Ceramic Components for Power Applications

PRODUCT SELECTION GUIDE
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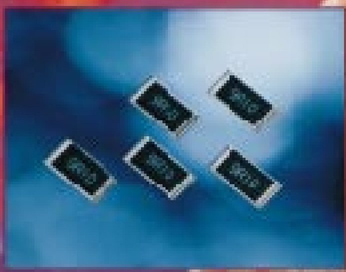

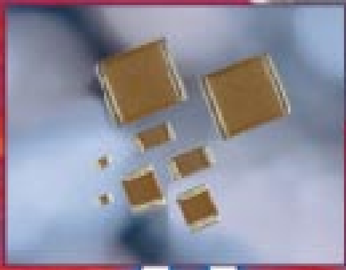

Philips Components
Advanced Ceramics & Modules

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Let's make things better.



Ceramic Components for Power Applications

Innovative solutions in ceramic and integrated components

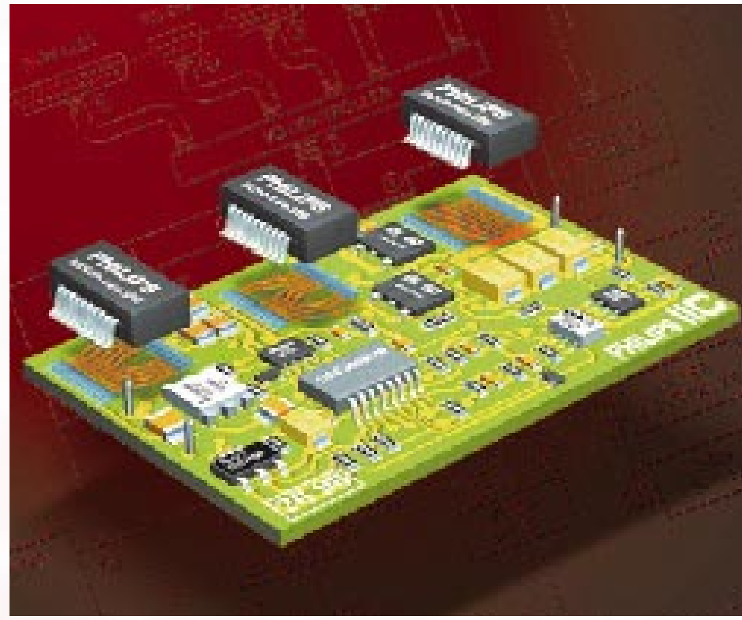
Philips Components is a leading innovator in ferrite, dielectric and piezo ceramic technologies. Our ferrite-based products, in particular, have been developed to support today's manufacturers of power supplies and inductive components in their drive for greater miniaturization, reduced power consumption and lower weight. What's more, our Ceramic Innovation Centers, strategically located worldwide, are constantly developing solutions for power applications for today's and for future generations of equipment.

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.
- Low-profile ferrite inductors with the windings completed by the PC board tracks.

Supporting your new designs

Our broad range of surface-mount discrete ceramic and integrated components supports our customers' innovative designs with functions such as RF filtering and tuning, impedance matching, line termination, signal delay, coupling and safety isolation. We also assist our 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.



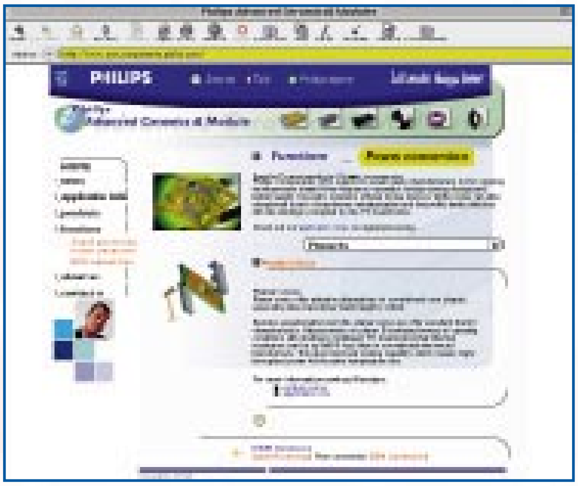
▲ *Integrated Inductive Components (IICs) for multiple magnetic functions in a single package*

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

Taking the lead in energy saving

Leading the way in energy saving, our new *Cool*Ferrite ceramics dissipate only half the power of standard ferrites. In Western Europe alone this means they offer a potential annual saving of 1000 gigawatt-hours if all standard ferrite in electrical equipment were replaced by *Cool*Ferrite. In fact, it's probably true to say that Philips' energy-saving *Cool*Ferrite is well on the way to becoming the eco standard for use in power converters.

Application-specific solutions



With our extensive know-how in power ferrites, we're uniquely qualified to support equipment manufacturers with innovative solutions dedicated to cutting size and weight of power supplies and reducing power consumption of equipment.

Power-transformer design, in particular, is a highly appli- cation-specific enterprise involving factors such as power-handling capacity, operating frequency and available space.
To meet the needs of today's designers, we offer a wide choice of core-type/ferrite-grade combinations offering finely-tuned performance characteristics tailored to specific applications.

Aiding your design-in decisions

This catalogue is dedicated to our broad range of com-ponents for power applications and is intended as a first selection guide to aid your design-in decisions.

Besides power conversion, we support designers in other key functional areas, notably:

- ***Signal processing*** with integrated ceramic-based and thin-film solutions to support today's equipment manufac-turer especially in the EDP and telecommunications industries
- ***EMI suppression*** with thin-film integrated solutions, multilayer suppressors and integrated inductive products, plus ferrite beads, cable shields, RC networks etc.

Our Product Selection Guide for signal processing is already available and a guide for EMI suppression will be available soon!

Need more information?
Visit our web site on
www.acm.components.philips.com

Our new site reflects our new focus on supporting the fast growing digital-electronics markets with a truly global range of ceramic and integrated products. 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.

For answers to specific questions there's also a 'talk' button that enables you email us directly. In addition, our worldwide sales offices and distributors are happy to answer any questions you may have.

Preferred types

In this catalogue you will find a broad range of ceramic components meeting the many and varied requirements of today's equipment manufacturers.

For some product sections we clearly indicate the preferred types.
"Preferred" means types which are generally easily available from our factories and through franchised distributors. These products are recommended for design-in.
In the sections Ferrite Ceramics and Piezoelectric Ceramics a more detailed classification is used.

Product status definition for Ferrite Ceramics and Piezoelectric Ceramics

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.

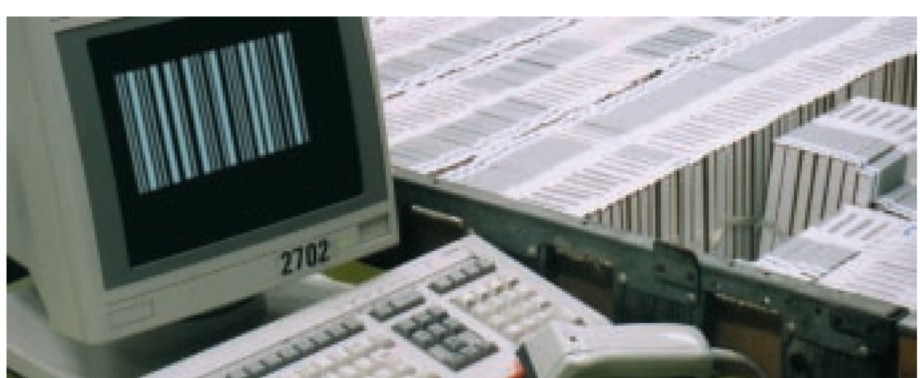
Besides the products listed in this catalogue, we can also offer application specific components and a custom-design service for customers with special requirements.

How to order

For most of the products you will be able to obtain the catalogue/type number in clear text code or the Philips unique 12-digit ordering code from this catalogue.

