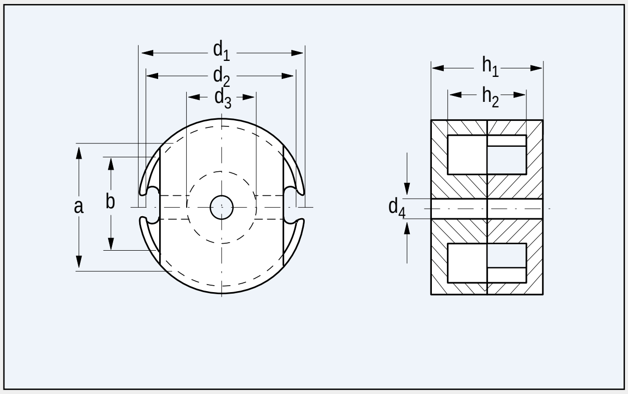
E63 —— gapped core set with A_L = 63 nH, symmetrical gap (E).
A315 —— gapped core set with A_L = 315 nH, asymmetrical gap (A).
2100 —— ungapped core set, A_L = 2100 nH.



A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

A_L tolerance: ± 3% ± 5% ± 25%

PT cores



A disadvantage of the classical P core design has always been the narrow wire slots, making it difficult to make strong coil formers with integrated solder pins.

In the PT design this problem is solved by cutting away the sides of one core half. This creates ample room for wires and coil former flanges.

A range of special PT coil formers in available but also most standard P core accessories can be used.

- complete range of core sizes
- special coil formers with integrated pins
- also P core accessories can be used

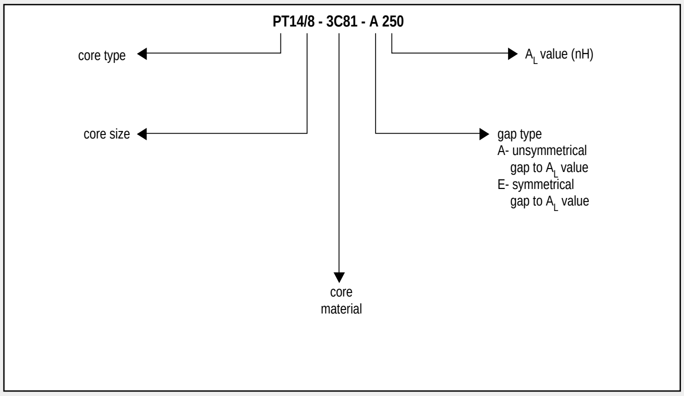
Core type		PT14/8	PT18/11	PT23/11	PT23/18
effective core parameters	core factor Σ l/A(mm^{-1})	0.910	0.670	0.470	0.670
	eff. volume V_e (mm^3)	492	1110	1740	2590
	eff. length l_e (mm)	21.1	27.2	28.6	41.6
	eff. area A_e (mm^2)	23.3	40.6	61.0	62.2
	min. area A_{min} (mm^2)	19.9	32.9	53.6	53.6
	mass of core set (g)	≈ 2.8	≈ 6	≈ 10.5	≈ 14
dimensions (mm)	a	9.4 ± 0.15	11.94 ± 0.2	15.2 ± 0.25	15.2 ± 0.25
	b	8.6 min	10.5 min	13.2 min	13.2 min
	d1	14.05 ± 0.25	18.0 ± 0.4	22.9 ± 0.45	22.9 ± 0.45
	d2	11.8 ± 0.2	15.15 ± 0.25	18.3 ± 0.35	18.3 ± 0.35
	d3	5.9 ± 0.1	7.4 ± 0.15	9.7 ± 0.2	9.7 ± 0.2
	d4	3.1 ± 0.075	3.1 ± 0.075	5.1 ± 0.1	5.1 ± 0.1
	h1	8.3 ± 0.15	10.6 ± 0.15	11 ± 0.25	18 ± 0.35
	h2	5.8 ± 0.2	7.4 ± 0.2	7.6 ± 0.25	14.4 ± 0.35
coil formers	CPV	1S - 6P		1S - 10P	1S - 10P
mounting parts	BPL/D-CLM/C	■			
	CLM/C	■			
	WAS-CLM/C	■			

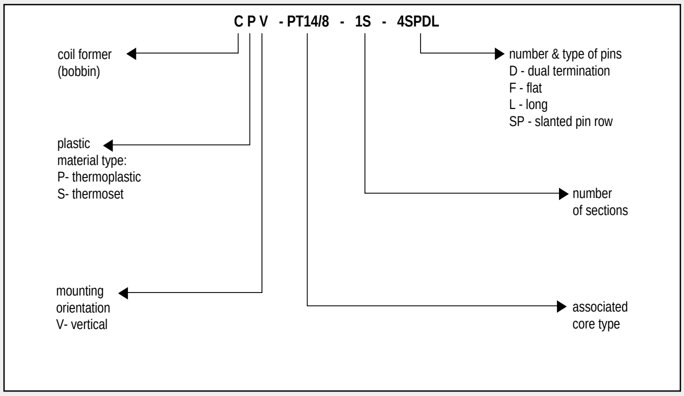
	Core type	PT14/8	PT18/11	PT23/11	PT23/18
core SETS for general purpose transformsers and power applications	**3C81**	A63	A100	A160	A160
		A100	A160	A250	A250
		A160	A250	A315	A315
		A250	A315	A400	A400
		A315	A400	A630	A630
		2400	3130	5500	4100
	3F3	A63	A100	A160	A160
		A100	A160	A250	A250
		A160	A250	A315	A315
		A250	A315	A400	A400
		A315	A400	A630	A630
		1650	2505	3700	2750
high µ SETS	**3E27**	4500	5760	8400	6400

E63 — gapped core set with A_L = 63 nH, symmetrical gap (E).
A315 — gapped core set with A_L = 315 nH, asymmetrical gap (A).
2000 — ungapped core set, A_L = 2000 nH.

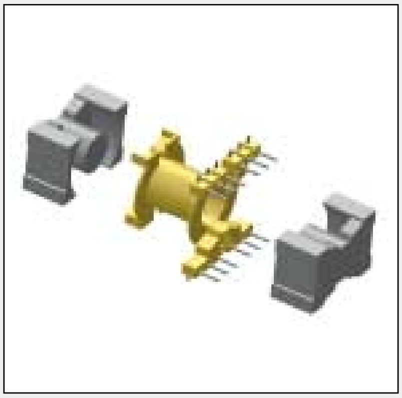
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

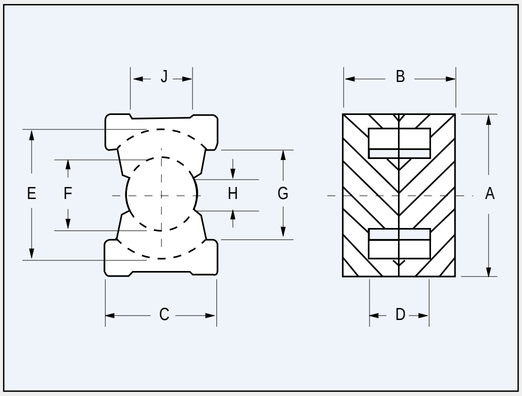
A_L tolerance: ± 3% ± 5% ± 25%





PQ cores





PQ cores, like RM/I cores, have round solid centre poles and round winding areas.

On the outside the design is rectangular. Top and bottom of a core set are completely flat, allowing good thermal contact with heat sinks.

PQ cores are mainly used in power conversion. Therefore they are only offered in power materials. For most core sizes matching coil formers are available.

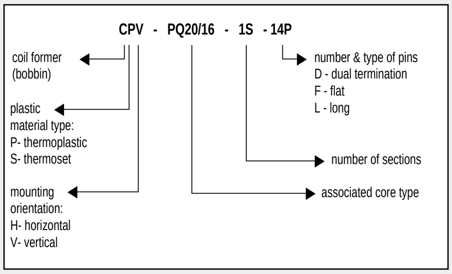
	Core type	PQ20/16	PQ20/20	PQ26/20	PQ26/25	PQ32/20	PQ32/30	PQ35/35
effective core parameters	core factor Σ l/A(mm^{-1})	0.607	0.731	0.372	0.451	0.331	0.447	0.454
	eff. volume V_e (mm^3)	2330	2850	5470	6530	9440	12500	16300
	eff. length l_e (mm)	37.6	45.7	45	54.3	55.9	74.7	86.1
	eff. area A_e (mm^2)	61.9	62.6	121	120	169	167	190
	min. area A_{min} (mm^2)	59.1	59.1	109	108	142	142	162
	mass of core set (g)	≈ 11	≈ 14	≈ 29	≈ 32	≈ 47	≈ 62	≈ 80
dimensions (mm)	A	21.3 ± 0.4	21.3 ± 0.4	27.3 ± 0.46	27.3 ± 0.46	33 ± 0.5	33 ± 0.5	36.1 ± 0.6
	B	16.2 ± 0.2	20.2 ± 0.2	20.2 ± 0.25	24.7 ± 0.25	20.6 ± 0.25	30.3 ± 0.25	34.7 ± 0.25
	C	14 ± 0.4	14 ± 0.4	19 ± 0.45	19 ± 0.45	22 ± 0.5	22 ± 0.5	26 ± 0.5
	D	10.3 ± 0.3	14.3 ± 0.3	11.5 ± 0.3	16.1 ± 0.3	11.5 ± 0.3	21.3 ± 0.3	25 ± 0.3
	E	18 ± 0.4	18 ± 0.4	22.5 ± 0.46	22.5 ± 0.46	27.5 ± 0.5	27.5 ± 0.5	32 ± 0.5
	F	8.8 ± 0.2	8.8 ± 0.2	12 ± 0.2	12 ± 0.2	13.5 ± 0.25	13.5 ± 0.25	14.4 ± 0.25
	G	12 min	12 min	15.5 min	15.5 min	19 min	19 min	23.5 min
	H	4 min	4 min	6 min	6 min	5.5 min	5.5 min	6 min
	J	7.9 min	7.9 min	10.5 min	10.5 min	11.6 min	11.6 min	11.8 min
coil formers	CPV	1S - 14P 1S - 14PD	1S - 14P 1S - 14PD	1S - 12P 1S - 12PD	1S - 12P 1S - 12PD	1S - 12P 1S - 12PD	1S - 12P 1S - 12PD	

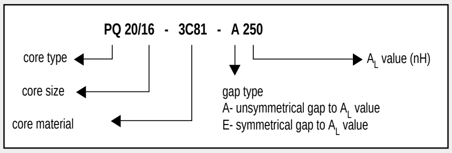
	Core type	PQ20/16	PQ20/20	PQ26/20	PQ26/25	PQ32/20	PQ32/30	PQ35/35
core SETS for general purpose transformers and power applicaitons	**3C81**	A160	A160	E250	E250	E315	E315	E315
		A250	A250	A315	A315	A400	A400	E400
		A315	A315	A400	A400	A630	A630	A630
		A400	A400	A630	A630	A1000	A1000	A1000
		A630	A630	A1000	A1000	A1600	A1600	A1600
		4080	3580	7020	6010	7560	6570	5330
	3C90	A160	A160	E250	E250	E315	E315	E315
		A250	A250	A315	A315	A400	A400	E400
		A315	A315	A400	A400	A630	A630	A630
		A400	A400	A630	A630	A1000	A1000	A1000
		A630	A630	A1000	A1000	A1600	A1600	A1600
		3250	2820	5530	4700	6000	5040	4300
	3C91 prot	4080	3580	7020	6010	7560	6570	5330
	3C94 des	3250	2820	5530	4700	6000	5040	4300
	3C96 prot	3250	2820	5530	4700	6000	5040	4300
	3F3	A160	A160	E250	E250	E315	E315	E315
		A250	A250	A315	A315	A400	A400	E400
		A315	A315	A400	A400	A630	A630	A630
		A400	A400	A630	A630	A1000	A1000	A1000
		A630	A630	A1000	A1000	A1600	A1600	A1600
		3080	2650	5200	4390	6000	4580	4570
	3F35 prot							

E63	gapped core set with A_L = 63 nH, symmetrical gap (E).
A315	gapped core set with A_L = 315 nH, asymmetrical gap (A).
4080	ungapped core set, A_L = 4080 nH.

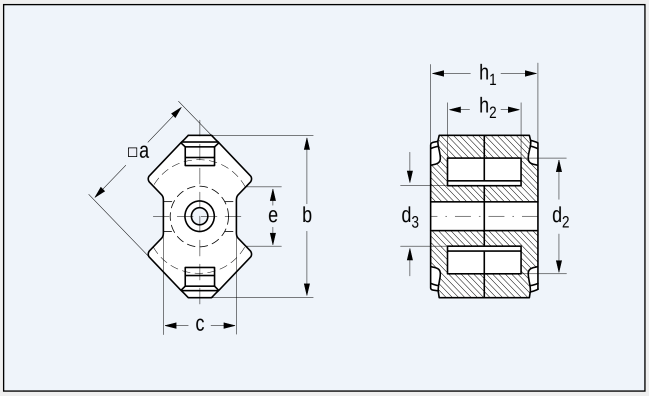
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

A_L tolerance: ± 3% ± 5% ± 25%





RM cores



RM cores were designed for use in high Q, high stability filter inductors. Their shape allows economic utilization of surface area on the PCB. The range is standardized in IEC 431 and is available worldwide from many suppliers. The sizes are based on the standard PCB grid distance. RM 5, for instance, fits on a board space of 5 x 5 modules of 2.5 mm grid. Coil formers and clips were optimized for automated winding and mounting.
The slots provide sufficient space for leads of windings. Magnetic shielding is not as good as with P-cores, but still effective.

Summary:

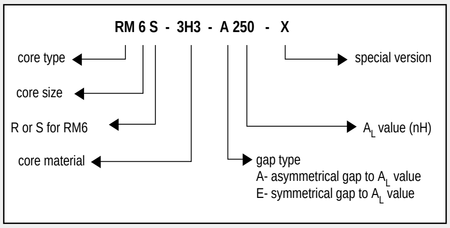
- standardized range
- complete range of accessories
- easy for automated winding
- simple mounting system
- efficient utilization of PCB area
- wider slots to get leads out
- good magnetic shielding
- good selection of coil formers

Core type		RM4	RM5	RM6S	RM8
effective core parameters	core factor Σ l/A(mm^{-1})	1.94	1.01	0.863	0.683
	eff. volume V_e (mm^3)	230	450	840	1850
	eff. length l_e (mm)	21.3	21.4	27.3	35.5
	eff. area A_e (mm^2)	11.0	21.2	31.0	52.0
	min. area A_{min} (mm^2)	8.1	14.8	23.8	39.5
	mass of core set (g)	≈ 1.4	≈ 3.0	≈ 4.5	≈ 10.9
dimensions (mm)	a	9.8 – 0.4	12.3 – 0.5	14.7 – 0.6	19.7 – 0.8
	b	11 – 0.5	14.9 max	17.9 – 0.7	23.2 – 0.9
	c	4.6 – 0.2	7.4 – 0.4	8.2 – 0.4	11 – 0.5
	d2	7.95 + 0.4	10.2 + 0.4	12.4 + 0.5	17 + 0.6
	d3	3.9 – 0.2	4.9 – 0.2	6.4 – 0.2	8.55 – 0.3
	e	5.8 min	6.0 min	8.4 min	9.5 min
	h1	10.4 ± 0.1	10.4 ± 0.1	12.4 ± 0.1	16.4 ± 0.1
	h2	7 + 0.4	6.3 + 0.4	8 + 0.4	10.8 + 0.4
coil formers	CSV	1S - 6P	1S - 4P 2S - 4P 1S - 5P 1S - 6P 2S - 5P 2S - 6P	1S - 4P 2S - 4P 1S - 6P 2S - 6P 1S - 8P	1S - 8P 1S - 12P 2S - 8P 2S - 12P
clips	CLI/P	RM4/5	RM4/5	RM6	RM8

remark: coil formers CSV series with other pin configurations available on request.

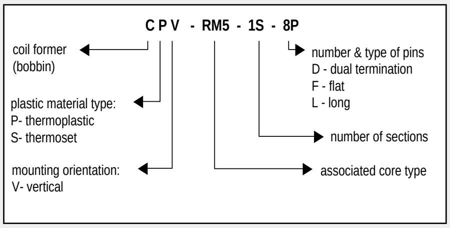
Core type		RM4	RM5	RM6S	RM8
core SETS in materials for low flux level applications	3D3	E40 A63 400	E40 E63 E100 800	E63 E100 A160 950	E100 E160 1240
	3H3	A63 A100 A160 900	A160 A250 A315 A400 1650	A160 A250 A315 A400 2100	A250 A315 A400 A630 2850

E63 — gapped core set with A_L = 63 nH, symmetrical gap (E).
A315 — gapped core set with A_L = 315 nH, asymmetrical gap (A).
950 — ungapped core set, A_L = 950 nH.

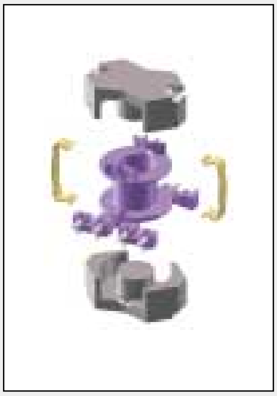


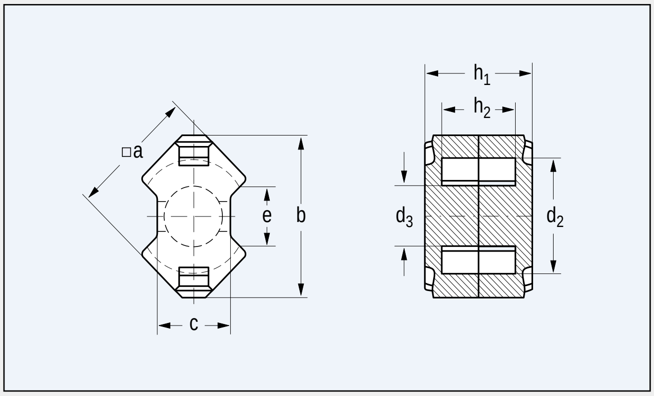
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, f ≤ 10 kHz, T = 25°C

A_L tolerance: ± 3% ± 5% ± 8% ± 10% ± 25%



RM/I cores





For applications other than filter inductors the centre hole in the RM core is not necessary. Inductance adjustment is generally not required. For wideband and power transformers core performance can be improved by using a solid centre pole.
A_L-values will be higher and less flux concentrations occur in the core because its cross section has become more uniform.

Although RM cores were not designed for the function of power transformer or output choke they are frequently used for this purpose. Reason is the availability of a complete and standardized range of cores and accessories. For power applications a range of special, dual termination, coil formers is available.