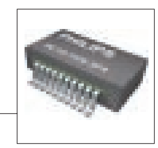
For ordering information of all other types consult our Data Handbooks or visit our internet site: **www.acm.components.philips.com**

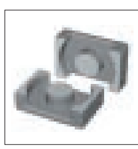
Minimum shipment quantities, price and delivery details can be obtained from the Philips Components sales contacts in your country or from one of our franchised distributors.

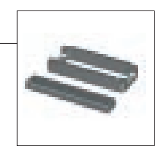


New products & highlights

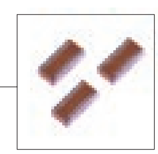
Ferrite Ceramics



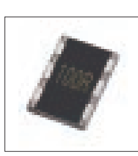




Ceramic Multilayer Capacitors, SMD



Fixed Resistors



Ferrite Ceramics

page

Soft ferrite cores are widely used throughout industry. The number of applications is growing and is virtually limitless.

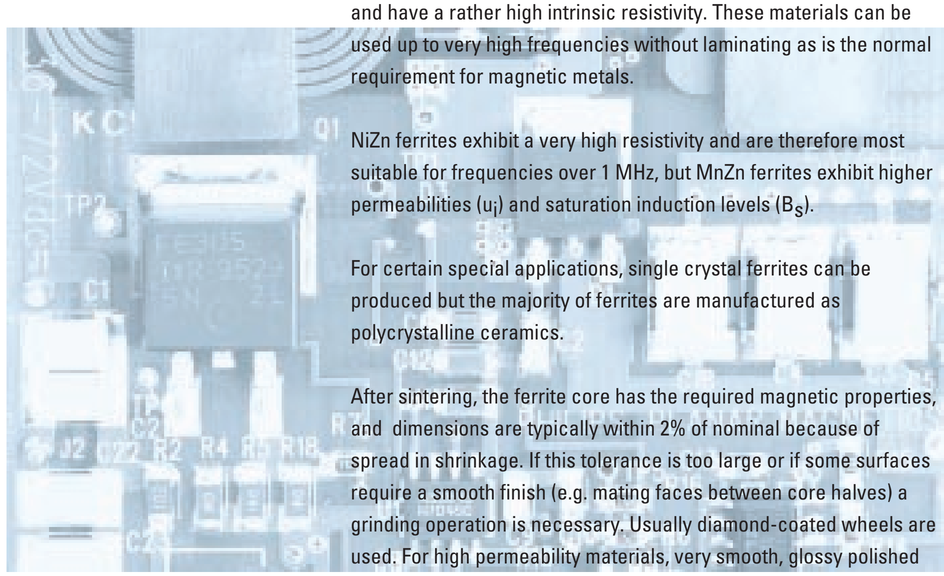
Main application areas are:

- **Consumer electronics**
- **Lighting**
- **Automotive electronics**
- **Electronic data processing (EDP)**
- **Telecommunications**
- **Measurement and control**

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 general composition of such ferrites is $MeFe_2O_4$ where Me represents one or several of the divalent transition metals such as manganese (Mn), zinc (Zn), nickel (Ni), cobalt (Co), copper (Cu), iron (Fe) or magnesium (Mg).

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 (u_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.

PRODUCT STATUS DEFINITIONS

STATUS	INDICATION	DEFINITION
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Preferred		These products are recommended for use in current designs and are available via our sales channels.
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*Cool*Ferrite

*Cool*Ferrite is Philips' new name for a series of energy saving, low loss ferrite materials. *Cool*Ferrite represents a class of ferrites including 3C30, 3C34, 3C91, 3C94, 3C96, 3F35 and 3F4. *Cool*Ferrite is well on the way to becoming the eco standard for use in power converters.

Ferrite Ceramics

Application matrix

Application area / Magnetic function	Telecommunication	Electronic Data Processing (EDP)	Sound and Vision	Lighting
Driver transformers	3C11, 3C81, 3C90, 3C91, 3E25, 3F3 E, EFD, EP, ER, P/I, Ring cores (T), RM/I	3C11, 3C81, 3C90, 3C91, 3E25, 3F3 E, EFD, EP, ER, P/I, Ring cores (T), RM/I	3C11, 3C81, 3C90, 3C91, 3E25, 3F3 E, EFD, EP, ER, P/I, Ring cores (T), RM/I	3C11, 3C81, 3C90, 3C91, 3E25, 3F3, 3F4 E, EFD, EP, ER, P/I, Ring cores (T), RM/I
Line output transformers (LOT)		3C15, 3C30, 3C34 UR	3C15, 3C30, 3C34 UR	
Magnetic regulators	3R1 Ring cores (T)	3R1 Ring cores (T)	3R1 Ring cores (T)	
Power inductors	2P, 3C81, 3C90, 3C91, 3C94, 3C96, 3F3, 3F4, 3F35 E, ER, ETD, IIC, P/I, Planar E, PQ, PT, PTS, Ring cores (T), RM/I, RM/ILP, U	2P, 3C81, 3C90, 3C91, 3C94, 3C96, 3F3, 3F4, 3F35 E, ER, ETD, IIC, P/I, Planar E, PQ, PT, PTS, Ring cores (T), RM/I, RM/ILP, U	2P, 3C81, 3C90, 3C91, 3F3 E, ER, ETD, IIC Planar E, Ring cores (T), U	2P, 3C81, 3C90, 3C91, 3C94, 3F3, 3F4, 3F35 E, ER, ETD, IIC Planar E, PQ, Ring cores (T), U
Power transformers	3C81, 3C90, 3C91, 3C94, 3C96, 3F3, 3F4, 3F35, 4F1 E, EFD, ETD, ER, IIC, Planar E, PQ, RM/I, RM/ILP, P/I, PT, PTS, Ring cores (T)	3C81, 3C90, 3C91, 3C94, 3C96, 3F3, 3F4, 3F35, 4F1 E, EFD, ETD, ER, IIC, Planar E, PQ, RM/I, RM/ILP, P/I, PT, PTS, Ring cores (T)	3C81, 3C90, 3C91, 3C94, 3C96, 3F3 E, EFD, ETD, ER, IIC, Planar E	3C81, 3C90, 3C91, 3C94, 3C96, 3F3, 3F4, 3F35, 4F1 E, EFD, ETD, ER, Planar E
Mains filers, EMI-suppression	3C11, 3C81, 3C90, 3E25, 3E26, 3E27, 3E5, 3E6 Toroids, U cores	3C11, 3C81, 3C90, 3E25, 3E26, 3E27, 3E5, 3E6 Toroids, U cores	3C11, 3C81, 3C90, 3E25, 3E26, 3E27, 3E5, 3E6 Toroids, U cores	3C11, 3C81, 3C90, 3E25, 3E26, 3E27, 3E5, 3E6 Toroids, U cores

Domestic Appliances	Automotive Electronics	Measurement, Control, Scientific and Medical	Electric Tools
3C11, 3C81, 3C90, 3C91, 3E25	3C11, 3C81, 3C90, 3C91, 3E25	3C11, 3C81, 3C90, 3C91, 3E25, 3F3, 3F4	3C11, 3C81, 3C90, 3C91, 3E25
E, EFD, EP, ER, P/I, Ring cores (T), RM/I	E, EFD, EP, ER, P/I, Ring cores (T), RM/I	E, EFD, EP, ER, P/I, Ring cores (T), RM/I	E, EFD, EP, ER, P/I, Ring cores (T), RM/I
		3C15, 3C30, 3C34	
		UR	
3R1			
Ring cores (T)			
3C81, 3C90, 3C94, 2P	3C81, 3C90, 3C91, 3C94, 3C96, 3F3, 3F35, 2P	3C81, 3C90, 3C91, 3C94, 3C96, 3F3, 3F4, 3F35, 2P	
E, ER, ETD, Planar E, PQ, Ring cores (T), U,	E, ER, ETD, IIC, Planar E, PQ, Ring cores (T), U,	E, ER, ETD, IIC, P/I, Planar E, PT, PTS, PQ, Ring cores (T), RM/I, RM/ILP, U	
3C81, 3C90, 3C94, 3F3	3C81, 3C90, 3C91, 3C94, 3C96, 3F3, 3F35, 3F4	3C81, 3C90, 3C91, 3C94, 3C96, 3F3, 3F35, 3F4, 4F1	
E, EFD, ER, ETD, Planar E, PQ	E, EFD, ER, ETD, IIC, Planar E, PQ, Ring cores (T), RM/I, RM/ILP	E, EFD, ER, ETD, IIC, P/I, Planar E, PQ, PT, PTS, Ring cores (T), RM/I, RM/ILP	
3C11, 3C81, 3C90, 3E25, 3E26, 3E27, 3E5, 3E6		3C11, 3C81, 3C90, 3E25, 3E26, 3E27, 3E5, 3E6	3C11, 3C81, 3C90, 3E25, 3E26, 3E27, 3E5, 3E6
Toroids, U cores		Toroids, U cores	Toroids, U cores

Ferrite Ceramics

Materials and applications

property	test conditions				power transformers and power inductors												
symbol	f (khz)	B̂ or H	T (°C)	unit	3C15	3C30	3C34*)	3C81	3C90	3C91*)	3C94	3C96*)	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 which are not subjected to external stresses.

*) preliminary specification   2) at 60 °C

property	test conditions				output chokes EMI-suppression				
symbol	f (khz)	B̂ or H	T (°C)	unit	2P40	2P50	2P65	2P80	2P90
μ_i (±10%)	≤ 10	≤ 0.1mT	25		40	50	65	80	90
B	10	25.10^3A/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 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	3C90, 3C94, 3C96
200-1000 kHz	3F3, 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 3F3 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.

Ring cores made from 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 ring cores can operate under bias fields of up to 2000 A/m.

Ferrite choice

frequency range	
< 500 kHz	2P.., 3C30, 3C90
< 1 MHz	3C90, 3F3, 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 is spoiled by any airgap in the magnetic circuit so a ring core 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. 3C10 is a special grade for this type of application. Switching frequency has recently increased to 32, 64 or 128 kHz for applications such as HDTV and special monitors. For these applications, 3C15, 3C30 and 3C34 with lower losses up to 300 kHz in combination with high saturation levels are available.

Ferrite choice

frequency range	
16 kHz	3C15
32 kHz	3C15
64 kHz	3C15, 3C30
128 kHz	3C30, 3C34

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	*3C11, 3E25*
high - level drive	*3C81, 3C90, 3F3*

Typical mechanical and thermal properties

Property	MnZn ferrite	NiZn ferrite	unit
Young's modulus	$(90 – 150) \times 10^{3}$	$(80 – 150) \times 10^{3}$	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	$(10 – 12) \times 10^{-6}$	$(7 – 8) \times 10^{-6}$	K^{-1}
Specific heat	700 – 800	≈ 750	$Jkg^{-1}\ K^{-1}$
Thermal conductivity	$(3.5 – 5.0) \times 10^{-3}$	$(3.5 – 5.0) \times 10^{-3}$	$Jmm^{-1}s^{-1}\ K^{-1}$

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

property	conditions				EMI-suppression				
symbol	f (kHz)	$\hat{B}$ or H	T (°C)	unit	3C11	3E25	3E26	3E27	3E5
μ_i (±20%)	≤ 10	≤ 0.1mT	25		4300	6000	7000	6000	10000
tan δ/μ_i	30	≤ 0.1mT	25	10^{-6}					≤ 25
	100				≤ 20	≤ 25	≤ 20	≤ 15	≤ 75
	300				≤ 200	≤ 200			
B	10	250A/m	100	mT	≈ 180	≈ 180	≈ 290	≈ 280	≈ 210
		3000A/m	25		≈ 340	≈ 380	≈ 450	≈ 400	≈ 380
H_c	10		25	A/m	≈ 10	≈ 5	≈ 5	≈ 5	≈ 5
B_r				mT	≈ 120	≈ 100	≈ 120	≈ 120	≈ 80
T_c				°C	≥ 125	≥ 125	≥ 155	≥ 150	≥ 125
ρ	DC		25	Ω m	≈ 1	≈ 0.5	≈ 0.5	≈ 0.5	≈ 0.5
density				kg/m^3	≈ 4900	≈ 4900	≈ 4900	≈ 4800	≈ 4900
ferrite type					MnZn	MnZn	MnZn	MnZn	MnZn

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.

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

EMI-suppression / Mains filters

The task of an Electro Magnetic Interference filter is to block high frequency noise, while allowing the signal to pass with negligible attenuation. In principle, an EMI-filter is a low- pass filter. In some cases, like in complete mains filters, inductive components (L) and capacitors (C) are combined to form an LC circuit. Near the frequency of parallel resonance high impedance levels are obtained to block major interference signals.
To save volume, the permeability of the ferrite core must be as high as possible in the frequency indent range of the interfering signal.

Ring cores are therefore very popular for this application (no airgap) but also U-cores are used. It is important to take into account any magnetic bias field, caused by DC or low frequency AC- currents.
In common-mode chokes saturation is avoided by placing 2 similar windings, carrying opposing currents, on the same core. In this way the flux generated by the bias current cancels out, while common-mode noise is still suppressed.
This is why such chokes are often called current-compensated chokes.

frequency range	
< 500 kHz	*3C11, 3E25, 3E27, 3E26, 3E5, 3C90*
500 kHz - 3 MHz	*3F3*

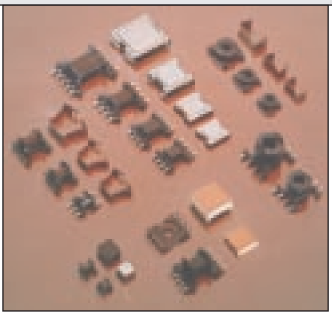
Ferrite Ceramics
Bobbins & Accessories

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.

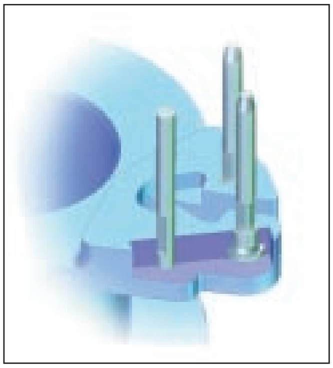
Philips Components makes ferrite cores to meet exacting requirements. And to ensure a perfect winding every time, the Bobbins & Accessories Group manufactures and supplies precision bobbins and support products. The bobbins are designed for perfect windings and zero-defect mounting on and in printed 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.