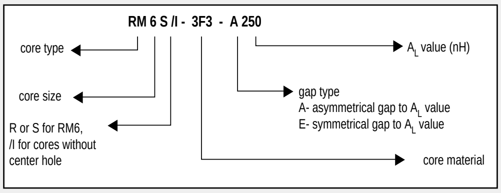
Summary:
- standardized range
- complete range of coil formers
- simple assembly and mounting
- small winding area

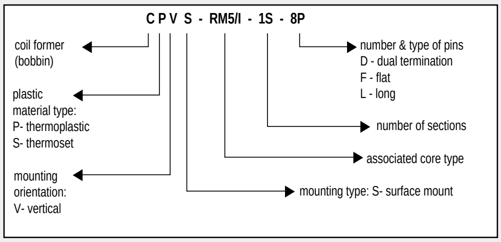
remark: coil formers CSV series with other pin configurations available on request.

	Core type	RM4/I	RM5/I	RM6S/I	RM8/I	RM10/I	RM12/I	RM14/I
effective core parameters	core factor Σ l/A(mm^{-1})	1.69	0.935	0.784	0.604	0.462	0.388	0.353
	eff. volume V_e (mm^3)	322	574	1090	2440	4310	8340	13900
	eff. length l_e (mm)	23.3	23.2	29.2	38.4	44.6	56.6	70.0
	eff. area A_e (mm^2)	13.8	24.8	37.0	63.0	96.6	146	198
	min. area A_{min} (mm^2)	11.5	18.1	31.2	55.4	89.1	125	168
	mass of core set (g)	≈ 1.7	≈ 3.3	≈ 4.9	≈ 12.0	≈ 22	≈ 45	≈ 74
dimensions (mm)	a	9.8 – 0.4	12.3 – 0.5	14.7 – 0.6	19.7 – 0.8	24.7 – 1.1	29.8 – 1.1	34.7 – 1.2
	b	11 – 0.5	14.9 max	17.9 – 0.7	23.2 – 0.9	28.5 – 1.3	37.4 – 1.3	42.2 – 1.4
	c	4.6 – 0.2	6.8 – 0.4	8.2 – 0.4	11 – 0.5	13.5 – 0.5	16.1 – 0.5	19 – 0.6
	d2	7.95 + 0.4	10.2 + 0.4	12.4 + 0.5	17 + 0.6	21.2 + 0.9	25 + 1	29 + 1.2
	d3	3.9 – 0.2	4.9 – 0.2	6.4 – 0.2	8.55 – 0.3	10.9 – 0.4	12.8 – 0.4	15 – 0.6
	e	5.8 min	6 min	8.4 min	9.5 min	10.9 min	12.9 min	17 min
	h1	10.4 ± 0.1	10.4 ± 0.1	12.4 ± 0.1	16.4 ± 0.1	18.6 ± 0.1	24.5 ± 0.1	30.1 ± 0.1
	h2	7 + 0.4	6.3 + 0.4	8 + 0.4	10.8 + 0.4	12.4 + 0.6	16.8 + 0.6	20.8 + 0.6
coil formers	CPV	1S - 6PD	1S - 8PD	1S - 8PD	1S - 12PD	1S - 12PD	1S - 12PD	1S - 12PD
	CSV	1S - 6P	1S - 6P 2S - 6P	1S - 6P 2S - 6P 1S - 8P	1S - 12P 2S - 12P	1S - 12P 2S - 12P		1S - 12P
	CPVS	1S - 6P						
	CSVS		1S - 8P	1S - 8P				
clips	CLI	RM4/5/I	RM4/5/I	RM6/I	RM8/I			
	CLI/P	RM4/5/I RM4/5	RM4/5/I RM4/5	RM6/I RM6	RM8/I RM8	RM10/I	RM12/I	RM14/I

	Core type	RM4/I	RM5/I	RM6S/I	RM8/I	RM10/I	RM12/I	RM14/I
core SETS for general purpose transformers and power applications	3D3 des			A160 A250 A315 1050	A250 A315 A400 1400	A315 A400 A630 1900		
	3H3 des			A315 A400 A630 2350	A400 A630 A1000 3250	A400 A630 A1000 4400		
	3C81			A63 A100 A160 A250 A315 3000	E100 A160 A250 A315 A400 3400	E160 A250 A315 A400 A630 5400		
	3C90	1125	A63 A100 A160 A250 A315 2000	A63 A100 A160 A250 A315 A400 A630 2600	A100 A160 A250 A315 A400 3600	A160 A250 A315 A400 A630 4950	A160 A250 A315 A400 A630 6200	A250 A315 A400 A630 A1000 7100
	3C91 prot			3000	3400	5400		
	3C94 des	1125	A63 A100 A160 A250 A315 2000	A63 A100 A160 A250 A315 A400 A630 2600	A100 A160 A250 A315 A400 3600	A160 A250 A315 A400 A630 4950	A160 A250 A315 A400 A630 6200	A250 A315 A400 A630 A1000 7100
	3C96 prot	1000	1800	2350	3250	4400	5500	6200
	3F3	A100 A160 A250 950	A63 A100 A160 A250 A315 1700	A63 A100 A160 A250 A315 2150	A100 A160 A250 A315 A400 3000	A160 A250 A315 A400 A630 4050	A160 A250 A315 A400 A630 5050	A250 A315 A400 A630 A1000 5700
	3F35 prot	800	1400	1750	2400			
	3F4 des	A100 A160 A250 560	A100 A160 A250 1000	A63 A100 A160 A250 A315 1250	A100 A160 A250 A315 A400 1700			
high μ SETS	3E1	1800	3150	4100	5800	8000		
	3E4	2500	4500	5750	8000	11000		
	3E27		4975	6000	8000	10700		
	3E5	3500	6700	8600	12500	16000		
	3E6		9500	12500	18000			

E63 — gapped core set with A_L = 63 nH, symmetrical gap (E).
A315 — gapped core set with A_L = 315 nH, asymmetrical gap (A).
2000 — ungapped core set, A_L = 2000 nH.

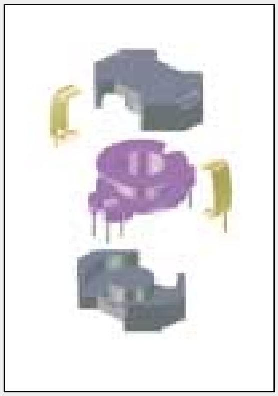


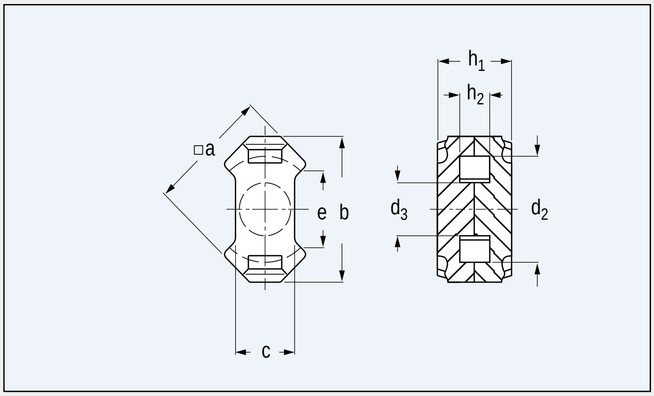


A_L value (nH) measured at
$\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

A_L tolerance: ± 3% ± 5% ± 8% ± 10% ± 25% + 40% − 30%

RM/ILP cores





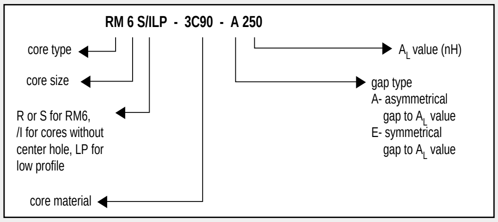
These low-profile RM cores have solid centre poles and a lower height than the standard RM range. They are ideal to construct transformers and inductors with a lower build height needed for low profile equipment. The cores can also be used for planar designs, either combined with PCB windings as a stand-alone device, or with integrated PCB-windings.

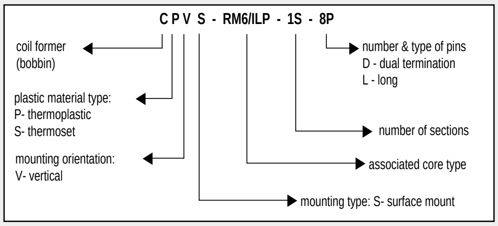
Summary:

- low build height
- suitable for planar designs

Core type		RM4/ILP	RM5/ILP	RM6S/ILP	RM8/ILP	RM10/ILP	RM12/ILP	RM14/ILP
effective core parameters	core factor Σ l/A(mm^{-1})	1.20	0.710	0.580	0.440	0.340	0.280	0.250
	eff. volume V_e (mm^3)	251	430	820	1860	3360	6200	10230
	eff. length l_e (mm)	17.3	17.5	21.8	28.7	33.9	42	50.9
	eff. area A_e (mm^2)	14.5	24.5	37.5	64.9	99.1	148	201
	min. area A_{min} (mm^2)	11.3	18.1	31.2	55.4	89.1	125	168
	mass of core set (g)	≈ 1.5	≈ 2.2	≈ 4.2	≈ 10	≈ 17	≈ 34	≈ 55
dimensions (mm)	a	9.8 – 0.4	12.3 – 0.5	14.7 – 0.6	19.7 – 0.8	24.7 – 1.1	29.8 – 1.1	34.7 – 1.2
	b	11 – 0.5	14.6 – 0.6	17.9 – 0.7	23.2 – 0.9	28.5 – 1.3	37.4 – 1.3	42.2 – 1.4
	c	4.6 – 0.2	6.8 – 0.4	8.2 – 0.4	11 – 0.5	13.5 – 0.5	16.1 – 0.5	19 – 0.6
	d2	7.95 + 0.4	10.2 + 0.4	12.4 + 0.5	17 + 0.6	21.2 + 0.9	25 + 1	29 + 1.2
	d3	3.9 – 0.2	4.9 – 0.2	6.4 – 0.2	8.55 – 0.3	10.9 – 0.4	12.8 – 0.4	15 – 0.6
	e	5.8 min	6 min	8.4 min	9.5 min	10.9 min	12.9 min	17 min
	h1	7.8 – 0.2	7.8 – 0.2	9 – 0.2	11.6 – 0.2	13 – 0.2	16.8 – 0.2	20.5 – 0.2
	h2	4.3 + 0.4	3.6 + 0.4	4.5 + 0.4	5.9 + 0.4	6.7 + 0.4	9 + 0.5	11.1 + 0.6
coil formers	CSV				1S - 10P 1S - 12P			
	CPV					1S - 12PD		
	CPVS							
	CSVS	1S - 8P	1S - 8P	1S - 8P				
clips	CLI	RM4/5/ILP	RM4/5/ILP	RM6/ILP				
	CLI/P				RM8/ILP	RM10/ILP		

Core type		RM4/ILP **des**	RM5/ILP **des**	RM6S/ILP **des**	RM8/ILP **des**	RM10/ILP **des**	RM12/ILP **des**	RM14/ILP **des**
core **SETS** for general purpose transformers and power applications	**3H3** **des**			A160 A250 A315 1350	A250 A315 A400 1850	A315 A400 A630 2500		
	3D3 **des**			A315 A400 A630 2900	A400 A630 A1000 4100	A400 A630 A1000 5600		
	3C90	1400	2350	3175	4550	6300	8100	9400
	3C94 **des**	1400	2350	3175	4550	6300	8100	9400
	3C96 **prot**	1250	2100	2900	4100	5600	7200	8300
	3F3	1200	2000	2700	3800	5200	6700	7700
	3F35 **prot**	1000	1700	2200	3100			
	3F4 **des**	750	1250	1600	2200	3000	3600	4200
high μ **SETS**	**3E5**	5000	8500	10500	16000	22000		
	3E6	6700	11500	15000	23000	32000		



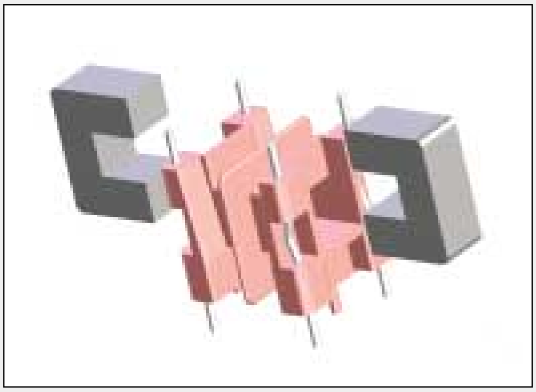


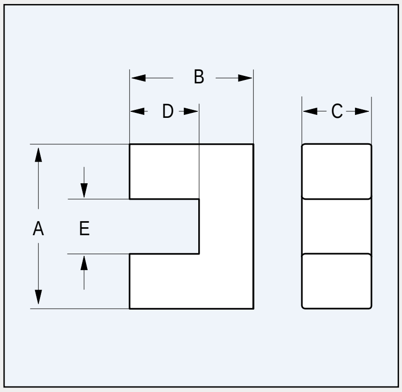
1300 — ungapped core set, A_L = 1300 nH

A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

A_L tolerance: ± 3% | ± 5% | ± 8% | ± 10% | ± 25% | $^{+40\%}_{-30\%}$

U cores





U cores, with rectangular cross-sections, are easy to produce and are relatively inexpensive. For this reason they are very popular in low cost applications such as interference filters and output chokes in radio and TV equipment. There is no real optimization for transformer winding designs and the core is rather bulky. Large U cores like U93 and U100 are suitable for very high throughput powers. They can be stacked to form transformers, capable of handling several kW's in applications such as industrial HF welding.

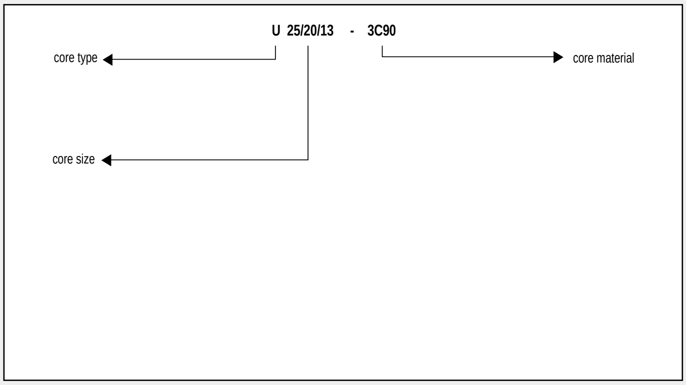
Summary:

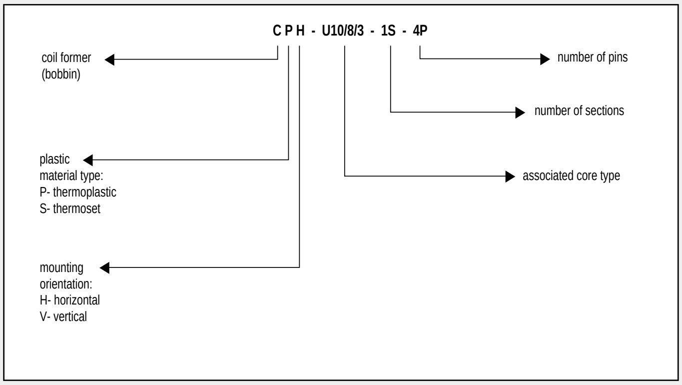
- simple, economic shape
- can be stacked for high power
- bulky sizes
- no self-shielding

Core type		U10/8/3	U15/11/6	U20/16/7	U25/16/6 (376U250)	U25/20/13	U30/25/16
effective core parameters	core factor Σ l/A(mm^{-1})	4.74	1.60	1.21	2.07	0.850	0.690
	eff. volume V_e (mm^3)	309	1680	3800	3380	9180	17900
	eff. length l_e (mm)	38.3	52	68	83.6	88.2	111
	eff. area A_e (mm^2)	8.07	32.3	56	40.3	104	161
	min. area A_{min} (mm^2)	7.91	32.3	56	40.3	104	161
	mass of core half (g)	≈ 0.9	≈ 4	≈ 9	≈ 8	≈ 23.5	≈ 43
dimensions (mm)	A	9.9 ± 0.3	15.4 ± 0.5	20.8 ± 0.6	25.4 + 0.5/ – 0.4	24.8 ± 0.7	31.3 ± 0.7
	B	8.2 – 0.2	11.45 ± 0.2	15.6 ± 0.2	15.9 ± 0.13	19.6 ± 0.2	25.3 ± 0.2
	C	2.85 ± 0.15	6.25 + 0.4	7.5 ± 0.25	6.4 ± 0.13	12.7 ± 0.3	16 + 0.5/ – 0.1
	D	5 + 0.3	6.4 ± 0.35	8.3 ± 0.3	9.5 ± 0.13	11.4 ± 0.4	14.9 ± 0.4
	E	4.35 ± 0.2	5.4 ± 0.4	6.4 ± 0.4	12.7 ± 0.25	8.4 ± 0.4	10.5 ± 0.5
coil formers	CPH	1S - 4P	1S - 4P 2S - 4P				
core HALVES	3C81				1400		
	3C90	420	1400	1900	1200	2900	3700
	3E25		3400 des	4800 des	2320 sup	6300 des	
	3E26						
	3E27		3400	4800	2320	6300	

540 — A_L = 540 nH measured in combination with another ungapped core half.
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, f ≤ 10 kHz, T = 25°C

A_L tolerance: ± 25%



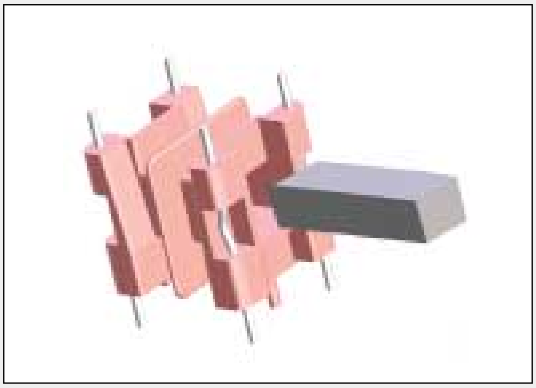


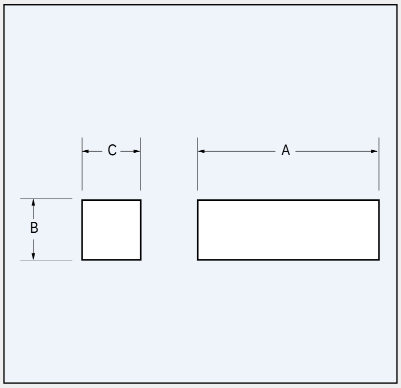
Core type		U33/22/9 (1F30)	U67/27/14 (1F10)	U93/76/16	U93/52/30	U93/76/30	U100/57/25
effective core parameters	core factor Σ l/A(mm^{-1})	1.27	0.850	0.790	0.307	0.421	0.478
	eff. volume V_e (mm^3)	9490	35200	159000	217000	297000	199000
	eff. length l_e (mm)	110	173	354	258	354	308
	eff. area A_e (mm^2)	86.5	204	448	840	840	645
	mass of core half (g)	≈ 24	≈ 85	≈ 400	≈ 560	≈ 760	≈ 500
dimensions (mm)	A	33.3 ± 0.8	67.3 ± 1.3	93 ± 1.8	93 ± 1.8	93 ± 1.8	101.6 ± 2
	B	22.2 ± 0.15	27 ± 0.15	76 ± 0.5	52 ± 0.5	76 ± 0.5	57.1 ± 0.4
	C	9.4 ± 0.25	14.3 ± 0.4	16 ± 0.6	30 ± 0.6	30 ± 0.6	25.4 ± 0.8
	D	12.7 ± 0.25	12.7 ± 0.25	48 ± 0.9	24 ± 0.45	48 ± 0.9	31.7 ± 0.75
	E	14.3 ± 0.5	38.8 ± 0.8	36.2 ± 1.2	36.2 ± 1.2	36.2 ± 1.2	50.8 ± 1
coil formers	CPH						
core HALVES	3C81	2300	3800				
	3C90			3400	8700	6400	5500
	3E25						
	3E27						

540 — A_L = 540 nH measured in combination with another ungapped core half.
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, f ≤ 10 kHz, T = 25°C

A_L tolerance: ± 25%

I cores

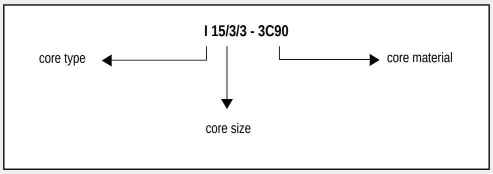




I cores are often used in combination with U-cores to build a simple transformer or inductor.
The smaller types, I 15, I 20 and I 25 fit the range of U coil formers.
This combination is suitable for easy to wind inductors in applications such as interference filters and output chokes.
As with rods, the magnetic circuit is open which is an advantage when the currents have a high DC content.