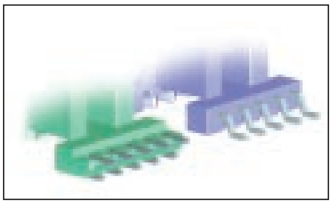
Our technological competence…
…your access to quality products

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

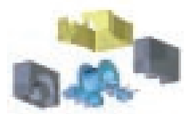
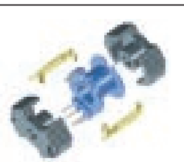
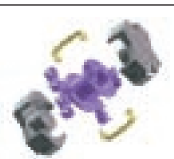
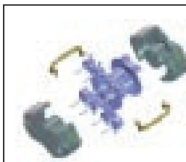
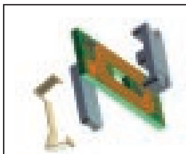
When selecting materials for our products, the design, production process, electrical- and mechanical requirements are important factors. But above all, we aim for optimum performance at an acceptable price. Many materials are used, ranging from industry-standard polyamide (PA) to the more exotic liquid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

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: EP7, 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		 9.5, 11, 14.5 Gullwing pin type in high performance thermoplastic. Clamps available	
RM	 Sizes: RM4, 5, 6, 7, 8, 10, 12, 14 Both in-moulded and post-inserted pin versions, Clips available	 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: FRM9, 10, 12, 15 C-pin version in high performance thermo-plastic material.	 Sizes: E14, 18, 22 Range of Clamps available

Ferrite Ceramics

Integrated Inductive Components (IIC)

Ferrite Ceramics

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

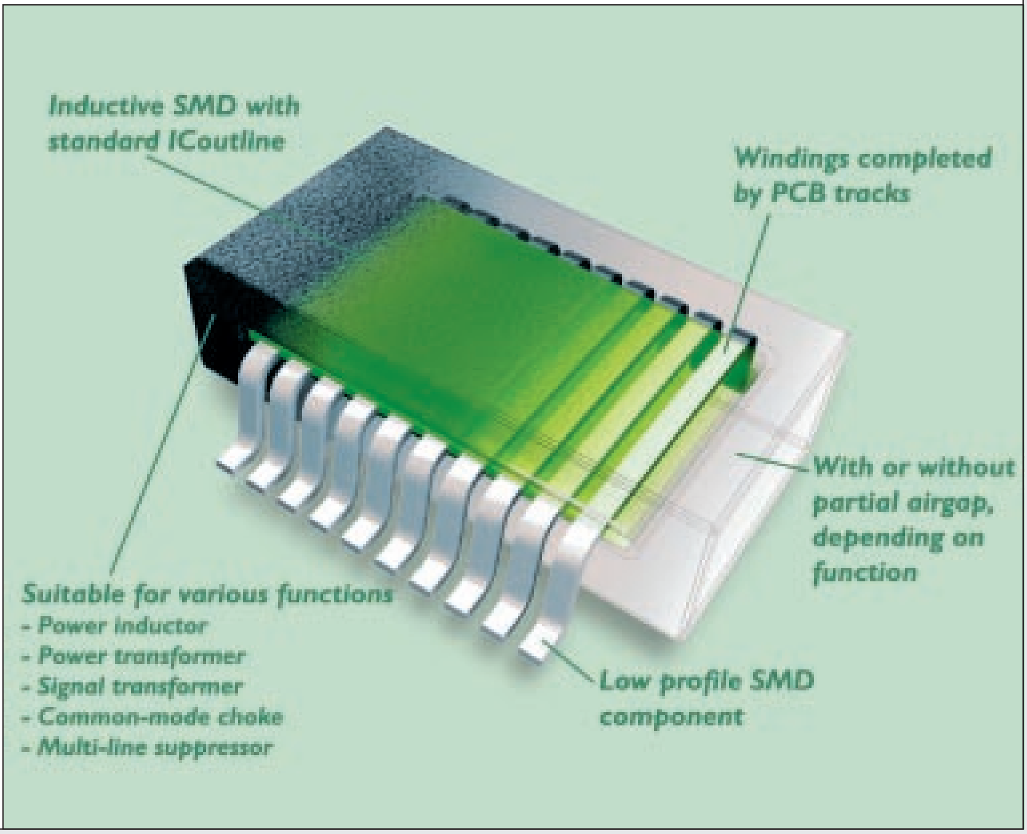
The IIC can be used as a low profile power transformer in high-frequency DC/DC converters, especially those working with low voltage and power levels.

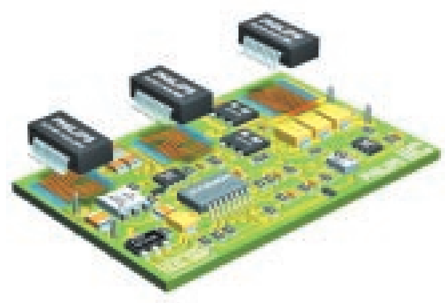
Although isolation voltage is specified at 500 V, the IIC10 should not be used in AC/DC applications as a safety isolation transformer. The short distance between the leads makes it unsuitable for that function.

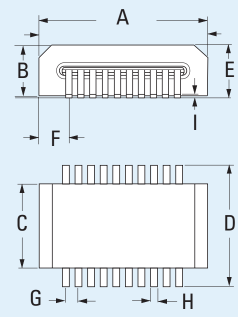
Made in our top-quality 3S4 suppression material or the high-permeability 3E6, the design is ideal for common-mode choke in signal or supply lines, especially if these carry large currents. The sturdy lead frame will take almost any current surge without damage.

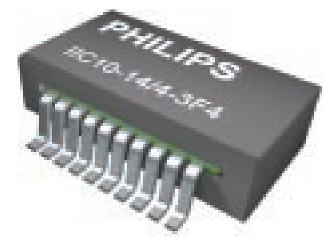
Features and Benefits:

- 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.









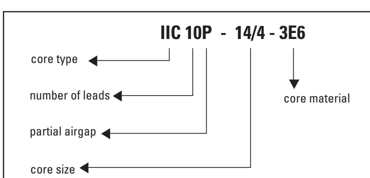
Core type		IIC10-14/4 IIC10P-14/4
effective core parameters	core factor Σ I/A(mm^{-1})	2.47
	eff. volume V_e (mm^3)	338
	eff. length l_e (mm)	28.9
	eff. area A_e (mm^2)	11.7
	min. area A_{min} (mm^2)	11.7
	mass of core set (g)	≈ 1.85
dimensions (mm)	A	14.4 ± 0.2
	B	4 ± 0.08
	C	7.2 ± 0.15
	D	10.45 max
	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	$\|Z\|_{typ}$ (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	-

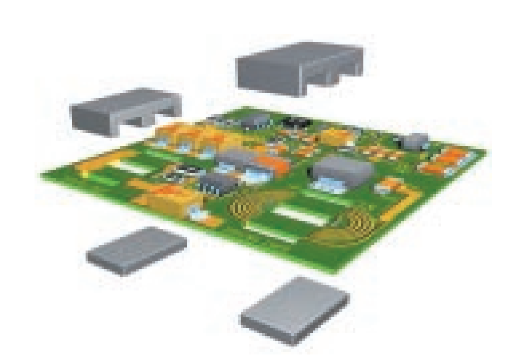
IICs without partial airgap

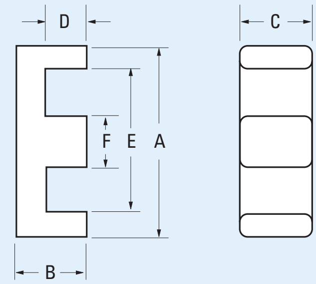
type number	L (μH) for 10 turns no bias current f = 100 kHz, T = 25°C	L (μH) for 10 turns no bias current f = 500 kHz, T = 25°C	L (μH) for 10 turns no bias current f = 1 MHz, T = 25°C	L (μH) for 10 turns with bias current 1A f = 100 kHz, T = 25°C	L (μH) for 10 turns with bias current 1A f = 500 kHz, 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	-



Ferrite Ceramics

Planar E cores





E core (E)

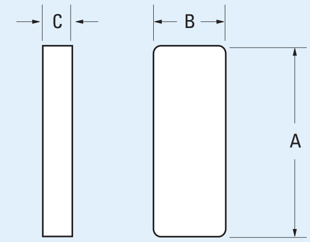


plate (PLT)

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 I/A (mm^{-1})	eff. volume V_e (mm^3)	eff. length l_e (mm)	eff.[1)] area A_e (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	≈ 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	≈ 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	≈ 2.4
PLT18/10/2 (E-PLT combination)	18 ± 0.35	10 ± 0.2	2 ± 0.05	-	-	-	0.514	800	20.3	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	≈ 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	≈ 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	≈ 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	≈ 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	≈ 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	≈ 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	≈ 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	≈ 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	≈ 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	≈ 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	≈ 100
PLT64/50/5 (E-PLT combination)	63.8 ± 1.3	50.3 ± 1	5.08 ± 0.13	-	-	-	0.136	35500	69.6	511	≈ 78

1) $A_{min} = A_e$

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 des			A160 - E	E160 - E	E250 - E	E250 - E	E315 - E	E630 - E
				A160 - P	A160 - P	A250 - P	A250 - P	A315 - P	A630 - P
			A100 - E	A250 - E	E250 - E	E315 - E	E315 - E	E400 - E	E1000 - E
			A100 - P	A250 - P	A250 - P	A315 - P	A315 - P	A400 - P	A1000 - P
		A63 - E	A160 - E	A315 - E	A315 - E	E400 - E	E400 - E	E630 - E	A1600 - E
		A63 - P	A160 - P	A315 - P	A315 - P	A400 - P	A400 - P	A630 - P	A1600 - P
		A100 - E	A250 - E	A400 - E	A400 - E	A630 - E	A630 - E	A1000 - E	A2500 - E
		A100 - P	A250 - P	A400 - P	A400 - P	A630 - P	A630 - P	A1000 - P	A2500 - P
		A160 - E	A315 - E	A630 - E	A630 - E	A1000 - E	A1000 - E	A1600 - E	A3150 - E
		A160 - P	A315 - P	A630 - P	A630 - P	A1000 - P	A1000 - P	A1600 - P	A3150 - P
		1280 / 1500	3200 / 3680	5150 / 6150	6425 / 7350	7940 / 9290	8030 / 9250	8480 / 9970	14640/16540
	3C94 des			A160 - E	E160 - E				
				A160 - P	A160 - P				
			A100 - E	A250 - E	E250 - E				
			A100 - P	A250 - P	A250 - P				
		A63 - E	A160 - E	A315 - E	A315 - E				
		A63 - P	A160 - P	A315 - P	A315 - P				
		A100 - E	A250 - E	A400 - E	A400 - E				
		A100 - P	A250 - P	A400 - P	A400 - P				
		A160 - E	A315 - E	A630 - E	A630 - E				
		A160 - P	A315 - P	A630 - P	A630 - P				
		1280 / 1500	3200 / 3680	5150 / 6150	6425 / 7350				
	3C96 prot	1200 / 1350	2900 / 3250	4600 / 5450	6425 / 7350				
	3F3 des			A160 - E	E160 - E	E250 - E	E250 - E	E315 - E	E630 - E
				A160 - P	A160 - P	A250 - P	A250 - P	A315 - P	A630 - P
			A100 - E	A250 - E	E250 - E	E315 - E	E315 - E	E400 - E	E1000 - E
			A100 - P	A250 - P	A250 - P	A315 - P	A315 - P	A400 - P	A1000 - P
		A63 - E	A160 - E	A315 - E	A315 - E	E400 - E	E400 - E	E630 - E	A1600 - E
		A63 - P	A160 - P	A315 - P	A315 - P	A400 - P	A400 - P	A630 - P	A1600 - P
		A100 - E	A250 - E	A400 - E	A400 - E	A630 - E	A630 - E	A1000 - E	A2500 - E
		A100 - P	A250 - P	A400 - P	A400 - P	A630 - P	A630 - P	A1000 - P	A2500 - P
		A160 - E	A315 - E	A630 - E	A630 - E	A1000 - E	A1000 - E	A1600 - E	A3150 - E
		A160 - P	A315 - P	A630 - P	A630 - P	A1000 - P	A1000 - P	A1600 - P	A3150 - P
		1100 / 1300	2700 / 3100	4300 / 5000	5900 / 6780	7250 / 8500	7310 / 8700	7710 / 9070	13300/15050
	3F35 prot	900 / 1050	2200 / 2500	3500 / 4100					
	3F4 des			A160 - E	E160 - E	E250 - E	E250 - E	E315 - E	E630 - E
				A160 - P	A160 - P	A250 - P	A250 - P	A315 - P	A630 - P
			A100 - E	A250 - E	E250 - E	E315 - E	E315 - E	E400 - E	E1000 - E
			A100 - P	A250 - P	A250 - P	A315 - P	A315 - P	A400 - P	A1000 - P
		A63 - E	A160 - E	A315 - E	A315 - E	E400 - E	E400 - E	E630 - E	A1600 - E
		A63 - P	A160 - P	A315 - P	A315 - P	A400 - P	A400 - P	A630 - P	A1600 - P
		A100 - E	A250 - E	A400 - E	A400 - E	A630 - E	A630 - E	A1000 - E	A2500 - E
		A100 - P	A250 - P	A400 - P	A400 - P	A630 - P	A630 - P	A1000 - P	A2500 - P
		A160 - E	A315 - E	A630 - E	A630 - E	A1000 - E	A1000 - E	A1600 - E	A3150 - E
		A160 - P	A315 - P	A630 - P	A630 - P	A1000 - P	A1000 - P	A1600 - P	A3150 - P
		650/780	1550 / 1800	2400 / 2900	3200 / 3700	3880 /4600	3870 / 4660	4030 / 4780	6960 / 7920

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.

E 32/6 - 3C90 - E 250 - E

- core type
- core size
- core material
- gap type: A-asymmetrical gap to A_L value; E-symmetrical gap to A_L value
- A_L value (nH)
- version: E-combine with ungapped E core; P-combine with plate

PLT 18 / 10 / 2 - 3C90

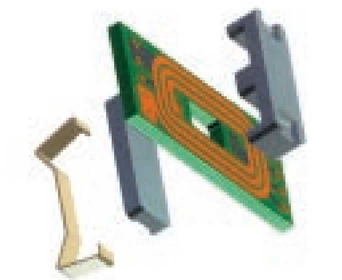
- core type (plate)
- plate size
- material

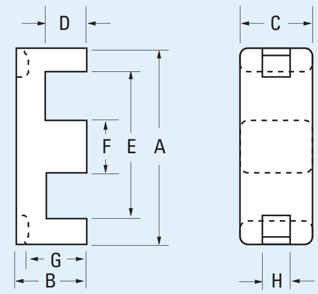
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, f ≤ 10 kHz, T = 25°C

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

Ferrite Ceramics

Planar E cores with recess





E core with recess (E/R)

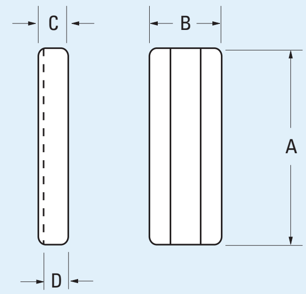


plate with slot (PLT/S)

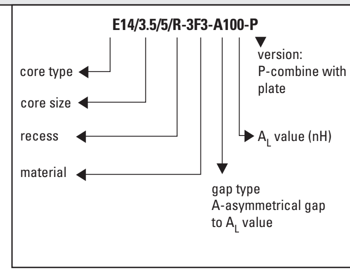
For those customers not in favor of glueing we developed a new range of planar E cores with matching plates and metal clamps. These cores can easily be mounted together with the PCB winding without the use of any glue. The E cores have recesses (E/R) to prevent the clamp from slipping off. The plates 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.

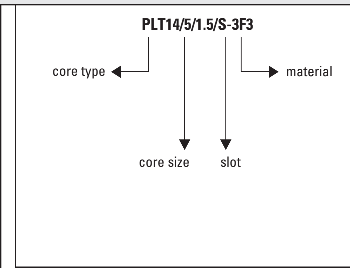
Summary:

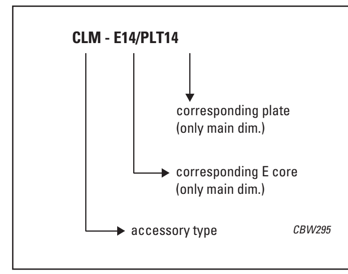
- no glue necessary
- plate with slot to prevent sideways movement
- no A_L reduction of high permeability cores due to glue on the mating faces

	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		■		■		■

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 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
	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 des	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







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%

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.