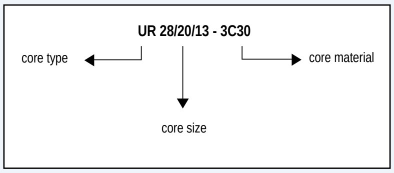
Summary:
- simple, economic shape
- often combined with U cores
- for open circuit inductors
- no self-shielding

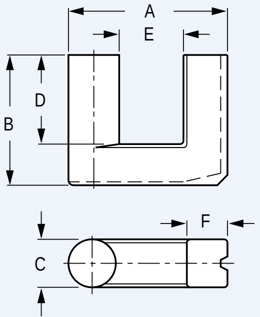
Core type		**I20/6/5**	**I25/7/7**	**I93/28/16**	**I93/28/30**	**I100/25/25**
dimensions (mm)	**A**	19.8 ± 0.5	25 ± 0.7	93 ± 1.8	93 ± 1.8	101.6 ± 2
	B	6.3 ± 0.25	7.5 + 0.2 /– 0.3	27.5 ± 0.5	30 ± 0.6	25.4 ± 0.8
	C	5.1 ± 0.2	7.5 + 0.2 /– 0.3	16 ± 0.6	27.5 ± 0.5	25.4 ± 0.8
	mass (g)	≈ 3	≈ 7	≈ 200	≈ 370	≈ 300
cores	**3C81**					
	3C90	■	■	■	■	■
	3E25					
	3E27					



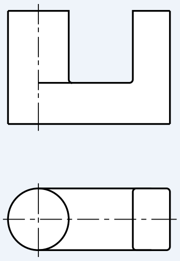
UR cores

This type is suitable for Line Output Transformers (LOT) in TV-sets. The round leg allows easy winding, also of strip conductors. Because of the high voltages involved, the round shape helps to prevent corona effect.

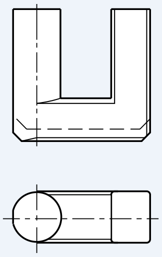




TYPE 1

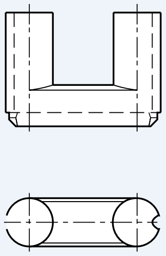


TYPE 2



TYPE 3

Core type	shape	dimensions (mm)						effective core parameters				
		A	B	C	D	E_{min}	F	core factor Σ l/A (mm^{-1})	eff. volume V_e (mm^3)	eff. length l_e (mm)	eff. area A_e (mm^2)	mass of core half (g)
UR28/20/14	6	28.3	20.4	11.2	13.0	8.5	7.5	0.990	9460	97	98	25
UR35/28/13	5	35.2	28.3	12.7	18.8	13.1	9.3	1.100	15900	132	120	42
UR39/35/15	3	38.7	35.2	14.9	24.8	15.0	9.1	1.094	24300	163	149	64
UR42/21/12	4	41.8	20.6	11.9	11.1	18.2	11.9	1.09	11800	113	104	31
UR42/32/15	5	42.5	31.8	15.2	20.2	14.4	12.0	0.832	26670	149	179	69
UR43/34/16	2	42.1	34.0	15.8	24.0	15.7	9.6	0.982	27100	163	166	71
UR44/36/15	1	43.8	35.9	14.65	24.45	16.65	11.8	1.006	28700	170	169	71
UR47/36/16	5	47.55	35.7	15.95	23.8	18.25	12.6	0.900	33800	174	194	86
UR48/39/17	5	48.0	39.4	17.0	26.4	17.4	13.0	0.865	39990	186	215	99
UR64/29/14	4	64.0	29.5	13.8	18.1	36.1	13.8	1.26	27000	185	147	71
UR64/40/20	7	64.0	40.5	20.0	26.5	23.2	20.0	0.726	61000	210	290	160



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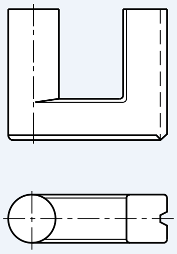
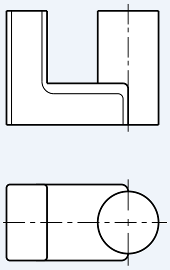
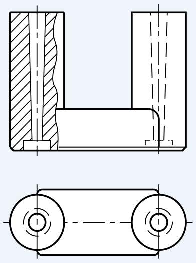


TYPE 5



TYPE 6



TYPE 7

shape	product range			
	3C81 / 3F3	3C15	3C30 des	3C34 prot
6	-	-	UR28/20/13 - 3C30	-
5	-	UR35/28/13 - 3C15	UR35/28/13 - 3C30	-
3	-	UR39/35/15 - 3C15	UR39/35/15 - 3C30	-
4	UR42/21/12 - 3C81	-	-	-
5	-	UR42/32/15 - 3C15	UR42/32/15 - 3C30	-
2	-	UR43/34/16 - 3C15	UR43/34/16 - 3C30	-
1	-	UR44/36/15 - 3C15	UR44/36/15 - 3C30	-
5	-	UR47/36/16 - 3C15	UR47/36/16 - 3C30	-
5	-	UR48/39/17 - 3C15	UR48/39/17 - 3C30	-
4	UR64/29/14 - 3C81	-	-	-
7	-	-	-	-
7	UR64/40/20 - 3F3		-	-

Our present selection is displayed in the table above. In principle any core type can be supplied in all available grades.
Other customized shapes can be manufactured on request.

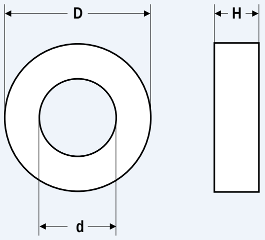
Ferrite Toroids

Ring cores have the best possible shape from the magnetic point of view. The flux path is completely closed so the capabilities of the ferrite are fully exploited. Especially for high permeability ferrites the effect of even a minor airgap in the magnetic circuit can spoil up to 50% of the effective permeability. A further advantage is the very low leakage field which makes it a suitable shape for power and pulse transformers.

Ring cores are mainly used for pulse- and wide band transformers and interference suppression coils but also in special power supplies.

Summary:

- simple economic shape
- very low stray flux and leakage inductance
- not easy to wind

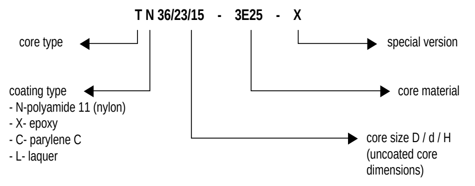


Core type	dimensions (mm)			effective core parameters				
	outside diameter D	inside diameter d	height H	core factor $\Sigma\, l/A (mm^{-1})$	eff. volume V_e (mm^3)	eff. length l_e (mm)	eff. area A_e (mm^2)	mass (g)
TC2.5/1.3/0.8	2.54 ± 0.1	1.27 ± 0.1	0.8 ± 0.1	11.3	2.7	5.53	0.49	0.012
TC2.5/1.3/1.3	2.54 ± 0.1	1.27 ± 0.1	1.27 ± 0.1	7.14	4.29	5.53	0.76	0.022
TC2,5/1.3/2.5	2.54 ± 0.1	1.27 ± 0.1	2.54 ± 0.1	3.57	8.57	5.53	1.55	0.044
TC2.5/1.5/0.8	2.5 ± 0.1	1.5 ± 0.1	0.8 – 0.1	16.4	2.21	6.02	0.37	0.012
TC2.5/1.5/1-S	2.5 ± 0.1	1.5 ± 0.1	1.0 ± 0.1	12.3	2.94	6.02	0.489	0.015
TC3.1/1.3/1.3	3.05 ± 0.15	1.27 ± 0.5	1.27 ± 0.15	5.65	6.35	5.99	1.06	0.033
TC3.1/1.8/2	3.05 ± 0.15	1.78 ± 0.15	2.03 ± 0.15	5.75	9.10	7.23	1.26	0.05
TC3.4/1.8/1.3	3.43 ± 0.18	1.78 ± 0.18	1.27 ± 0.18	7.93	7.3	7.62	0.96	0.035
TC3.4/1.8/2	3.35 ± 0.13	1.78 ± 0.13	2.03 ± 0.13	4.90	11.6	7.54	1.54	0.059
TC3.5/1.6/1.3	3.5 ± 0.15	1.6 ± 0.15	1.27 ± 0.15	6.32	8.3	7.25	1.15	0.043
TC3.5/1.8/1.8	3.46 ± 0.15	1.78 ± 0.1	1.78 ± 0.1	5.31	11.0	7.65	1.44	0.06
TC3.9/1.8/1.8	3.94 ± 0.2	1.78 ± 0.15	1.78 ± 0.15	4.44	14.8	8.1	1.83	0.086
TC3.9/1.8/2.5	3.94 ± 0.15	1.78 ± 0.15	2.54 ± 0.15	3.11	21.1	8.1	2.6	0.12
TC3.9/2.2/1.3	3.94 ± 0.17	2.24 ± 0.18	1.27 ± 0.18	9.20	9.2	9.2	1.00	0.045
TC4/2/2	4.0 ± 0.15	2.0 ± 0.1	2.0 ± 0.1	4.54	16.7	8.71	1.92	0.095
TC4/2.2/1.1	4.0 ± 0.15	2.2 ± 0.1	1.1 ± 0.1	9.55	8.82	9.18	0.961	0.04
TC4/2.2/1.3	4.0 ± 0.15	2.2 ± 0.1	1.27 ± 0.1	8.28	10.2	9.18	1.11	0.05
TC4/2.2/1.6	4.0 ± 0.15	2.2 ± 0.1	1.6 ± 0.1	6.56	12.9	9.2	1.40	0.06
TC4/2.2/1.8	4.0 ± 0.15	2.2 ± 0.1	1.78 ± 0.1	5.9	14.3	9.18	1.56	0.07
TC5.8/3.1/1.5	5.84 ± 0.18	3.05 ± 0.18	1.52 ± 0.18	6.52	26.1	13.0	2.00	0.13
TC5.8/3.1/3.2	5.84 ± 0.15	3.05 ± 0.15	3.17 ± 0.15	3.04	55.8	13.0	4.28	0.31
TC5.9/3.1/3	5.85 ± 0.15	3.05 ± 0.15	3 ± 0.15	3.2	53	13.0	4.05	0.14
TC6/4/2	6.0 ± 0.15	4.0 ± 0.15	2.0 ± 0.1	7.75	30.2	15.3	1.97	0.15
TC6.3/3.8/2.5	6.3 ± 0.15	3.8 ± 0.15	2.5 ± 0.15	4.97	46.5	15.2	3.06	0.23
TC7.6/3.2/4.8	7.6 ± 0.25	3.18 ± 0.2	4.78 ± 0.2	1.51	148	15.0	9.92	0.7
TN9/6/3	9.5 ± 0.3	5.4 ± 0.3	3.4 ± 0.25	5.17	102	22.9	4.44	0.5
TC9.5/4.8/3.2	9.5 ± 0.31	4.75 ± 0.18	3.2 ± 0.18	2.98	144	20.7	6.95	0.7
TN10/6/4	10.6 ± 0.3	5.2 ± 0.3	4.4 ± 0.3	3.07	188	24.1	7.8	0.95
TX13/7.1/4.8	12.95 ± 0.4	6.9 ± 0.35	5.03 ± 0.3	2.40	361	29.5	12.3	1.8
TN13/7.5/5	13.0 ± 0.35	6.8 ± 0.35	5.4 ± 0.3	2.46	368	30.1	12.2	1.8
TX13/7.9/6.4	12.95 ± 0.4	7.67 ± 0.4	6.6 ± 0.4	2.21	442	31.2	14.1	2.2
TN14/9/5	14.6 ± 0.4	8.2 ± 0.35	5.5 ± 0.3	2.84	430	35	12.3	2.1
TN14/9/9	14.8 ± 0.4	8.0 ± 0.4	9.5 ± 0.4	1.58	774	35	22.1	3.8
TX16/9.1/4.7	16.13 ± 0.5	8.82 ± 0.4	4.95 ± 0.3	2.53	548	37.2	14.7	2.7
TN16/9.6/6.3	16.7 ± 0.5	8.7 ± 0.4	6.8 ± 0.4	1.95	760	38.5	19.7	3.8
TN19/11/10	19.7 ± 0.6	9.7 ± 0.4	10.5 ± 0.5	1.08	1795	44.0	40.8	9.2
TN19/11/15	19.9 ± 0.6	9.5 ± 0.4	15.5 ± 0.55	0.718	2692	44.0	61.2	13.8
TN20/10/7	20.6 ± 0.6	9.2 ± 0.4	7.5 ± 0.45	1.30	1465	43.6	33.6	7.7
TX22/14/6.4	22.35 ± 0.7	13.47 ± 0.6	6.6 ± 0.4	2.20	1340	54.2	24.8	6.5
TX22/14/13	22.35 ± 0.7	13.47 ± 0.6	12.95 ± 0.5	1.07	2750	54.2	50.9	14
TN23/14/7	23.7 ± 0.7	13.1 ± 0.6	7.5 ± 0.45	1.81	1722	55.8	30.9	8.4
TN25/15/10	25.8 ± 0.7	14.0 ± 0.6	10.6 ± 0.5	1.23	2944	60.2	48.9	15
TN26/15/10	26.8 ± 0.7	13.5 ± 0.6	10.6 ± 0.5	1.08	3360	60.1	55.9	17

T = Toroid (Ring Core), TN = Toroid Nylon coated, TL = Toroid Laquered, TX = Toroid epoXy coated, TC = Toroid parylene C coated (no colour code)

Ferrite Toroids

Core type	dimensions (mm)			effective core parameters				
	outside diameter D	inside diameter d	height H	core factor $\Sigma l/A(mm^{-1})$	eff. volume V_e (mm^3)	eff. length l_e (mm)	eff. area A_e (mm^2)	mass (g)
TN26/15/20	26.9 ± 0.7	13.2 ± 0.6	20.5 ± 0.6	0.538	6720	60.1	112	34
TN29/19/7.5	29.7 ± 0.7	18.2 ± 0.6	8.1 ± 0.5	1.98	2700	73.2	36.9	13.5
TX29/19/7.6	29.25 ± 0.7	18.75 ± 0.6	7.85 ± 0.5	2.06	2600	73.2	35.5	13
TN29/19/15	29.9 ± 0.7	18.1 ± 0.6	15.5 ± 0.6	0.98	5410	73.2	73.9	28
TN32/19/13	32.2 ± 0.8	18.1 ± 0.6	13 ± 0.5	0.99	5820	76	76.5	29
TE36/23/10	39.4 max	20.45 min	12.65 max	1.40	5730	89.6	63.9	30
TN36/23/10	36.8 ± 0.9	22.1 ± 0.7	10.7 ± 0.6	1.40	5730	89.6	63.9	28
TX36/23/10	36.25 ± 0.9	22.75 ± 0.7	10.42 ± 0.5	1.46	5540	89.7	61.8	27
TE36/23/15	39.4 max	20.45 min	12.65 max	0.935	8600	89.6	95.9	45
TN36/23/15	36.9 ± 0.9	21.9 ± 0.7	15.7 ± 0.6	0.935	8600	89.6	95.9	42
TX36/23/15	36.25 ± 0.9	22.75 ± 0.7	15.5 ± 0.6	0.96	8440	89.7	94.1	40
TX39/20/13	39.15 ± 0.9	19.3 ± 0.7	12.95 ± 0.5	0.76	9513	84.9	112	45
TL42/26/13	42.1 ± 1.1	25.9 ± 0.8	12.75 ± 0.5	1.076	9860	103	95.8	53
TL42/26/18	42.1 ± 1.1	25.9 ± 0.8	17.8 ± 0.7	0.769	13810	103	134	55
T50/30/19	50 ± 1	30 ± 0.7	19 ± 0.5	0.65	22378	120.4	186	100
TX51/32/19	51.05 ± 1.5	31.5 ± 1	19.3 ± 0.6	0.73	21500	125	172	100
TL55/32/18	55.8 ± 1.7	32.1 ± 1	18.3 ± 0.9	0.651	26580	131.5	202	134
TL58/41/18	58.7 ± 1.1	40.5 ± 0.9	17.9 ± 0.7	1.0	23200	152.4	152.4	110
TL63/38/25	63.4 ± 2.1	37.7 ± 1.3	25.3 ± 1	0.497	46500	152	306	220
TX74/39/13	73.9 ± 1.52	38.61 ± 1.32	12.95 ± 0.5	0.80	34300	165	208	170
TL87/54/14	87.4 ± 1.35	54 ± 1	13.8 ± 0.45	0.987	46400	214	217	220
T87/56/13	87 ± 1.25	56 ± 0.9	12.7 ± 0.25	1.123	42133	217.5	194	200
TL102/66/15	102.4 ± 2.1	65.5 ± 1.4	15.3 ± 0.7	0.956	68200	255	267	325
TL107/65/18	107.4 ± 2	64.7 ± 1.4	18.3 ± 0.55	0.700	96000	259	370	456
T140/106/25	140 ± 3	106 ± 2	25 ± 1	0.903	161100	382	422	800