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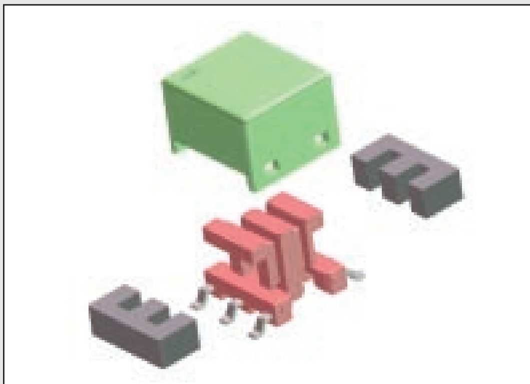
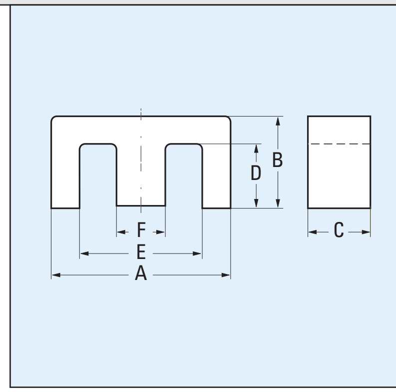
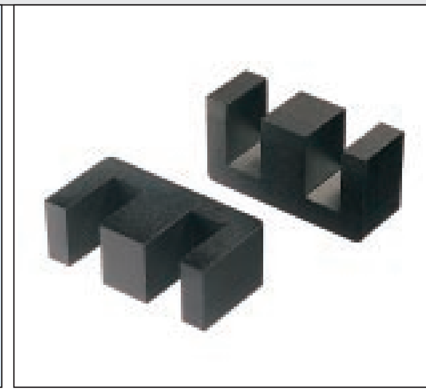
E cores (IEC 1246)







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)	E16/12/5
effective core parameters	core factor Σ I/A(mm^{-1})	4.70	3.67	3.13	2.74	1.37	2.39	1.87	2.85
	eff. volume V_e (mm^3)	33.3	40.6	78	281	559	369	750	1070
	eff. length l_e (mm)	12.5	12.2	15.6	27.8	27.7	29.7	37.6	55.3
	eff. area A_e (mm^2)	2.66	3.3	5.0	10.1	20.2	12.4	20.1	19.4
	min. area A_{min} (mm^2)	2.63	2.6	3.6	10.1	20.2	12.2	19.3	19.4
	mass of core half (g)	≈ 0.08	≈ 0.12	≈ 0.25	≈ 0.7	≈ 1.4	≈ 0.9	≈ 2.0	≈ 2.6
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	16 ± 0.3
	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	12.25 ± 0.2
	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	4.85 ± 0.2
	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	10.25 ± 0.25
	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	12 ± 0.3
	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	4 ± 0.2
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								
	CSHS						1S - 10P		
mounting parts	CLM	■							
	CLA								
	CLI	■							
	SPR								
	COV	■	■				■		

E 25/13/7 - 3C90 - A 250

- core type
- core size
- core material
- gap type: A- asymmetrical gap to A_L value; E- symmetrical gap to A_L value; G- mechanical gap
- A_L value (nH) or gap size (µm)

C S H S - E13/4 - 1S - 10P - T

- coil former (bobbin)
- plastic material type: P- thermoplastic; S- thermoset
- mounting orientation: H- horizontal; V- vertical; CI-coaxial, inner part; CO-coaxial, outer part
- mounting type: S- surface mount
- associated core type
- number of sections
- number & type of pins: D - dual termination; F - flat; L - long
- special version

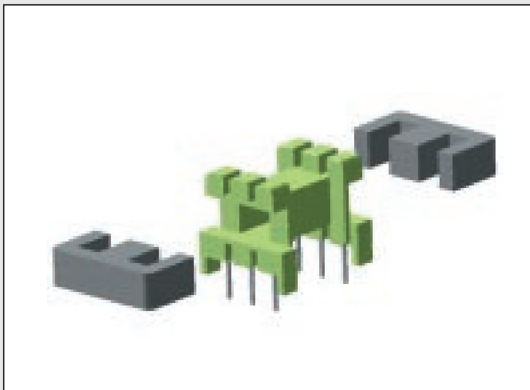
CLM - E25/13/7

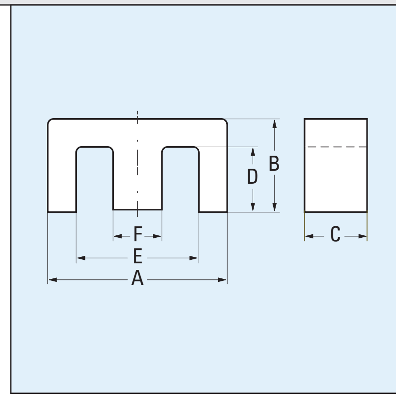
- hardware type: CLM - clamp; CLA - clasp; SPR - spring; CLI - clip
- associated core type

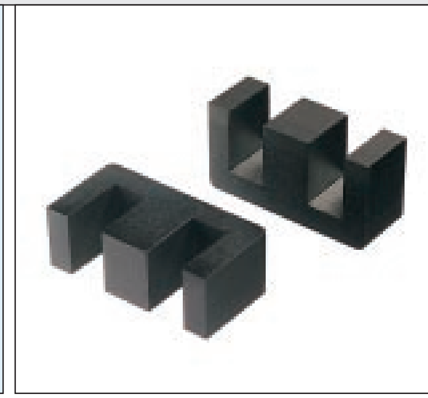
	Core type (old core description)	E19/8/5 (813E187)	E19/8/9 (813E343)	E20/10/5	E20/10/6 (EF20)	E20/14/5 (EL19)	E22/16/10	E25/9/6	E25/10/6 (812E250)	E25/13/7 (EF25)	E25/13/11	E30/15/7
effective core parameters	core factor Σ I/A(mm^{-1})	1.77	0.960	1.37	1.45	2.54	0.695	1.23	1.24	1.11	0.733	1.12
	eff. volume V_e (mm^3)	900	1650	1340	1490	1513	5143	1860	1930	2990	4500	4000
	eff. length l_e (mm)	39.9	39.9	42.8	46.0	62	59.8	47.4	49.0	58.5	57.5	67.0
	eff. area A_e (mm^2)	22.6	41.3	31.2	32.0	24.4	86	38.4	39.5	52.0	78.4	60.0
	min. area A_{min} (mm^2)	22.1	41.1	25.2	32.0	22.8	80	37.0	37.0	52.0	78.4	49.0
	mass of core half (g)	≈ 2.3	≈ 4	≈ 4	≈ 3.7	≈ 4.2	≈ 14	≈ 4.8	≈ 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	20 ± 0.3	22 ± 0.5	25.4 ± 0.6	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	13.55 ± 0.15	15.75 ± 0.5	9.45 ± 0.2	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	5 ± 0.2	10 ± 0.25	6.3 ± 0.3	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	11.15 ± 0.15	9.75 ± 0.25	6.5 ± 0.3	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	14.3 min	13 min	19.3 ± 0.5	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	4.55 ± 0.15	8 ± 0.25	6.35 ± 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			■								■

Ferrite Ceramics

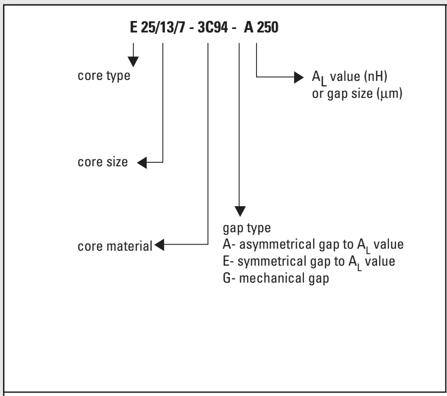
E cores (IEC 1246)