Isolation voltage

Toroids with polyamide, epoxy and laquer coating (TN, TX and TL)

diameter: < 12 : 1000 V_{DC}
12-20 : 1500 V_{DC}
> 20 : 2000 V_{DC}

Toroids with parylene coating (TC): 1000 V_{DC}

Toroids with plastic caps (TE): 3000 V_{DC}

T = Toroid (Ring Core), TN = Toroid Nylon coated, TL = Toroid Laquered, TX = Toroid epoXy coated, TC = Toroid parylene C coated, TE = Toroid Encapsulated in plastic caps

Ferrite Toroids

Core type / Material / Colour Code	3B7	3C11	3C81	3C90	3D3	3E5	3E6	3E7	3E25
		white				yellow /white	purple /white		orange
TC2.5/1.3/0.8									
TC2.5/1.3/1.3							1835 des		970 des
TC2.5/1.3/2.5									
TC2.5/1.5/0.8							765 des		
TC2.5/1.5/1-S						920 des	1020 des		
TC3.1/1.3/1.3									1225 des
TC3.1/1.8/2									
TC3.4/1.8/1.3	375 sup				110 sup		1580 des		
TC3.4/1.8/2									1420 des
TC3.5/1.6/1.3		862							
TC3.5/1.8/1.8									
TC3.9/1.8/1.8									
TC3.9/1.8/2.5									
TC3.9/2.2/1.3	325 sup				97 sup				
TC4/2/2		1190							
TC4/2.2/1.1						1120	1315 des		725
TC4/2.2/1.3									720
TC4/2.2/1.6						1630	1915 des		1050
TC4/2.2/1.8							2130 des		
TC5.8/3.1/1.5	450 sup								
TC5.8/3.1/3.2	940 sup						4130 des		
TC6/4/2						1380	1620 des		890
TC6.3/3.8/2.5						2150	2530 des	3600 des	1390
TC7.6/3.2/4.8							8360 des		
TN9/6/3				560		2070 2)	2435 1) des		1340
TC9.5/4.8/3.2	1000 sup		1200		330 sup		4390 des	5323 des	
TN10/6/4		1750		940 des		3470 2)	4085 2) des		2250
TX13/7.1/4.8			1475	1260 des	415 sup		5400 des		
TN13/7.5/5		2200		1170 des		4340 2)	5095 2) des		2810
TX13/7.9/6.4			1620	1380 des			5900 des		3000
TN14/9/5		1900		1015 des		3760 2)	4415 2) des		2430
TN14/9/9		3400		1825 des		6760 2)	7955 2) des		4370

1200 — nominal A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, f ≤ 10 kHz, T = 25°C

1) coated with parylene C (no colour code)
2) lacquered with polyurethane

A_L tolerance: ± 20% ± 25% ± 30% + 40% − 30%
+ 25% − 20% + 30% − 40% + 20% − 40%

T = Toroid (Ring Core), TN = Toroid Nylon coated, TL = Toroid Laquered, TX = Toroid epoXy coated, TC = Toroid parylene C coated (no colour code)

Core type / Material	3E27	3E28	3F3	3F4	3R1	3S4	4A11	4B1	4C65
Colour Code	*green*		*blue*	*beige*	*black*				
TC2.5/1.3/0.8							94 **des**		
TC2.5/1.3/1.3						300 **des**	150 **des**		
TC2.5/1.3/2.5		1400 **des**							
TC2.5/1.5/0.8									
TC2.5/1.5/1-S							71 **des**		
TC3.1/1.3/1.3							190 **des**		
TC3.1/1.8/2		1100 **des**							
TC3.4/1.8/1.3	660								
TC3.4/1.8/2									
TC3.5/1.6/1.3									
TC3.5/1.8/1.8		950 **des**							
TC3.9/1.8/1.8		1400 **des**							
TC3.9/1.8/2.5		2020 **des**							
TC3.9/2.2/1.3	575								
TC4/2/2		1110 **des**							
TC4/2.2/1.1			260				92		16
TC4/2.2/1.3							122		
TC4/2.2/1.6			380			325 **des**	134		24
TC4/2.2/1.8									
TC5.8/3.1/1.5	890							50 **des**	25
TC5.8/3.1/3.2		1650 **des**							
TC6/4/2			325			275 **des**	114		20
TC6.3/3.8/2.5			500				177		
TC7.6/3.2/4.8		3800 **des**							
TN9/6/3			440		■		170		30
TC9.5/4.8/3.2	2135								
TN10/6/4			740				286		52
TX13/7.1/4.8	2750		990						
TN13/7.5/5			900	460 **des**	■		360		64
TX13/7.9/6.4	3000		1100						
TN14/9/5			790		■		310		55
TN14/9/9			1430				560		

1200 — nominal A_L value (nH) measured at $\hat{B} \lesssim 0.1$ mT, f ≤ 10 kHz, T = 25°C

[1] coated with parylene C (no colour code)

[2] lacquered with polyurethane

■ = available (no A_L spec.)

A_L tolerance: ± 20% | ± 25% | ± 30% | + 40% − 30% | + 25% − 20% | + 30% − 40% | + 20% − 40%

T = Toroid (Ring Core), TN = Toroid Nylon coated, TL = Toroid Laquered, TX = Toroid epoXy coated, TC = Toroid parylene C coated (no colour code)

Ferrite Toroids

Core type \ Material Colour Code	3B7	3C11 white	3C81	3C90	3D3	3E5 yellow/white	3E6 purple/white	3E7	3E25 orange
TX16/9.1/4.7			1400	1215 des			5200 des		
TN16/9.6/6.3		2700		1480 des		5470 2)	6430 2) des		3540
TN19/11/10		5000		2680 des					6420
TN19/11/15		7500		4020 des					9630
TN20/10/7		4150		2230 des		8250 2)	9685 2) des		5340
TX22/14/6.4			1650	1400 des			6000 des		
TX22/14/13							12080 des		
TN23/14/7		3000		1600 des					3820
TN25/15/10		4400		2350 des		8680 2)	10200 2) des		5620
TN26/15/10		5000		2645 des		10000 2)			6420
TN26/15/20		10000		5400 des					12800
TN29/19/7.5		2700		1460			6340 2) des		3550
TX29/19/7.6			1740						
TN29/19/15							12850 2) des		7000
TN32/19/13		5450		2910 des		10700 2)			6950
TE36/23/10		3900		2060 des			9090 des		
TN36/23/10		3900		2060 des					
TE36/23/15		5800	3670	3090 des		12100	13600 des		7390
TN36/23/15		5800		3090 des		11400 2)	13400 2) des		7390
TX36/23/15			3670				13600 des		
TX39/20/13			4700	3800 des					
TL42/26/13		5000		2690 des					6425
TL42/26/18						12900			
T50/30/19							19400 des		
TX51/32/19			4800	3980 des			17300 des		8890
TL55/32/18									10620
TL58/41/18		5400		2890 des					6900
TL63/38/25									13900
TX74/39/13			4350	3620 des			15776 2) des		8060
TL87/54/14		5470		2930 des					
T87/56/13							11190 des		
TL102/66/15		5300							7900 des
TL107/65/18									9900 des
T107/65/25									
T140/106/25									7700 des

1200 — nominal A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

A_L tolerance: ± 20% | ± 25% | ± 30% | + 40% − 30% | + 25% − 20% | + 30% − 40% | + 20% − 40%

1) coated with parylene C (no colour code)

2) lacquered with polyurethane

T = Toroid (Ring Core), TN = Toroid Nylon coated, TL = Toroid Laquered, TX = Toroid epoXy coated, TC = Toroid parylene C coated, TE = Toroid Encapsulated in plastic caps

Material Colour Code Core type	3E27	3E28	3F3	3F4	3R1	3S4	4A11	4B1	4C65
	green		blue	beige	black				
TX16/9.1/4.7	2600								
TN16/9.6/6.3			1160				450		
TN19/11/10									
TN19/11/15									
TN20/10/7									121
TX22/14/6.4	3055								75[2]
TX22/14/13	6110		2200						
TN23/14/7			1250		■		485		87
TN25/15/10			1840						
TN26/15/10									
TN26/15/20									
TN29/19/7.5									
TX29/19/7.6	3225								
TN29/19/15									
TN32/19/13			2270						
TE36/23/10	4545								112
TN36/23/10									112
TE36/23/15	6800		2420		■		940		168
TN36/23/15			2420		■	2285 des	940		170
TX36/23/15	6800								
TX39/20/13	8720								
TL42/26/13							820		
TL42/26/18									
T50/30/19									
TX51/32/19	8890		3200						
TL55/32/18	10620						1350		
TL58/41/18									
TL63/38/25			4550						
TX74/39/13			2900						
TL87/54/14									
T87/56/13									
TL102/66/15									165 des
TL107/65/18			3230	1354 des					
T107/65/25			4485 des	1870 des					
T140/106/25									

1200 — nominal A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, f ≤ 10 kHz, T = 25°C

A_L tolerance: ± 20% | ± 25% | ± 30% | + 40% − 30% | + 25% − 20% | + 30% − 40% | + 20% − 40%

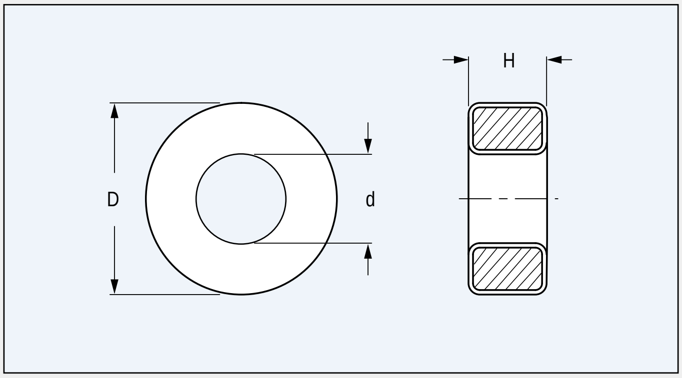
[1] coated with parylene C (no colour code)

[2] lacquered with polyurethane

■ = available (no A_L spec.)

T = Toroid (Ring Core), TN = Toroid Nylon coated, TL = Toroid Laquered, TX = Toroid epoXy coated, TC = Toroid parylene C coated, TE = Toroid Encapsulated in plastic caps

Iron Powder Toroids

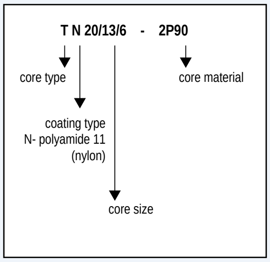


Due to the high saturation flux density of iron powder (950...1600 mT) these ring cores are very suitable for output chokes carrying high DC currents. Another application is found in lamp dimmers as ballast choke.

The cores are made of electrolytic iron powder, mixed with a small amount of resin for insulation. They are coated with polyamide 11 (thickness 0.1 - 0.3 mm). The isolation voltage between core and winding is up to 1500 V.

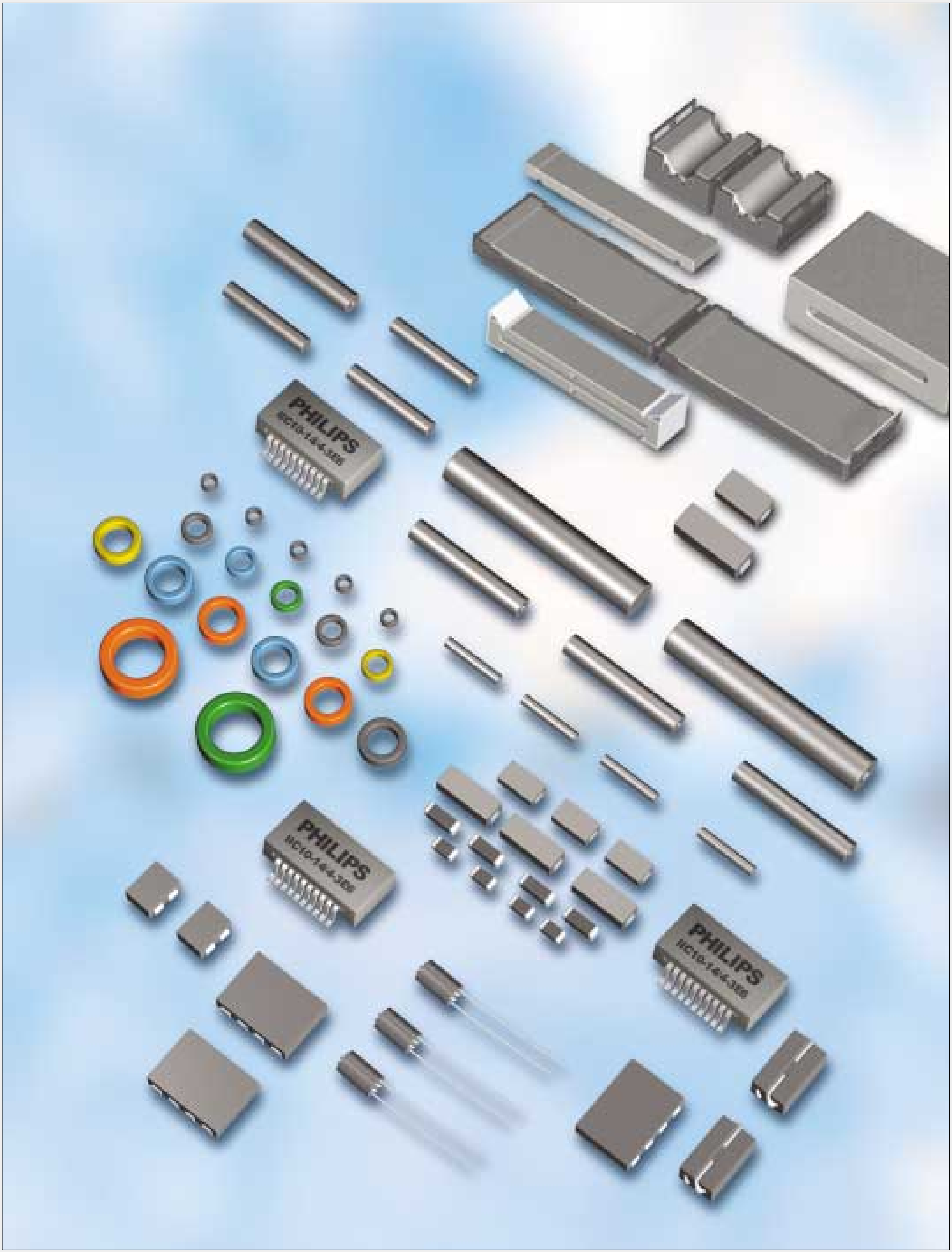
Summary:

- high saturation flux density
- suitable for output chokes
- for EMI-suppression with high DC bias



Core type		TN7.5/4.1/3 sup	TN12/8/4.4 sup	TN17/9.8/4.4 sup	TN20/13/6 sup	TN24/15/7.5 sup	TN27/15/11 sup	TN33/20/11 sup
effective core parameters	core factor Σ l/A(mm^{-1})	3.58	3.30	2.55	2.44	1.76	1.02	1.23
	eff. volume V_e (mm^3)	83	290	635	1020	1895	3720	5200
	eff. length l_e (mm)	17.3	30.9	40.2	49.9	57.8	61.6	80.0
	eff. area A_e (mm^2)	4.81	9.37	15.8	20.4	32.8	60.4	65.0
	mass (g)	≈ 0.6	≈ 2	≈ 5	≈ 7.5	≈ 13	≈ 25	≈ 35
dimensions (mm)	D	8.1 ± 0.3	13.0 ± 0.3	17.8 ± 0.3	20.5 ± 0.5	24.3 ± 0.5	27.5 ± 0.5	33.6 ± 0.5
	d	3.5 ± 0.3	7.4 ± 0.3	8.9 ± 0.3	12.3 ± 0.5	13.8 ± 0.5	14.0 ± 0.5	19.2 ± 0.5
	H	3.3 ± 0.5	4.8 ± 0.5	4.8 ± 0.5	6.5 ± 0.5	8.1 ± 0.5	11.4 ± 0.5	11.5 ± 0.5
A_L (nH) ± 10%	2P40 *dark yellow*	14	15	20	21	29	49	41
	2P50 *dark blue*	18	19	25	26	36	62	51
	2P65 *dark red*	23	25	32	34	47	80	67
	2P80 *dark green*	28	31	40	41	57	94	82
	2P90 *dark brown*	30[1]	33[1]	42[1]	44[1]	61[1]	105[1]	87[1]

[1] A_L tolerance: + 10/ −15%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Materials and applications for EMI-suppression

property	conditions				EMI-suppression										
symbol	**f (kHz)**	**$\hat{B}$ or H**	**T (°C)**	**unit**	**3B1**	**3C11**	**3E5**	**3E6**	**3E25**	**3E26**	**3E27**	**4A11**	**4A15**	**4B1**	**4C65**
μ_i (±20%)	≤ 10	≤ 0.1mT	25		900	4300	10 000	12 000	6000	7000	6000	700	1200	250	125
tan δ/μ_i	30	≤ 0.1mT	25	10^{-6}			≤ 25	≤ 30							
	100					≤ 20	≤ 75		≤ 25	≤ 20	≤ 15				
	300					≤ 200			≤ 200						
	450				≤ 50										
	1000											≤ 100	≤ 300	≤ 90	
	3000											≤ 1000	≤ 1500	≤ 300	≤ 80
	10 000														≤ 130
B	10	250A/m	100	mT	≈ 200	≈ 180	≈ 210	≈ 210	≈ 180	≈ 290	≈ 280	≈ 180	≈ 180	≈ 260	≈ 250
		3000A/m	25		≈ 370	≈ 340	≈ 380	≈ 380	≈ 380	≈ 450	≈ 400	≈ 320	≈ 340	≈ 350	≈ 380
H_c	10		25	A/m	≈ 25	≈ 10	≈ 5	≈ 4	≈ 5	≈ 5	≈ 5	≈ 35	≈ 25	≈ 150	≈ 250
B_r				mT	≈ 190	≈ 120	≈ 80	≈ 100	≈ 100	≈ 120	≈ 120	≈ 110	≈ 150	≈ 240	≈ 280
T_c				°C	≥ 150	≥ 125	≥ 125	≥ 130	≥ 125	≥ 155	≥ 150	≥ 125	≥ 125	≥ 250	≥ 350
ρ	DC		25	Ω m	≈ 0.2	≈ 1	≈ 0.5	≈ 0.1	≈ 0.5	≈ 0.5	≈ 0.5	≈ 10^5	≈ 10^5	≈ 10^5	≈ 10^5
density				kg/m^3	≈ 4800	≈ 4900	≈ 4900	≈ 4900	≈ 4900	≈ 4900	≈ 4800	≈ 5100	≈ 5100	≈ 4600	≈ 4500
ferrite type					MnZn	MnZn	MnZn	MnZn	MnZn	MnZn	MnZn	NiZn	NiZn	NiZn	NiZn

Properties measured on sintered, non ground ring cores of dimensions ∅25 x ∅15 x 10 mm which are not subjected to external stresses.

property	conditions				EMI-suppression					
symbol	**f (MHz)**	**$\hat{B}$ or H**	**T (°C)**	**unit**	**3S1**	**3S3**	**3S4**	**4S2**	**4S4**	**4S7**
μ_i	≤ 0.01	≤ 0.1mT	25		≈ 4000	≈ 350	≈ 1700	≈ 700	≈ 250	≈ 200
|Z| 1)	1	≤ 0.1mT	25	Ω	≥ 30					
	3						≥ 25			
	10				≥ 60					
	30					≥ 25	≥ 60	≥ 50		
	100					≥ 60	≥ 80			
	300					≥ 100	≥ 90	≥ 90		
B	≤ 0.01	250A/m	100	mT	≈ 180	≈ 250	≈ 140	≈ 180	≈ 130	≈ 120
		3000A/m	25		≈ 400	≈ 350	≈ 350	≈ 350	≈ 300	≈ 300
H_c	0.01		25	A/m	≈ 10	≈ 60	≈ 20	≈ 30	≈ 160	≈ 180
B_r				mT	≈ 120	≈ 230	≈ 170	≈ 120	≈ 130	≈ 170
T_c				°C	≥ 125	≥ 225	≥ 110	≥ 125	≥ 130	≥ 140
ρ	DC		25	Ω m	≈ 1	≈ 10^4	≈ 10^3	≈ 10^5	≈ 10^5	≈ 10^5
density				kg/m^3	≈ 4900	≈ 4800	≈ 4800	≈ 5000	≈ 5000	≈ 5000
ferrite type					MnZn	MnZn	MnZn	NiZn	NiZn	NiZn

Properties measured on sintered, non ground ring cores of dimensions ∅25 x ∅15 x 10 mm which are not subjected to external stresses.