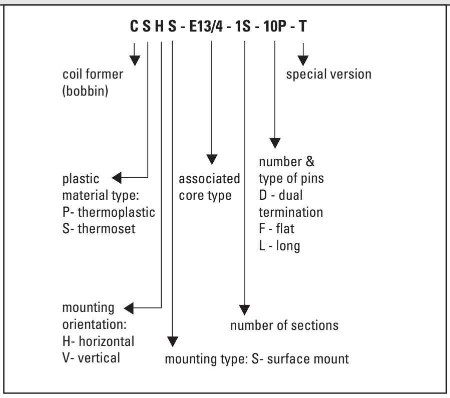


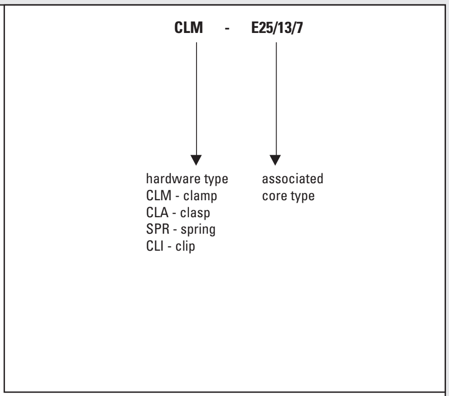




	Core type (old core description)	E31/13/9	E32/16/9 (EF32)	E34/14/9 (E375)	E35/18/10	E36/21/12	E41/17/12 (E21)	E42/21/15	E42/21/20	E42/33/20
effective core parameters	core factor Σ l/A(mm^{-1})	0.740	0.894	0.850	0.807	0.762	0.517	0.548	0.417	0.614
	eff. volume V_e (mm^3)	5150	6180	5590	8070	12160	11500	17300	22700	34200
	eff. length l_e (mm)	61.9	74	69.3	80.7	96	77.0	97.0	97.0	145
	eff. area A_e (mm^2)	83.2	83	80.7	100	126	149	178	233	236
	min. area A_{min} (mm^2)	83.2	83	80.7	100	121	142	175	233	234
	mass of core half (g)	$\approx$ 13	$\approx$ 16	$\approx$ 14	$\approx$ 15	$\approx$ 31	$\approx$ 30	$\approx$ 44	$\approx$ 56	$\approx$ 82
dimensions (mm)	A	30.9 $\pm$ 0.5	32 + 0.9/-0.7	34.3 $\pm$ 0.6	35 $\pm$ 0.5	36 $\pm$ 0.7	40.6 $\pm$ 0.65	43 - 1.7	43 - 1.7	42 + 1/ -0.7
	B	13.4 $\pm$ 0.15	16.4 - 0.4	14.1 $\pm$ 0.15	17.5 $\pm$ 0.25	21.75 - 0.4	16.6 $\pm$ 0.2	21 $\pm$ 0.2	21 $\pm$ 0.2	32.8 - 0.4
	C	9.4 $\pm$ 0.3	9.5 - 0.7	9.3 $\pm$ 0.25	10 $\pm$ 0.3	12 - 0.6	12.4 $\pm$ 0.3	15.2 - 0.6	20 - 0.8	20 - 0.8
	D	8.6 min	11.2 + 0.6	9.8 $\pm$ 0.13	12.5 $\pm$ 0.25	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 min	24.5 + 1.2	28.6 min	29.5 + 1.4	29.5 + 1.4	29.5 + 1.4
	F	9.4 $\pm$ 0.25	9.5 - 0.6	9.3 $\pm$ 0.2	10 $\pm$ 0.3	10.2 - 0.5	12.45 $\pm$ 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 l/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			■			■		

Ferrite Ceramics

E cores (IEC 1246)

	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)	E16/12/5 (EL16)	E19/8/5 (813E187)	E19/8/9 (813E343)	E20/10/5
core HALVES for general purpose transformers and power applications	3C81					A63 A100 A160 A250 A315 1950				A63 A100 A160 A250 A315 1500	E100 A160 A250 A315 A400 2740	
	3C90				730	A63 A100 A160 A250 A315 1470	800	1100	800	A63 A100 A160 A250 A315 1170	E100 A160 A250 A315 A400 2150	1500
	3C94	300 des	400 des	530 prot		1470	800	1100		1170	2150	1500 des
	3C96	275 prot	380 prot	480 prot								
	3F3	265	360	460 prot		A63 A100 A160 A250 A315 1250 des	700	980		A63 A100 A160 A250 A315 995 des	E100 A160 A250 A315 A400 1830 des	1400 des
	3F35	225 prot	300 prot	380 prot								
	3F4	165 des	225 des	280 prot								
high µ HALVES	3C11											2600
	3E1		700				1200	1800				
	3E25					2600 sup	1500 sup	2200 sup		2300 sup	4250 sup	2800 des
	3E26								2000			
	3E27				1300	2600	1500	2200		2300	4250	

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: ±3% ±5% ±10% ±25% +30% −20% +40% −30%

	Core type (old core description)	E20/10/6 (EF20)	E20/14/5 (EL19)	E22/16/10	E25/9/6	E25/10/6	E25/13/7 (EF25)	E25/13/11	E25/16/6	E30/15/7	E31/13/9
core HALVES for general purpose transformers and power applications	3C81					A100 A160 A250 A315 A400 2340	A160 A250 A315 A400 A630 2460			A160 A250 A315 A400 A630 2500	A250 A315 A400 A630 A1000 3735
	3C90	1450	900	3090	2000	A100 A160 A250 A315 A400 1600	A160 A250 A315 A400 A630 G50 G150 G500 1900	2800	1300	A160 A250 A315 A400 A630 1900	A250 A315 A400 A630 A1000 2970
	3C94	1380 des			1600 des	1600 des	1900 des	2800 des	1300 des	2000 des	2970
	3C96										
	3F3	1350 des				A100 A160 A250 A315 A400 1470 des	A160 A250 A315 A400 A630 1650 des	2700 des		A160 A250 A315 A400 A630 1600 des	A250 A315 A400 A630 A1000 2650 des
	3F35										
	3F4										
high μ HALVES	3C11	2600				2600	3100			3300	
	3E25	2700 des			3300 des	3000 des	4000		2700 des	4100 sup	6790 sup
	3E26		2300								
	3E27					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: ±3% ±5% ±25% $^{+35\%}_{-25\%}$

Ferrite Ceramics

E cores (IEC 1246)

	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		A250 A315 A400 A630 A1000 3200			E250 E315 A400 A630 A1000 5370	E250 E315 A400 A630 A1000 5300	E250 E315 E400 A630 A1000 6950	
	3C90	2500	A250 A315 A400 A630 A1000 2440	2500	2650	E250 E315 A400 A630 A1000 4100	E250 E315 A400 A630 A1000 3900	E250 E315 E400 A630 A1000 5000	4000
	3C94	2500 des	2440			4100 des	4100 des	5200 des	4000 des
	3C96								
	3F3	2300 des	A250 A315 A400 A630 A1000 2125 des			E250 E315 A400 A630 A1000 3575 des	E250 E315 A400 A630 A1000 3600 des	E250 E315 E400 A630 A1000 4600 des	3700 des
	3F35								
	3F4								
high μ HALVES	3C11	4000					8000		
	3E25	5000 des	4695 sup			9400 sup	8000 sup	10500 sup	
	3E27		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: ± 3% | ± 5% | ± 10% | ± 25%