1) Measured on a bead ∅5 x ∅2 x 10 mm

Products generally comply with the material specification. However, deviations may occur due to shape, size and grinding operations etc. Specified product properties are given in the data sheets or product drawings.

EMI-suppression on PCB

Suppression beads and wideband chokes show high impedance levels over a wide frequency range caused by ferrimagnetic resonant losses in the ferrite material. This impedance is used to absorb interference signals over a wide frequency range.
Our S-materials were developed for maximum impedance for frequencies up to 1GHz.
In multilayer suppressors several layers of ferrite are used to create more winding turns, resulting in higher impedance levels

frequency range	material
< 30 MHz	3S1
30 MHz - 1000 MHz	3S3, 3S4, 4S2

EMI-suppression in power lines

Often a DC supply or AC current is passing through the inductor to allow normal operation of the connected equipment. This current induces a high magnetic field strength in the ferrite core, which can lead to saturation. Impedance levels then decrease along with permeability, especially at low frequencies. The influence of a bias current can be limited by choosing a ferrite core with a lower permeability, an airgap or with an open magnetic circuit, like rods, tubes or bobbin cores.
When the interference is common-mode, current compensation can be applied to avoid negative effects.
In common-mode chokes 2 similar windings on a ferrite core carry opposing currents. The magnetic fluxes resulting from bias currents or large differential signals cancel out. In this way saturation as well as damping of the useful signals is avoided.

frequency range	material
< 30 MHz	2P, 3B1, 3C90, 3S1
30 MHz - 1000 MHz	3S3, 3S4, 4B1, 4S2, 4A15

EMI-suppression in mains filters

In mains input filters, effective use is made of the permeability of the ferrite to form an LC filter. To save volume, the permeability of the ferrite core must be as high as possible in the frequency range of the interfering signal. Ring cores are therefore very popular for this application (no airgap) but also U-cores have been used. It is important to take into account any magnetic bias field, caused by DC or low frequency AC-currents. To avoid saturation of the ferrite, the use of current- compensation is common practice.
Two windings with an equal number of turns are applied to the core. The winding directions are such that the incoming current through one winding and the equally large outgoing current through the other generate opposite fluxes of equal magnitude. Current-compensation would be almost ideal with both windings along the total circumference, one over the other. But in practical cases each winding is placed on one half of the core because of insulation requirements.
However, a current-compensated choke is only active against common-mode interference. If differential-mode suppression is required, cores with an airgap or made of a low permeability material like iron powder should be applied.

frequency range	material
< 500 kHz	3C11, 3E25, 3E26, 3E27, 3E5, 3E6
500 kHz - 3 MHz	3C90,
3 MHz - 30 MHz	4A11, 4A15
> 30 MHz	4C65

EMI-suppression on signal wires and cables

When interference signals are conducted by cables of a considerable length these will act as an antenna and radiate RF power. Special cable shields are available to suppress the currents and to avoid problems with EMC limits. The product can be in one piece for mounting during manufacturing or split for retrofit solution. A split product uses special clamps to prevent a parasitic airgap with loss of impedance. Toroids can be effective as well, especially when more than a single turn is required to reach the minimum damping. Also here current-compensation is applied.
In the case of an I/O cable, such as coax or flat cable, the problem is not saturation by high currents.
The reason for the current-compensation is now that the actual signal is also of RF frequency and it would be suppressed together with the interference. The current-compensated inductor has the limitation that it is only active against common-mode interference.

frequency range	material
< 30 MHz	3C11, 3C90, 3E25, 3E26, 3E27, 3E5, 3E6, 3S1
30 MHz - 1000 MHz	3S4, 4B1, 4S2, 4A11, 4A15, 4C65

Materials and applications for EMI-suppression

Ferrites supporting the drive for Electromagnetic Compatibility

To help circuit designers meet EMC requirements, Ferroxcube supplies a broad range of ferrite products for interference-suppression applications. We offer smart solutions to comply with stringent EMC regulations. In the field of electromagnetic compatibility several trends attribute to a growing necessity of EMC engineering.

In signal processing :

- Change from analogue to digital
  (steep pulse edges, overshoot, ringing).
- Increase of clock frequencies.

In power conversion :

- Change from linear to switched-mode power supplies
  (high switching frequency, harmonics).
- Increase of switching frequencies.

These trends, directed to functional upgrading or reducing cost, inevitably also contribute to an increasing level of electromagnetic interference (EMI). Together with the increasing use of electronics this leads to a general EMC degradation. As a consequence, legislation is getting more strict in many countries.

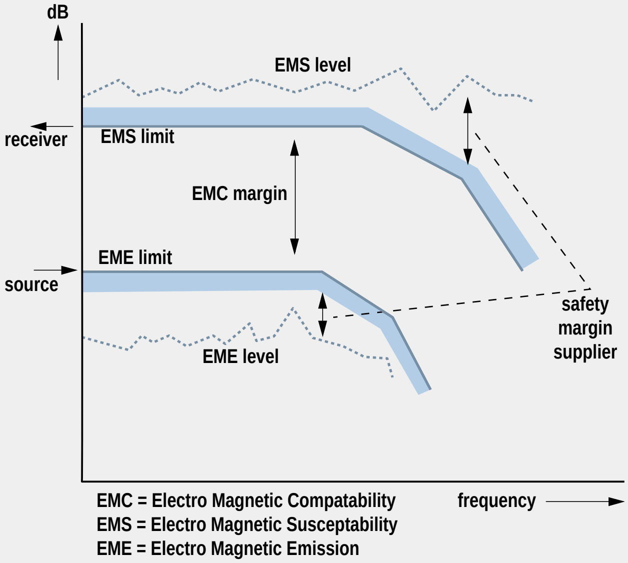
Most important regulations were issued by VDE in Germany, FCC in the United States and VCCI in Japan. Today there is a uniform legislation in the European Community along the lines of the EMC directive 89/336/EEC. It applies to all electric and electronic products, no matter how trivial they seem to be.
All equipment has to be tested to acquire the CE mark before being offered on the market. Since the European EMC regulations are the most advanced, they are used as a yardstick worldwide.

Regulations

Historically, all EMC regulations stated emission limits only. These define the maximum level of interference allowedas a function of frequency.
In case of conducted interference it applies to the voltage on all inputs and outputs of the equipment, in case of radiated interference it applies to the field strength at a certain distance. Often two levels are stated :

- Class A for commercial and industrial areas.
- Class B for domestic and residential areas.

Class B is always stricter than class A. Recently, also immunity is becoming subject of regulation. Taking into account the severity of the EMC problem, equipment must also be able to operate without functional degradation in a minimum EMI ambient.
The difference between the actual level of emissions or susceptibility and the EMC limits is the required attenuation by filtering or shielding.



Principles of Electromagnetic Compatibility

Sources and propagation

The source determines whether the interference is a transient or random variation in time or a periodical signal . The frequency spectrum will be continuous for a random interference source. Examples are commutation motors, broadcast transmitters etc. Switched-mode power supplies generate periodic signals, causing emissions with a line spectrum.
In practice both types of sources can be broadband.

Interferences can propagate as an electromagnetic wave in free space, but also as a current via conductive paths such as the mains network, to which the majority of electrical equipment is connected.
Below 30 MHz this is the main propagation mode. Effective suppression is achieved by placing a high impedance in series (inductor), a low impedance in parallel (capacitor) or a combination of both (filter).

Propagation via the mains can take place in two different modes: common-mode and differential-mode or a mix of both.

Common-mode :
Phase and null interference voltages are equal. This is likely to occur if phase and null are close together and interference is coupling in from an external field (radiation or cross-talk).

Differential-mode :
Phase and null interference voltages have opposite phase angle but equal magnitude. This is likely to occur in case of switching equipment connected to the mains.

Design considerations

When starting a design, many problems can be avoided by using good design practices. In order of priority these are :

- avoid generating interference by lowering clock rates and/or using smoother pulse shapes

- keep away from the interference source by separating power components and circuits from signal tracks

- impede its propagation by decreasing the length of conductors and component leads

- suppress with ferrites and/or capacitors

The following points should be considered while taking EMI-suppression measures:

- The insertion of ferrite components lowers equally well emission and susceptibility, the essence is blocking the propagation path. The ferrite part should always be located as close to the source as possible. All intermediate circuitry and cable length acts as antenna and produces radiated interference.

- The ferrite and the conductor should be close together. Beads, tubes and cable shields should fit close around the wire or cable. If this is not the case, stray flux is generated, which converts into mutual inductance if other circuits are close enough to be in the stray field.

- Especially for open core types like rods and bobbin cores, stray flux can be a problem. Bobbin cores are better than rods in this respect. Apart from keeping distance to other circuit parts, the positioning is important. For long thin rods a horizontal position is the best. The core axis is horizontal and the magnetic field almost parallel to the PCB. This results in low induced voltages in PCB tracks.

- For inductors with many turns, the winding method influence the parasitic coil capacitance. Too high capacitance values causes early frequency roll-off of the impedance. Methods to reduce parasitic capacitance are multi-chamber winding (separation of turns in groups), and 90 degree cross-winding (electrical decoupling of adjacent turns).

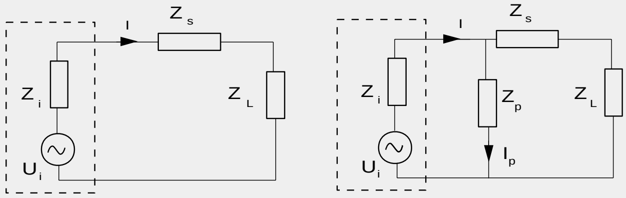
EMI-suppression with ferrites

At RF frequencies a ferrite inductor shows a high impedance which suppresses unwanted interference. The resulting voltage over the load impedance will be lower than without suppression component, the ratio of the two is the insertion loss.

The insertion loss is expressed as:

$$\begin{aligned} IL &= 20 \,.\, \log_{10}\ (E_0 / E)\ \ [\text{dB}] \\ &= 20 \,.\, \log_{10} \frac{|Zi+ZL+Zs|}{|Zi+ZL|}\ \ [\text{dB}] \end{aligned}$$

where E is the voltage on the load with inductor and E_0 without.



Basic suppression circuits

At low frequencies, a ferrite inductor behaves like a low-loss inductance. Interferences occur at elevated frequencies and there the picture changes. Losses start to increase and at a certain frequency, the ferrimagnetic resonant frequency, permeability drops rapidly and the impedance becomes almost completely resistive. For applications where inductance is required the operating frequency should stay well below this resonance. However, effective interference suppression is achieved up to much higher frequencies. The impedance peaks at the resonant frequency but the ferrite is effective in a wide frequency band around it.

The material choice depends on the critical interference frequencies. Ideally its ferrimagnetic resonant frequency and thus the maximum in the impedance curve should coincide with these frequencies. According to Snoek's law, the resonant frequency is inversely proportional to the initial permeability.
The higher the interference frequency, the lower the material permeability should be. The whole RF spectrum can be covered with a few materials if the right permeability steps are chosen.
Our range of S-materials (e.g. 3S3, 3S4, 4S2) are optimized to offer high impedance levels over a wide frequency range.
At the resonant frequency and above, the impedance is largely resistive, which is a favourable characteristic of ferrites.
A resistive impedance dissipates interfering signals rather than reflecting them back to the source. Small oscillations at high frequency could otherwise damage semiconductors or negatively affect circuit operation. Therefore it is better to absorb them.

Materials and applications for EMI-suppression

Sample boxes containing specially selected ranges of ferrite products are available from Philips to help equipment manufacturers develop optimum solutions for EMI-suppression.

Each sample box contains an assortment of suppression cores that aids circuit designers in the often trial-and-error process of finding the most suitable EMI-suppression component.

Surface Mount Beads and Chokes box

contains a range of beads, common mode chokes and wideband chokes for Surface Mount applications. These SMD components are suitable to prevent generated interference and to suppress incoming noise signals and parasitic oscillations. All products are delivered in tape-and-reel according to IEC and EIA standards ready for use on automatic mounting machines.

Ordering code: SAMPLEBOX9

Cable shielding sample box

offers a broad range of cable shielding products. This includes tubular cable shields for coaxial cables and rectangular cores for flat ribbon cables as well as split types for retro-fit solutions with the proper accessories. These products provide a high level of impedance over a wide frequency range and allow EMI-suppression techniques to be used on both internal and external cabling in electronic equipment.

Ordering code: SAMPLEBOX10

EMI-suppression Products box

contains leaded cores for automatic insertion in PCB's with different design configurations, plus beads and multihole cores in several materials, specially developed for interference applications, and ranging from small to large sizes to cover the different mechanical requirements for the particular design.

Ordering code: SAMPLEBOX11

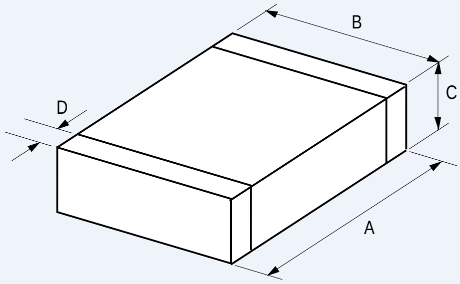
Multilayer Suppressors box

contains a selection of suppressors in 4 different sizes: 0603, 0805, 1206 and 1806.

Ordering code: SAMPLEBOX12

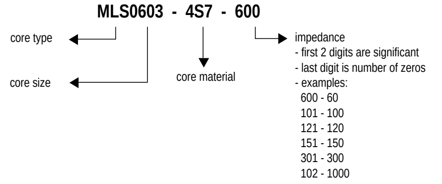
All sample boxes come with a specific brochure with all necessary information about product types, product description, location of the components and electrical performance and characteristics.

Multilayer Suppressors (MLS)



Size	A (mm)	B (mm)	C (mm)	D (mm)	Weight (mg)
0603	1.60 ± 0.15	0.80 ± 0.15	0.80 ± 0.15	0.36 ± 0.15	≈ 5
0805	2.00 ± 0.20	1.25 ± 0.20	0.90 ± 0.20	0.51 ± 0.25	≈ 11
1206	3.20 ± 0.20	1.60 ± 0.20	1.10 ± 0.20	0.51 ± 0.25	≈ 28
1806	4.50 ± 0.25	1.60 ± 0.25	1.60 ± 0.25	0.61 ± 0.25	≈ 55

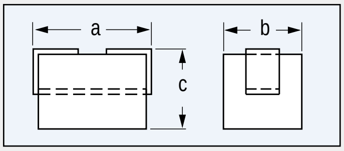
type number	size	Z@100MHz	R_{DC} max (Ω)	I max (mA)
MLS0603-4S7-600 des	0603	60	0.2	300
MLS0603-4S7-101 des	0603	100	0.3	250
MLS0603-4S7-121 des	0603	120	0.3	250
MLS0603-4S7-151 des	0603	150	0.3	250
MLS0603-4S7-301 des	0603	300	0.35	230
MLS0603-4S7-601 des	0603	600	0.45	210
MLS0603-4S7-102 des	0603	1000	0.6	190
MLS0805-4S4-300 des	0805	30	0.1	600
MLS0805-4S4-600 des	0805	60	0.1	600
MLS0805-4S7-121 des	0805	120	0.2	400
MLS0805-4S7-151 des	0805	150	0.3	200
MLS0805-4S7-301 des	0805	300	0.3	200
MLS0805-4S7-601 des	0805	600	0.3	240
MLS0805-4S7-102 des	0805	1000	0.4	200
MLS1206-4S4-300 des	1206	30	0.1	600
MLS1206-4S4-700 des	1206	70	0.1	600
MLS1206-4S4-900 des	1206	90	0.2	400
MLS1206-4S4-121 des	1206	120	0.2	300
MLS1206-4S4-601 des	1206	600	0.5	200
MLS1206-4S7-102 des	1206	1000	0.7	150
MLS1806-4S4-800 des	1806	80	0.1	600
MLS1806-4S4-151 des	1806	150	0.2	500



- ◆ R_{DC}: resistance of component for DC current
- ◆ Maximum rated current: measure of current capacity of the component. When the maximum rated current is applied, temperature rise shall not exceed 20°C
- ◆ Standard tolerance on impedance is ±25%
- ◆ Other tolerances or electrical specifications can be provided upon request
- ◆ Operating temperature: -55°C - +125°C

EMI-suppression products

SMD beads



BDS3/1.8/5.3-3S1

a	b	c
5.3 ± 0.35	3.05 ± 0.15	1.8 max

IZI_{typ} = 28 Ω (10 MHz)

BDS3/1.8/5.3-4S2

a	b	c
5.3 ± 0.35	3.05 ± 0.15	1.8 max

IZI_{typ} = 38 Ω (100 MHz)

BDS3/3/4.6-3S1

a	b	c
4.6 ± 0.3	3.05 ± 0.15	3 max

IZI_{typ} = 45 Ω (10 MHz)

BDS3/3/4.6-4S2

a	b	c
4.6 ± 0.3	3.05 ± 0.15	3 max

IZI_{typ} = 50 Ω (100 MHz)

BDS3/3/8.9-3S1

a	b	c
8.9 ± 0.35	3.05 ± 0.15	3 max

IZI_{typ} = 80 Ω (10 MHz)

BDS3/3/8.9-4S2

a	b	c
8.9 ± 0.35	3.05 ± 0.15	3 max

IZI_{typ} = 100 Ω (100 MHz)

BDS4.6/3/8.9-4S2

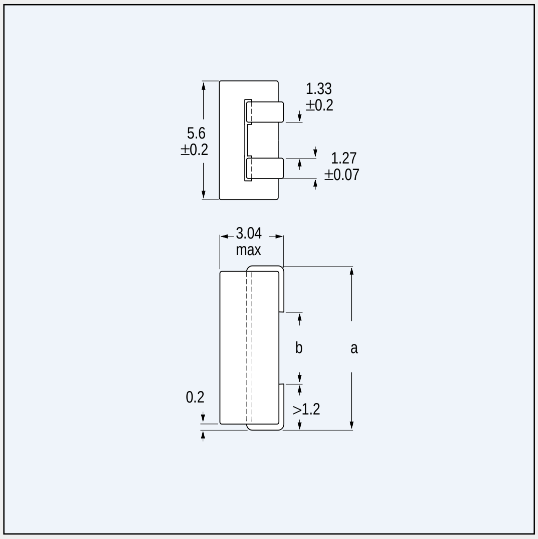
a	b	c
8.9 ± 0.35	4.6 ± 0.3	3 max

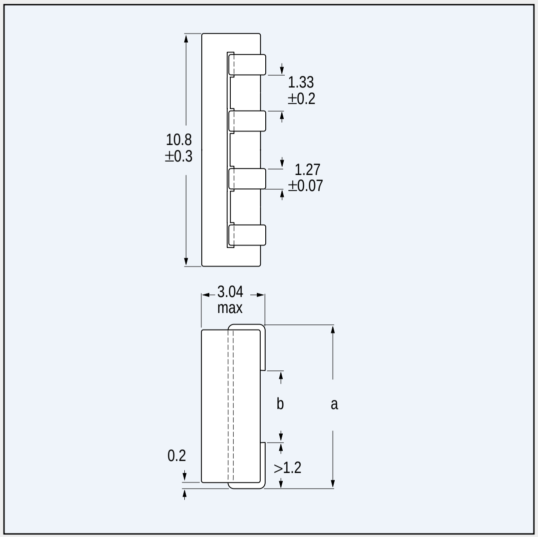
IZI_{typ} = 100 Ω (100 MHz)

Our range of SMD beads replace the well known beads on wire in applications where SMD components are required.
They consist of a rectangular ferrite body and a lenght of flat copper wire, which is inserted through the ferrite and bent around to form two solder pads. The wire is presoldered and complies with solderability test TA (method 1) in IEC 60068-2-58.

Taping method IEC 60286-3 and 481-1.

SMD common mode chokes





CMS2-5.6/3/4.8-4S2

a = 4.75 ± 0.3 mm / b > 1.1

IZI_{typ} = 35 Ω (100 MHz)

CMS2-5.6/3/8.9-4S2

a = 8.9 – 0.5 mm / b > 5

IZI_{typ} = 60 Ω (100 MHz)

CMS4-11/3/4.8-4S2

a = 4.75 ± 0.3 mm / b > 1.1

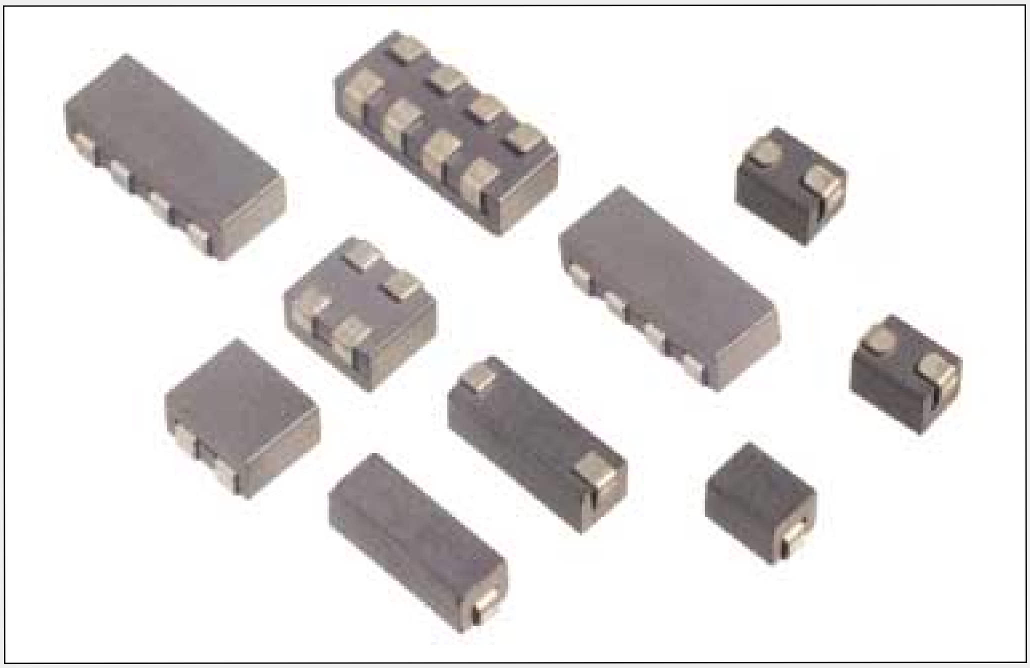
inner channel	IZI_{typ} = 23 Ω (100 MHz)
outer channel	IZI_{typ} = 30 Ω (100 MHz)

CMS4-11/3/8.9-4S2

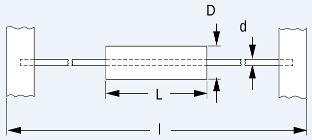
a = 8.9 – 0.5 mm / b > 5

inner channel	IZI_{typ} = 45 Ω (100 MHz)
outer channel	IZI_{typ} = 60 Ω (100 MHz)

In SMD Common mode chokes 2 or 4 conductors within a single soft-ferrite block are connected along their lengths by an air gap. Common-mode signals - interference signals passing in the same direction along the input and output channels of a device (an IC for instance) - reinforce the magnetic flux around both conductors, and are therefore attenuated. In contrast, the wanted signal passing along the input and output channels cancel the flux around the conductors and therefore passes unattenuated.



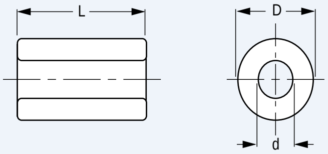
beads on wire



type number	dimensions				IZI$_{typ}$ (Ω) at 100 MHz
	D	L	l	d	
BDW3.5/3.5-4S2	3.5 ± 0.2	3.5 – 0.5	64.4	0.65	58
BDW3.5/4.7-4S2	3.5 ± 0.2	4.7 – 0.5	64.4	0.65	75
BDW3.5/5.3-4S2	3.5 ± 0.25	5.25 ± 0.25	64.4	0.64	82
BDW3.5/6-4S2	3.5 ± 0.2	6.0 ± 0.25	64.4	0.65	100
BDW3.5/6.7-4S2	3.5 ± 0.2	6.7 ± 0.25	64.4	0.65	110
BDW3.5/7.6-4S2	3.5 ± 0.2	7.6 ± 0.35	64.4	0.65	131
BDW3.5/8.9-4S2	3.5 ± 0.2	8.9 ± 0.35	64.4	0.65	146
BDW3.5/9.5-4S2	3.5 ± 0.25	9.5 ± 0.3	64.4	0.64	150
BDW3.5/11-4S2	3.5 ± 0.25	11.4 ± 0.4	64.4	0.64	180
BDW3.5/14-4S2	3.5 ± 0.25	13.8 ± 0.5	64.4	0.64	220

Beads-on-wire are suitable to suppress unwanted signals between parts of a PCB. They consist of a suppression bead fixed on a length of wire and taped on a bandolier. The bandolier fits most commonly used automatic mounting machines.
The tape complies to tape standards IEC 60286 part 1 and EIA-RS-96-D.

EMI suppression beads



type number	dimensions (mm)			IZI$_{typ}$ (Ω) at 10 MHz
	D	d	L	
BD3/0.7/4-3S1 sup	3 ± 0.1	0.7 + 0.1	4 ± 0.2	49
BD5.1/0.8/4-3S1 sup	5.1 – 0.3	0.75 + 0.1	4 ± 0.2	66
BD3/1/10-3S1 sup	3 ± 0.1	1+0.1/ – 0.05	10 ± 0.3	91
BD5.1/0.8/10-3S1	5.1 – 0.3	0.75 + 0.1	10 ± 0.3	
BD5.1/1.5/4-3S1	5.1 – 0.3	1.5 + 0.15	4 ± 0.2	40
BD5.1/1.5/10-3S1	5.1 – 0.3	1.5 + 0.15	10 ± 0.3	100
BD5.1/2/4-3S1	5.1 – 0.3	2+ 0.2	4 ± 0.2	30
BD5.1/2/10-3S1 sup	5.1 – 0.3	2 + 0.2	10 ± 0.3	76

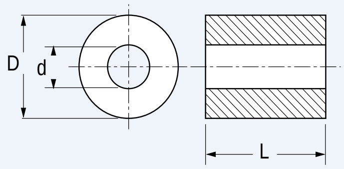
type number	dimensions (mm)			IZI$_{typ}$ (Ω) at 100 MHz
	D	d	L	
BD1.9/0.8/9.8-4S2 sup	1.9 + 0.2	0.8 + 0.2	9.75 – 0.2	69
BD 5.1/0.8/10-4S2 sup	5.1 – 0.3	0.75 + 0.1	10 ± 0.3	213
BD3/1/4-4S2	3 ± 0.1	1+0.1/– 0.05	4 ± 0.2	48
BD3.5/1.3/3.3-4S2	3.5 ± 0.2	1.3 ± 0.1	3.25 ± 0.25	40
BD3.5/1.3/6-4S2	3.5 ± 0.2	1.3 ± 0.1	6 ± 0.25	60
BD3.5/1.3/13-4S2	3.5 ± 0.2	1.3 ± 0.1	12.7 ± 0.35	125
BD5.1/1.5/4-4S2	5.1 – 0.3	1.5 + 0.15	4 ± 0.2	51
BD5.1/1.5/10-4S2	5.1 – 0.3	1.5 + 0.15	10 ± 0.3	130
BD5.1/2/4-4S2	5.1 - 0.3	2 + 0.2	4 ± 0.2	40
BD5.1/2/7.1-4S2	5.1 – 0.3	2 + 0.2	7.1 ± 0.2	78
BD8/2/4-4S2	8 ± 0.2	2 + 0.2	4 ± 0.2	61
BD5.1/2/10-4S2 sup	5.1 – 0.3	2 + 0.2	10 ± 0.3	100
BD6.4/3/25-4S2	6.35 ± 0.15	2.95 + 0.45	25.4 ± 0.75	200
BD7.7/2.3/7.6-4S2	7.65 – 0.25	2.25 + 0.25	7.55 ± 0.25	92
BD8/3/4-4S2	8 ± 0.2	3 + 0.2	4 ± 0.2	43
BD8/3/10-4S2	8 ± 0.2	3 + 0.2	10 ± 0.3	106

Color code: 4S2 has a flash of yellow paint

EMI-suppression products

cable shields

tubular cable shields



type number	dimensions			IZI$_{typ}$ (Ω) at 100 MHz
	D	d	L	
CST7.8/5.3/9.8-3S4 des	7.8 ± 0.2	5.3 + 0.3	9.8 ± 0.2	50
CST8.3/3.5/10-3S4 des	8.3 – 0.4	3.5 + 0.3	10 – 0.6	96
CST9.5/4.8/6.4-4S2 des	9.5 ± 0.25	4.75 ± 0.25	6.35 ± 0.35	50
CST9.5/4.8/10-4S2 des	9.5 ± 0.25	4.75 ± 0.15	10.4 ± 0.25	80
CST9.5/4.8/19-4S2 des	9.5 ± 0.25	4.75 ± 0.15	19.05 ± 0.7	145
CST9.5/5.1/15-3S4 des	9.5 ± 0.3	5.1 ± 0.15	14.5 ± 0.45	110
CST9.7/5/5.1-4S2 des	9.65 ± 0.25	5 ± 0.2	5.05 – 0.45	43
CST14/6.4/29-4S2 des	14.3 ± 0.45	6.35 ± 0.25	28.6 ± 0.75	250
CST14/7.3/29-4S2 des	14.3 ± 0.45	7.25 ± 0.15	28.6 ± 0.75	215
CST16/7.9/14-4S2 des	16.25 – 0.75	7.9 ± 0.25	14.3 ± 0.35	113
CST16/7.9/29-4S2 des	16.25 – 0.75	7.9 ± 0.25	28.6 ± 0.75	213
CST17/9.5/13-4S2 des	17.45 ± 0.4	9.5 ± 0.25	12.7 ± 0.5	88
CST17/9.5/29-3S4 des	17.45 ± 0.35	9.53 ± 0.25	28.55 ± 0.75	200
CST17/11/60-3S4 des	17.2 – 1.2	11 ± 0.5	60 – 2.5	320
CST19/10/29-4S2 des	19 – 0.65	10.15 ± 0.25	28.6 ± 0.75	196
CST19/11/12-3S4 des	19 ± 0.4	10.6 ± 0.3	11.5 ± 0.4	75
CST26/13/29-4S2 des	25.9 ± 0.75	12.8 ± 0.25	28.6 ± 0.8	225
CST29/19/7.5-4S2 des	29 ± 0.75	19 ± 0.5	7.5 ± 0.25	47

cable shields for round cable (split)

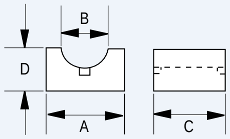


fig. 1

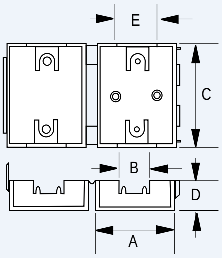


fig. 2

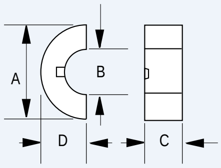


fig. 3

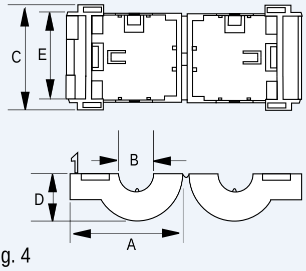


fig. 4

type number	fig.	dimensions					IZI$_{typ}$ (Ω) at 100 MHz
		A	B	C	D	E	
CSA15/7.5/29-4S2 des	1	15 ± 0.25	6.6 ± 0.3	28.6 ± 0.8	7.5 ± 0.15		275
nylon case	2	17.9	7.0	32.3	9.2	9.0	
CSA15/7.5/29-4S2-EN des	1+2	17.9	7.0	32.3	9.2	9.0	275
CSA19/9.4/29-4S2 des	1	18.65 ± 0.4	10.15 ± 0.3	28.6 ± 0.8	9.4 ± 0.15		225
nylon case	2	22.1	10.2	32.3	11.7	9.0	
CSA19/9.4/29-4S2-EN des	1+2	22.1	10.2	32.3	11.7	9.0	225
CSA26/13/29-4S2 des	1	25.9 ± 0.5	13.05 ± 0.3	28.6 ± 0.8	12.95 ± 0.25		250
nylon case	2	29	13.4	32.5	14.8	18.0	
CSA26/13/29-4S2-EN des	1+2	29	13.4	32.5	14.8	18.0	250
CSC16/7.9/14-4S2 des	3	15.9 ± 0.4	7.9 ± 0.3	14.3 ± 0.4	7.95 ± 0.2		113
nylon case	4	24.7	7.6	22.8	10.2	17.8	
CSC16/7.9/14-4S2-EN des	3+4	24.7	7.6	22.8	10.2	17.8	113

Cable shields are ideal to suppress high frequency noise on cables. For maximum efficiency the ferrite should be placed as close as possible to the conductors. Therefore we offer several sizes to fit most standard round and flat cables. The split cable shields can be mounted with metal clips or nylon cases without removing connectors.

cable shields

flat cable shields (split)

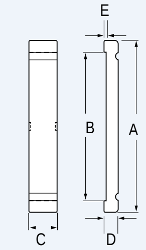


fig. 1

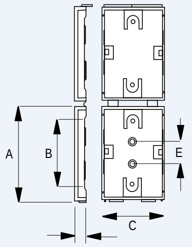


fig. 2

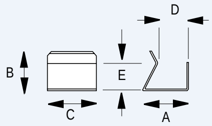


fig. 3

flat cable shields with matching nylon cases

type number	fig.	dimensions					IZI$_{typ}$ (Ω) at 100 MHz
		A	B	C	D	E	
CSU45/6.4/29-4S2 des	1	45.1 ±0.75	34.4 ± 0.7	28.6 ± 0.7	6.35 ±0.25	0.85 ±0.2	225
nylon case	2	49.5	34.3	32.3	8.1	20.0	
CSU45/6.4/29-4S2-EN des	1+2	49.5	34.3	32.3	8.1	20.0	225
CSU76/6.4/29-4S2 des	1	76.2 ± 1.5	65.3 ± 1.3	28.6 ± 0.8	6.35 ±0.25	0.85 ± 0.2	215
nylon case	2	80.8	65.5	32.2	8.1	50.8	
CSU76/6.4/29-4S2-EN des	1+2	80.8	65.5	32.2	8.1	50.8	215

type number	fig.	dimensions					IZI$_{typ}$ (Ω) at 100 MHz
		A	B	C	D	E	
CSU76/6.4/13-3S4 des	1	76.2 ± 1.5	65.3 ± 1.3	12.7 ± 0.4	6.35 ±0.25	0.85 ± 0.2	110
CSU76/6.4/15-3S4 des	1	76.2 ± 1.5	65.3 ± 1.3	15.0 ± 0.6	6.35 ±0.25	0.85 ± 0.2	160
CSU76/6.4/29-3S4*) des	1	76.2 ± 1.5	65.3 ± 1.3	28.6 ± 0.8	6.35 ± 0.25	0.85 ± 0.2	235
CLI-CSU6.4 des	3	16.1	11.0	12.7	11.4	8.0	

*) can be supplied with nylon case upon request

flat cable shields

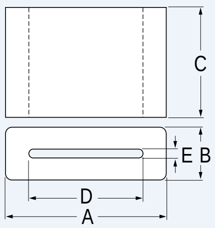


fig. 4

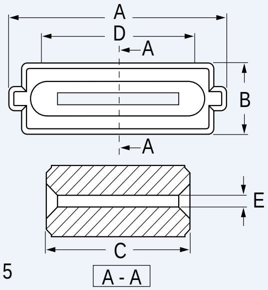
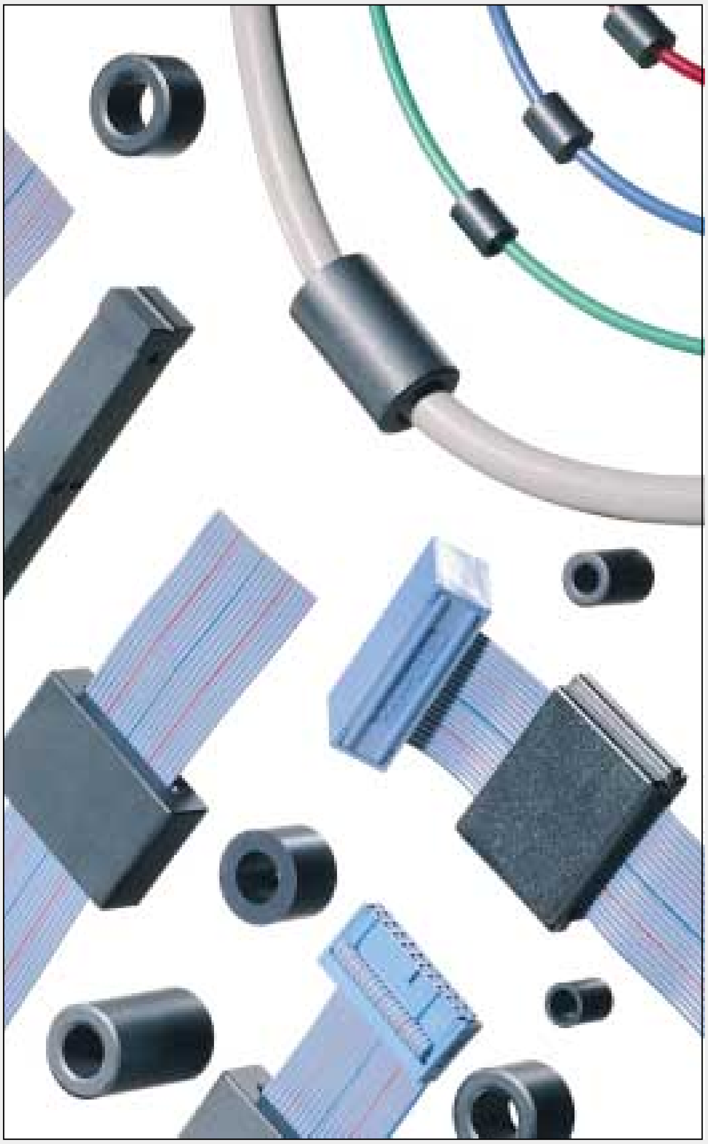


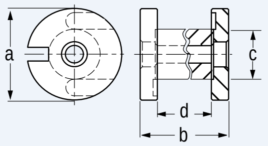
fig. 5

type number	fig.	dimensions					IZI$_{typ}$ (Ω) at 100 MHz
		A	B	C	D	E	
CSF38/12/25-3S4 des	4	38.1 ± 1.0	12.1 ± 0.35	25.4 ± 0.75	26.7 ± 0.75	1.9 ± 0.35	215
CSF38/12/15-3S4-S des	5	38.5 ± 0.6	12.1 ± 0.4	25.4 ± 0.8	26.8 ± 0.8	1.9 ± 0.4	196



EMI-suppression products

bobbin cores



BC13/4.8/16-3C90 1) sup

a	b	c	d
12.8 – 0.5	16	4.8 ± 0.2	10

A_L (nH) ≈ 50

BC22/12/14-3C90 sup

a	b	c	d
22 ± 1	14 ± 1	12 ± 0.3	8.6 ± 0.6

A_L (nH) ≈ 86

BC22/12/18-3C90 sup

a	b	c	d
22 ± 1	18 ± 1	12 ± 0.3	12.6 ± 0.6

A_L (nH) ≈ 85

BC22/12/19-3C90 sup

a	b	c	d
22 ± 1	18.5 ± 1	12 ± 0.3	10.5 + 0.6

A_L (nH) ≈ 91

BC22/12/38-3C90 sup

a	b	c	d
22 ± 1	38 ± 1.4	12 ± 0.3	30 + 1.4

A_L (nH) ≈ 74

BC23/12/14-3C90 2) sup

a	b	c	d
22.6 ± 1	14 ± 1	12 ± 0.3	8.6 ± 0.6

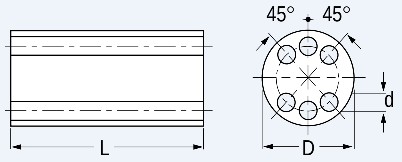
A_L (nH) ≈ 92

Bobbin cores are easy to wind with thick copper wire. Application is mainly as power inductor in output stages of converters or as EMI choke in lines with high DC currents. The magnetic circuit is open, resulting in high current capability, but also in quite some stray flux.

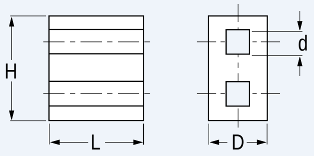
A_L measured with fully wound bobbin

1) no central hole, 2 wire slots
2) no wire slots

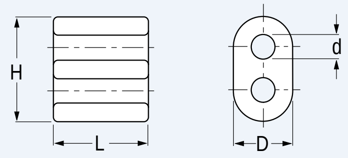
multi hole cores



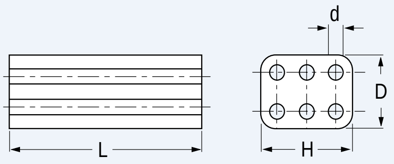
MHC6



MHR2



MHB2



MHR6

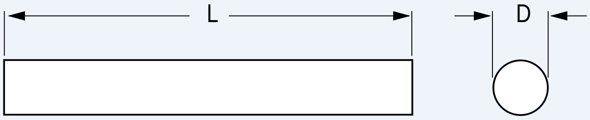
type number	dimensions (mm)			
	D	d	L	H
MHC6-6/10-3S4	6 ± 0.3	0.7 + 0.2	10 ± 0.5	-
MHC6-6/10-4B1	6 ± 0.3	0.7 + 0.2	10 ± 0.5	-
MHC6-6/5-4S2	6 ± 0.3	0.7 + 0.2	5 – 0.2	-
MHB2-14/8.5/8-4B1 sup	8.5 – 0.5	3.5 + 0.5	8 ± 0.3	14 ± 0.5
MHB2-14/8.5/14-4B1	8.5 – 0.5	3.5 + 0.5	14 ± 0.4	14 ± 0.5
MHB2-13/8/6-4B1 1)	8.0 ± 0.3	3 ± 0.3	6 ± 0.3	13 ± 0.3
MHB2-13/8/6-3C90 1)	8.0 ± 0.3	3 ± 0.3	6 ± 0.3	13 ± 0.3
MHR2-11/5.4/11-4A11 sup	5.4 ± 0.3	2.0 ± 0.3	10.9 ± 0.3	10.8 ± 0.3
MHR2-11/5.4/11-3C90 sup	5.4 ± 0.3	2.0 ± 0.3	10.9 ± 0.4	10.8 ± 0.3
MHR6-6.1/4/10-3B1 sup	4 ± 0.2	0.7 + 0.3	10 ± 0.5	6.1 ± 0.3

Multi-hole cores are used for small HF transformers, for voltage or impedance matching in TV, communications, data transmission, instrumentation and similar applications. They are available with 2 and 6 holes (twin cores and six-hole cores), in round and rectangular shapes.

Summary:
- wide range of shapes
- several materials
- for HF matching and suppression

1) Chamfered holes and sides.

rods



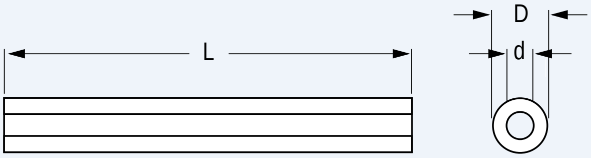
type number			dimensions (mm)	
3B1	**3S3**	**4B1**	**D**	**L**
ROD2/20-3B1-D sup			2 – 0.05	20 – 0.9
		ROD3/15-4B1-D	3 – 0.05	15 – 0.8
	ROD3/20-3S3		3 – 0.3	20 ± 0.4
ROD3/20-3B1-D			3 – 0.05	20 – 0.9
ROD3/25-3B1-D			3 – 0.05	25 – 1.0
	ROD3.3/17-3S3		3.3 ± 0.1	17 ± 0.3
ROD4/15-3B1-D		**ROD4/15-4B1-D**	4 – 0.05	15 – 0.8
ROD4/25-3B1-D			4 – 0.05	25 – 1.0
	ROD5/20-3S3		5 – 0.30	20 ± 0.5
ROD5/20-3B1-D		**ROD5/20-4B1-D** sup	5 – 0.05	20 – 0.9
	ROD5/25-3S3		5 – 0.30	25 – 1.0
ROD5/25-3B1-D			5 – 0.05	25 – 1.0
ROD5/30-3B1-D		**ROD5/30-4B1-D** sup	5 – 0.05	30 – 1.2
	ROD5.3/18-3S3		5.25 – 0.3	18 ± 0.3
	ROD6/25-3S3		6 – 0.30	25 ± 0.6
	ROD6/30-3S3		6 – 0.30	30 ± 0.9
ROD6/30-3B1-D		**ROD6/30-4B1-D** sup	6 – 0.10	30 – 1.2
		ROD6/40-4B1-D sup	6 – 0.10	40 – 1.6
		ROD6/50-4B1-D sup	6 – 0.10	50 ± 1.0
	ROD6.5/25-3S3		6.5 – 0.30	25 ± 0.6
	ROD8/25-3S3 des		8 – 0.5	25 ± 0.75
ROD8/50-3B1 sup		**ROD8/50-4B1** sup	8 – 0.40	50 ± 1.0
		ROD8/150-4B1 sup	8 – 0.40	150 ± 3.0
ROD10/200-3B1 sup		**ROD10/200-4B1** sup	10 – 0.50	200 ± 4.0

Generally, ferrite rods are used as the core of solenoidal chokes. Such a choke can carry a high DC current without being saturated because of the open magnetic circuit. In most cases, the frequency range will not be limited by the material, but by the coil capacitance. Curvature and mechanical tolerances of the standard range fulfil the requirements of DIN41291 or its equivalent IEC 60233-1966.

The L value and Q-factor are measured (up to 6 mm outer diameter) in a standard coil, according to DIN 41276 or its equivalent IEC 732-1982, and compared with a standard rod.

Summary:
- for solenoidal coils
- open circuit, no self shielding
- not easily saturated by load currents

tubes



type number			dimensions (mm)		
4B1	3B1	3C90	D	d	L
	TUB3.1/1.3/19-3B1-DL sup		3.1 – 0.02	1.3 + 0.2	18.8 – 0.5
	TUB3.5/1.3/7.5-3B1 sup		3.5 ± 0.2	1.3 + 0.2	7.5 + 0.5
	TUB3.5/1.3/3-3B1 sup		3.5 + 0.1 / – 0.2	1.3 + 0.2	3.0 + 0.5
TUB3.7/1.2/3.5-4B1 sup	TUB3.7/1.2/3.5-3B1 sup		3.7 – 0.4	1.2 + 0.2	3.5 – 0.5
TUB3.8/2.8/8-4B1 sup			3.8 ± 0.1	2.8 ± 0.1	8 ± 0.25
TUB4/1.6/40-4B1 sup			4.0 – 0.25	1.6 + 0.15	40 – 1.6
	TUB4/2/5-3B1 sup		4 ± 0.2	2 ± 0.2	5 ± 0.5
TUB4/3/9.5-4B1 sup			4 ± 0.1	3 + 0.2	9.45 + 0.75
	TUB4.1/2/7-3B1-D sup		4.1 ± 0.1	2 + 0.2	7 ± 0.2
	TUB4.1/2/11-3B1-D sup		4.1 + 0.1	2 + 0.2	11 ± 0.2
TUB4.1/2/26-4B1 sup			4.1 – 0.2	2 + 0.2	25.5 – 1
TUB4.2/2/12-4B1-DL sup			4.15 – 0.05	2 + 0.2	12.2 – 0.4
TUB4.3/2/15-4B1 sup	TUB4.3/2/15-3B1 sup		4.3 – 0.2	2 + 0.2	15.4 – 0.8
	TUB4.3/2/26-3B1 sup		4.3 – 0.2	2 + 0.2	25.5 – 1
		TUB5/2/50-3C90 sup	5.0 – 0.30	2.0 + 0.2	50 ± 1
	TUB5.3/3/22-3B1 sup		5.3 – 0.2	3.0 + 0.2	22.4 – 0.8
	TUB6/3/20-3B1 sup	TUB6/3/20-3C90 sup	6.0 – 0.3	3.0 + 0.2	20 – 0.9
		TUB6/3/30-3C90 sup	6.0 – 0.3	3.0 + 0.2	30 – 1.2
TUB8/4/20-4B1 sup	TUB8/4/20-3B1 sup		8.0 – 0.4	4.0 + 0.3	20 – 0.9
	TUB8/4/40-3B1 sup		8.0 – 0.4	4.0 + 0.3	40 – 1.6
	TUB9.5/6.5/17-3B1		9.5 ± 0.3	6.5 ± 0.2	17 + 0.5 / – 0.4
	TUB10/4.2/20-3B1 sup		10.0 – 0.5	4.2 + 0.3	20 – 0.9

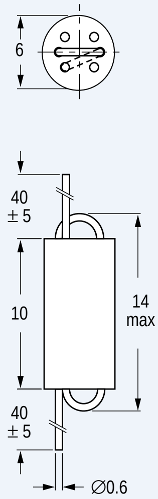
Tubes can be used in solenoid coils with almost the same effect as rods. The inner hole is often used to insert wires to make a ferrite coil former. In EMI suppression applications tubes can also be shifted over wires. Because the magnetic flux path is then closed, a steep increase in impedance results. In such cases however the sensitivity for DC currents is rather high. Curvature and mechanical tolerances of the standard range fulfil the requirements of DIN 41291 or its equivalent IEC 60233-1966.

Summary:
- full range of standard sizes
- for general EMI-suppression
- with wires inserted used as ferrite coil former

EMI-suppression products

wide band chokes

WBC1.5/A



WBC1.5/A-4S2

\|Z\| at f

Ω	MHz
213$^{1)}$	10
400$^{1)}$	50
470$^{1)}$	100

WBC1.5/A-3S4

\|Z\| at f

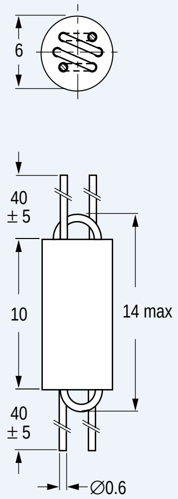
Ω	MHz
≥ 300	120

WBC1.5/A-4B1

\|Z\| at f

Ω	MHz
≥ 350	250

WBC1.5/1.5/A



WBC1.5/1.5/A-4S2

\|Z\| at f

Ω	MHz
213$^{3)}$	10
400$^{3)}$	50
470$^{3)}$	100

WBC1.5/1.5/A-3S4

\|Z\| at f

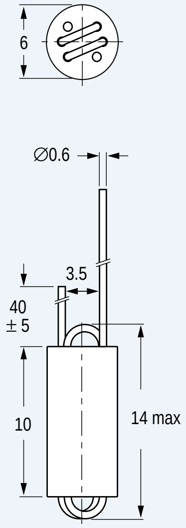
Ω	MHz
≥ 700$^{2)}$	50

WBC1.5/1.5/A-4B1

\|Z\| at f

Ω	MHz
≥ 800$^{2)}$	110

WBC2/R

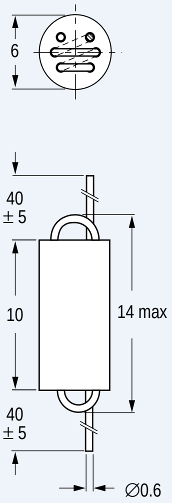


WBC2/R-4S2

\|Z\| at f

Ω	MHz
300$^{1)}$	10
650$^{1)}$	50
600$^{1)}$	100

WBC2.5/A



WBC2.5/A-4S2

\|Z\| at f

Ω	MHz
400$^{1)}$	10
850$^{1)}$	50
725$^{1)}$	100

WBC2.5/A-3S4

\|Z\| at f

Ω	MHz
≥ 600	50

WBC2.5/A-4B1

\|Z\| at f

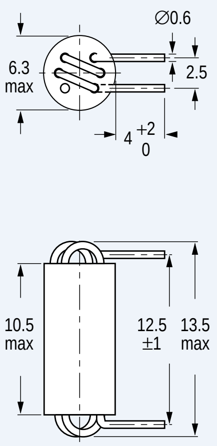
Ω	MHz
≥ 700	180

Wide-band chokes are an alternative to a bead when more impedance or damping is required. In these products the conductor wire is wound through holes in a multi-hole ferrite core, thus separating them physically and reducing coil capacitance. The result is a high impedance over a wide frequency range, a welcome feature for many interference problems. The present design has excellent properties and reliability by keeping the number of electrical interfaces to an absolute minimum.

$^{1)}$ Minimum guaranteed impedance is IZI$_{typ}$ -20%.
$^{2)}$ IZI measured with both windings connected in series.
$^{3)}$ Minimum guaranteed impedance is IZI$_{typ}$ -20%; measured with one winding.

wide band chokes

WBC2.5/R



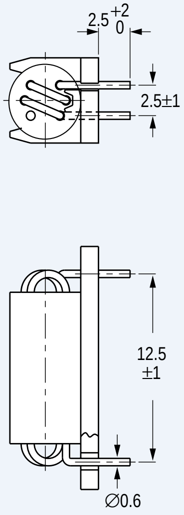
WBC2.5/R-3S4 sup

|Z| at f	
Ω	MHz
≥ 600	50

WBC2.5/R-4B1 sup

|Z| at f	
Ω	MHz
≥ 700	75

WBC2.5/SP



colour code
3S4 = blue
4B1 = green

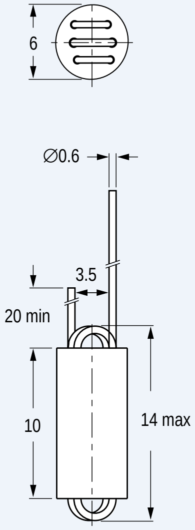
WBC2.5/SP-3S4 sup

|Z| at f	
Ω	MHz
≥ 600	50

WBC2.5/SP-4B1 sup

|Z| at f	
Ω	MHz
≥ 700	75

WBC3/R



WBC3/R-4S2

|Z| at f	
Ω	MHz
500[1]	10
1000[1]	50
688[1]	100

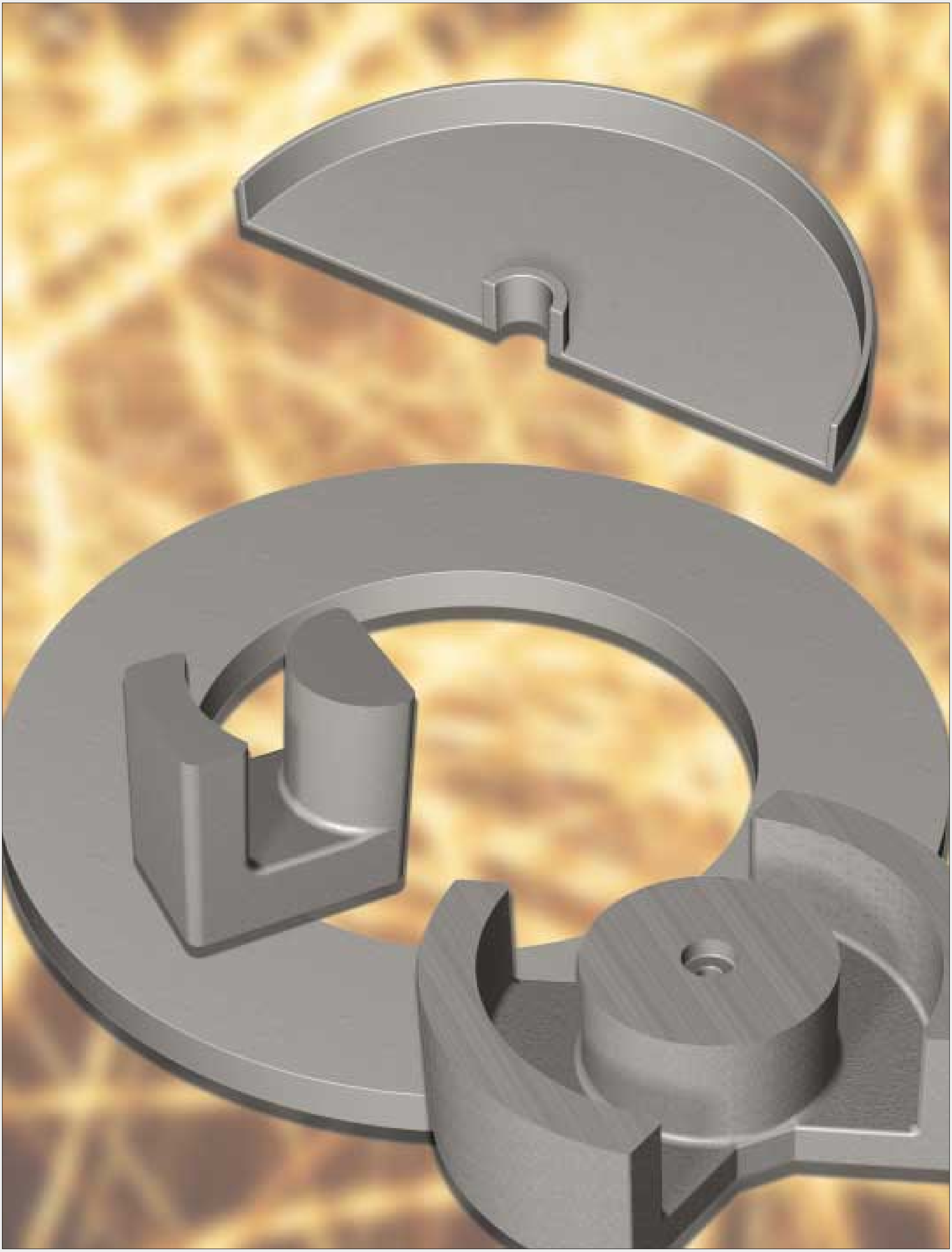
[1] Minimum guaranteed impedance is $|Z|_{typ}$ -20%.

WBC3/R-3S4

|Z| at f	
Ω	MHz
≥ 650	63

WBC3/R-4B1

|Z| at f	
Ω	MHz
≥ 800	110



Specialty ferrite materials and applications

property	conditions				particle accellerators				
symbol	**f (kHz)**	**$\hat{B}$ or H**	**T (°C)**	**unit**	**4E2**	**4M2**	**4B3**	**8C12**	**8C11**
μ_i (±20%)	< 10	< 0.1mT	25		25	140	300	900	1200
B	10	250A/m	100	mT	≈ 150	≈ 150	≈ 250	≈ 150	≈ 200
		3000A/m			≈ 320	≈ 300	≈ 400	≈ 270	≈ 300
H_c	10		25	A/m	≈ 400	≈ 100	≈ 60	≈ 30	≈ 20
B_r	10		25	mT	≈ 200	≈ 100	≈ 200	≈ 110	≈ 150
T_C				°C	≥ 400	≥ 200	≥ 250	≥ 125	≥ 125
ρ	DC		25	Ω m	$\approx 10^5$	$\approx 10^5$	$\approx 10^5$	$\approx 10^5$	$\approx 10^5$
density				kg/m^3	≈ 4000	≈ 5000	≈ 5000	≈ 5100	≈ 5100
ferrite type					NiZn	NiZn	NiZn	NiZn	NiZn

Properties measured on sintered, unground ring cores of dimensions ∅25 x ∅15 x 10 mm which are not subjected to external stresses.

Products generally comply with the material specification. However deviations may occur due to shape, size and grinding operations etc. Specified product properties are given in the data sheets or product drawings.

Accellerator cores and pulse shapers

Scientific particle accellerators generally use large ferrite rings to tune caveties and concentrate the beam. Ferrite pole pieces, often called kicker magnets, concentrate the magnetic flux bursts which deflect the beam into experiment chambers. Ferrite rings on supply lines of e.g. short pulsed radar equipment, delay current rise until they saturate causing very steep pulses.

Ferrite choice

frequency range	
< 1 MHz	*8C11, 8C12*
< 10 MHz	*4B3, 4M2*
< 100 MHz	*4E2*

Machined ferrite products

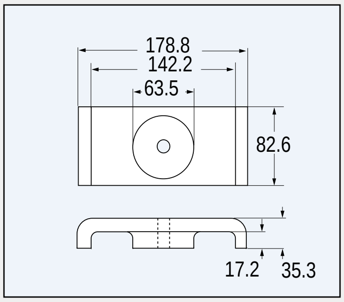
Machined ferrites and specialty shapes

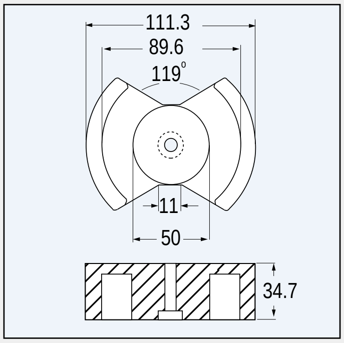
We stock blocks of most of our material grades and are able to machine all sorts of prototype cores from these blocks. Very close tolerances can be realized, if required.

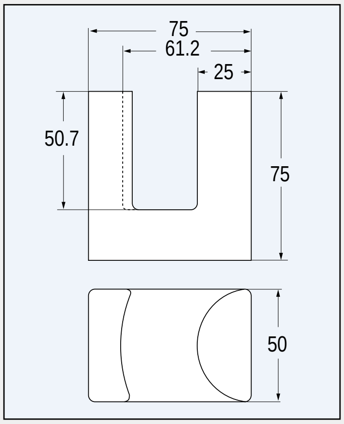
Ferrites are very hard and brittle and, therefore, difficult to work. Machining and grinding ferrites and similar materials to micron precision places stringent requirements on machines and men. To attain optimum standards requires very close cooperation between us and the manufacturers of the machines and the machine tools we use.

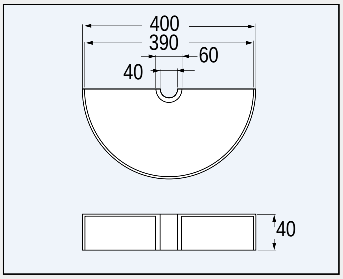
There are several reasons to go for machined ferrite cores. Sometimes samples are required on very short notice, while pressing tools are not yet available. On other occasions only a limited number of cores will be needed and it is not worthwhile to make a tool at all. Cores can be so complicated or large that machining is the only viable solution.

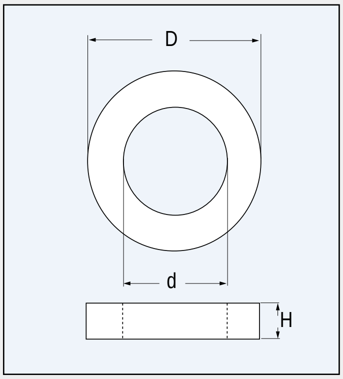
The following drawings provide a good impression of the variety of cores we have produced. For some of the cores we also have pressing tools available.





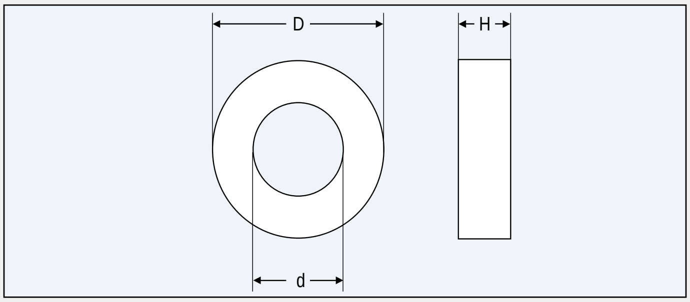


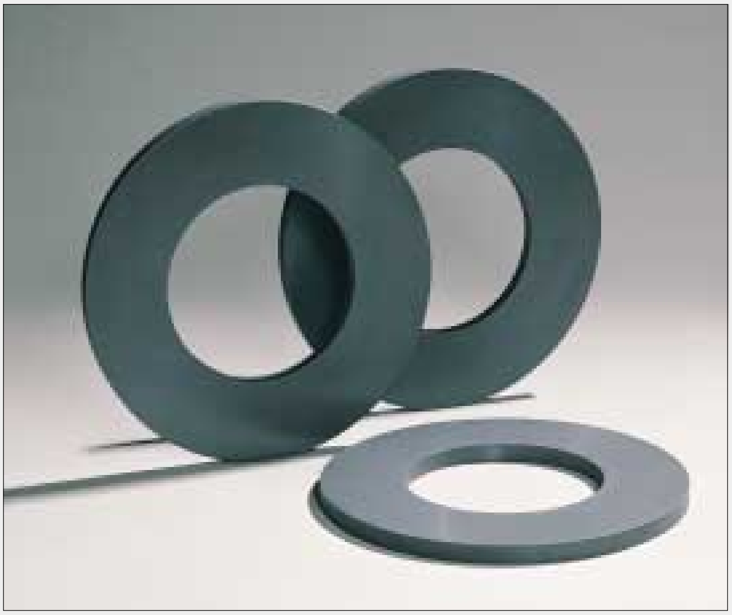




Specialty ferrites

Ferrite toroids for particle accelerators





type number	D	d	H	mass (g)
T76/38/13	76.2 ± 0.1	38.1 ± 0.1	12.7 ± 0.1	≈ 220
T170/110/20	170 ± 0.2	110.2 ± 0.2	20 ± 0.2	≈ 1300
T240/160/20	240 ± 0.3	160 ± 0.3	20 ± 0.3	≈ 2500
T498/270/25	498 ± 0.1	270 ± 0.2	25 ± 0.2	≈ 17 000
T498/300/25	498 ± 0.1	300 ± 0.2	25 ± 0.2	≈ 15 000
T500/240/25	500 ± 2	240 ± 0.2	25 ± 0.2	≈ 19 000
T500/300/25	500 ± 0.1	300 ± 0.1	25 ± 0.1	≈ 16 000

core type	4M2	4B3	8C11	8C12
T76/38/13	◆		◆	◆
T170/110/20			◆	
T240/160/20			◆	
T498/270/25				◆
T498/300/25				◆
T500/240/25		◆		
T500/300/25	◆			

Our product range

Our range of large ring cores and blocks was developed especially for use in scientific particle accelerators. Applications include kicker magnets and acceleration stations. Dynamic behaviour under pulse conditions is important for both applications, so special ferrite grades are optimized for low losses at high flux densities. These large rings have also been used successfully in delay lines for very high powers such as in pulsed lasers or radar equipment. Sizes other than those mentioned in the tables can be made on request.

- standard range of sizes
- optimized grades for particle accelerators
- other sizes on request

Definition of terms

Permeability

When a magnetic field is applied to a soft magnetic material, the resulting flux density is composed of that of free space plus the contribution of the aligned domains.

$$B = \mu_0 H + J \quad \text{or} \quad B = \mu_0 (H + M) \qquad [1]$$

where μ_0 = 4π.10^{-7} H/m, J is the magnetic polarization and M is the magnetization.
The ratio of flux density and applied field is called absolute permeability.

$$\frac{B}{H} = \mu_0\left(1 + \frac{M}{H}\right) = \mu_{absolute} \qquad [2]$$

It is usual to express this absolute permeability as the product of the magnetic constant of free space and the relative permeability (μ_r).

$$\frac{B}{H} = \mu_0 \mu_r \qquad [3]$$

Since there are several versions of μr depending on conditions the index 'r' is generally removed and replaced by the applicable symbol e.g. μ_i, μ_a, μ_Δ etc.

Initial permeability

The initial permeability is measured in a closed magnetic circuit (ring core) using a very low field strength.

$$\mu_i = \frac{1}{\mu_0} \times \frac{\Delta B}{\Delta H} \quad (\Delta H \rightarrow 0) \qquad [4]$$

Initial permeability is dependent on temperature and frequency.

Effective permeability

If an airgap is introduced in a closed magnetic circuit, magnetization becomes more difficult. As a result, the flux density for a given magnetic field strength is lower.
Effective permeability is dependent on the initial permeability of the soft magnetic material and the dimensions of airgaps and circuit.

$$\mu_e = \frac{\mu_i}{1 + \frac{G \times \mu_i}{l_e}} \qquad [5]$$

where G is the gap length and l_e is the effective length of magnetic circuit. This simple formula is a good approximation only for small airgaps. For longer airgaps some flux will cross the gap outside its normal area (fringing flux) causing an increase of the effective permeability.

Amplitude permeability

The relationship between higher field strength and flux densities without the presence of a bias field, is given by the amplitude permeability (μa).

$$\mu_a = \frac{1}{\mu_0} \times \frac{B}{H} \qquad [6]$$

Since the BH loop is far from linear, values depend on the applied field strength.

Incremental permeability

The permeability observed when an alternating magnetic field is superimposed on a static bias field, is called the incremental permeability.

$$\mu_\Delta = \frac{1}{\mu_0}\left[\frac{\Delta B}{\Delta H}\right]_{H_{DC}} \qquad [7]$$

If the amplitude of the alternating field is negligibly small, the permeability is then called the reversible permeability (μrev).

Effective core dimensions

To facilitate calculations on a non-uniform soft magnetic core, the effective dimensions are given on each data sheet. These dimensions, effective area (A_e), effective length (l_e) and effective volume (V_e) define a hypothetical ring core which would have the same magnetic properties as the non-uniform core.
The reluctance of the ideal ring core would be:

$$\frac{l_e}{\mu \times A_e} \qquad [9]$$

For the non-uniform core shapes, this is usually written as:

$$\frac{1}{\mu_e} \times \Sigma\frac{l}{A} \qquad [10]$$

the core factor divided by the permeability.
The inductance of the core can now be calculated using this core factor:

$$L = \frac{\mu_0 \times N^2}{\frac{1}{\mu_e} \times \Sigma\frac{l}{A}} = \frac{1.257 \times 10^{-9} \times N^2}{\frac{1}{\mu_e} \times \Sigma\frac{l}{A}} (\text{in H}) \qquad [11]$$

The effective area is used to calculate the flux density in a core, for sine wave:

$$B = \frac{U\sqrt{2} \times 10^9}{\omega A_e N} = \frac{2.25U \times 10^8}{fNA_e} (\text{in mT}) \qquad [12]$$

for square wave:

$$B = \frac{0.25U \times 10^9}{fNA_e} (\text{in mT}) \qquad [13]$$

where:
A e is the effective area in mm 2 .
U is the voltage in V
f is the frequency in Hz
N is the number of turns.

The magnetic field strength (H) is calculated using the effective length (l e):

$$H = \frac{IN\sqrt{2}}{l_e} (\text{A/m}) \qquad [14]$$

If the cross-sectional area of a core is non-uniform, there will always be a point where the real cross-section is minimal. This value is known as A_{min} and is used to calculate the maximum flux density in a core. In well designed ferrite core a large difference between A_e and A_{min} is avoided. Narrow parts of the core could saturate or cause much higher hysteresis losses.

Inductance factor (A_L)

To facilitate inductance calculations, the inductance factor, known as the A_L value (nH), is given in each data sheet. The inductance factor of a core is defined as:

$$L = N^2 \times A_L \ (\text{nH}) \qquad [15]$$

The value of A_L is calculated from the core factor and the effective permeability:

$$A_L = \frac{\mu_0 \mu_e \times 10^6}{\Sigma(l/A)} = \frac{1.257\mu_e}{\Sigma(l/A)} (\text{nH}) \qquad [16]$$

Inductance calculations on rods and tubes

Rods and tubes are generally used to increase the inductance of a coil. The magnetic circuit is very open and therefore the mechanical dimensions have more influence on the inductance than the ferrite's permeability (see Fig.1) unless the rod is very slender. In order to establish the effect of a rod on the inductance of a coil, the following procedure should be carried out:

- Calculate the length to diameter ratio of the rod (l/d).
- Find this value on the horizontal axis and draw a vertical line.

The intersection of this line with the curve of the material permeability gives the effective rod permeability (μ_{rod}).

The inductance of the coil, provided the winding covers the whole length of the rod is given by:

$$L = \mu_0 \mu_{rod} \frac{N^2 A}{l} (H) \qquad [17]$$

where:
N = number of turns
A = cross sectional area of rod (mm^2)
l = length of coil. (mm)

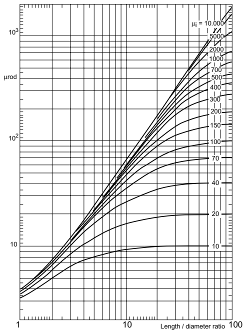


Fig.1 Rod permeability (μ_{rod}) as a function of length to diameter ratio with material permeability as a parameter.