	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	E250 E315 E400 A630 A1000 7540	E250 E315 E400 A630 A1000 5500	E315 E400 E630 A1000 A1600 8625		E315 E400 E630 A1000 A1600 9500			E315 E400 E630 A1000 A1600 6730
	3C90	E250 E315 E400 A630 A1000 5500	E250 E315 E400 A630 A1000 4355	E315 E400 E630 A1000 A1600 6300	8000	E315 E400 E630 A1000 A1600 6900	8600	10800	E315 E400 E630 A1000 A1600 5070
	3C94								
	3F3	E250 E315 E400 A630 A1000 5100 des		E315 E400 E630 A1000 A1600 5700 des	7400 des		7300 des	10000 des	E315 E400 E630 A1000 A1600 4590 des
	3F35								
	3F4								
high μ HALVES	3C11			12800			16700		
	3E25	11475 sup		14000 des		14580 sup			
	3E27	11475		15400		14580			

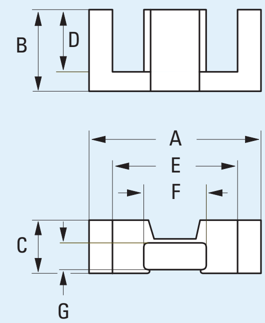
E63 — gapped core half with symmetrical gap (E). A_L = 63 nH measured in combination with an Equal-gapped core half.
A315 — gapped core half with asymmetrical gap (A). A_L = 315 nH measured in combination with a non-gapped core half.
5100 — ungapped core half. A_L = 5100 nH measured in combination with another ungapped core half.

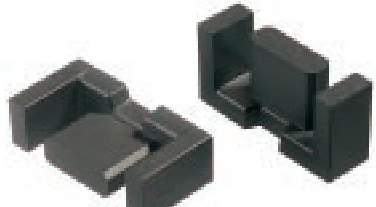
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

A_L tolerance: ± 3% (yellow) | ± 5% (pink) | ± 10% (turquoise) | ± 25% (green)

Ferrite Ceramics

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	■	■	■	■		

cores for general purpose transformers and power applications

Core type		EFD10 SETS des	EFD12 SETS des	EFD15 SETS	EFD20 HALVES/SETS	EFD25 HALVES	EFD30 HALVES/SETS
3C90		A25-S	A40-S	A63-S			
		A40-S	A63-S	A100-S			
		A63-S	A100-S	A160-S			
		585-S	825-S	950-S	1300	2200	2100
3C94	des	A25-S	A40-S	A63-S			
		A40-S	A63-S	A100-S			
		A63-S	A100-S	A160-S			
		585-S	825-S	950-S			
3C96	prot	525	750	850			
3F3		A25-S	A40-S	A63-S	E63-S	2000	A160-S
		A40-S	A63-S	A100-S	A100-S		A250-S
		A63-S	A100-S	A160-S	A160-S		A315-S
		500-S	700-S	780-S	A250-S		A400-S
					A315-S		A630-S
					1200		1900
3F35	prot	400	550	630			
3F4	des	A25-S	A40-S	A63-S	E63-S	1000	A160-S
		A40-S	A63-S	A100-S	A100-S		A250-S
		A63-S	A100-S	A160-S	A160-S		A315-S
		280-S	380-S	400-S	A250-S		A400-S
					A315-S		A630-S
					650		1050

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.

C P H S - EFD15 - 1S - 8P

- coil former (bobbin)
- plastic material type: P- thermoplastic, S- thermoset
- mounting orientation: H- horizontal
- number of pins or solder pads
- number of sections
- associated core type
- mounting type: S- surface mount

EFD 15 - 3F3 - A 250 - S

- core type
- core size
- core material
- gap type: A- asymmetrical gap to A_L value, E- symmetrical gap to A_L value, G- mechanical gap
- A_L value (nH) or gap size (µm)
- set

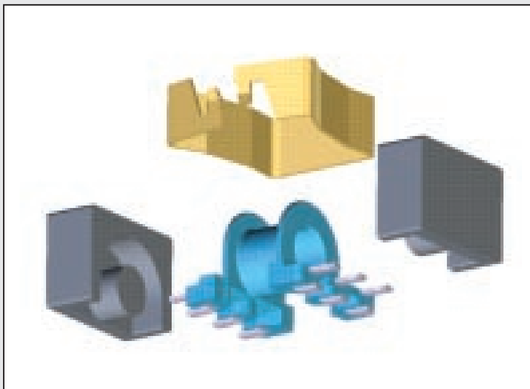
1) preliminary specification

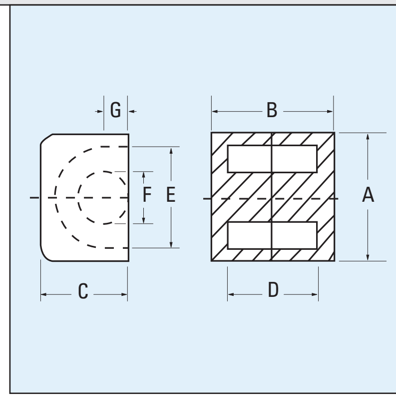
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

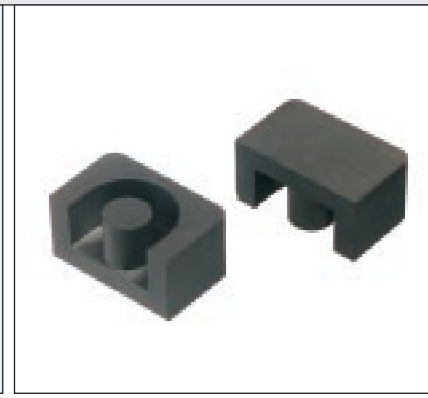
A_L tolerance: ± 3% | ± 5% | ± 8% | ± 10% | ± 25% | + 40% – 30%

Ferrite Ceramics

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:

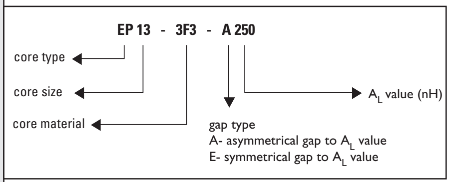
- cubical design for dense packing
- excellent magnetic shielding
- easy design of multiple output transformers

	Core type	EP7	EP10	EP13	EP17	EP20
effective core parameters	core factor Σ l/A(mm^{-1})	1.45	1.70	1.24	0.870	0.520
	eff. volume V_e (mm^3)	165	215	472	999	3230
	eff. length l_e (mm)	15.5	19.3	24.2	29.5	41.1
	eff. area A_e (mm^2)	10.7	11.3	19.5	33.7	78.7
	min. area A_{min} (mm^2)	8.55	8.55	14.9	25.5	60.8
	mass of core set (g)	≈ 0.8	≈ 1.1	≈ 2.4	≈ 5	≈ 16
dimensions (mm)	A	9.4 - 0.4	11.5 ± 0.3	12.8 - 0.6	18 ± 0.4	24 ± 0.5
	B	7.5 - 0.2	10.2 ± 0.2	13 - 0.3	16.8 ± 0.2	21.4 ± 0.2
	C	6.5 - 0.3	7.6 ± 0.2	9 - 0.4	11 ± 0.25	15 ± 0.35
	D	5 + 0.4	7.85 - 0.4	9 + 0.4	11.4 ± 0.3	14.4 ± 0.3
	E	7.2 + 0.4	9.4 ± 0.2	9.7 + 0.6	12 ± 0.4	16.5 ± 0.4
	F	3.4 - 0.2	3.3 ± 0.15	4.5 - 0.3	5.7 ± 0.18	8.8 ± 0.25
	G	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 - 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 SETS for general purpose transformers and power applications

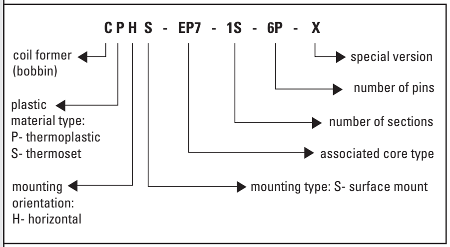
Core type		EP7	EP10	EP13	EP17	EP20
3C81		E25	E25	E40	E63	E160
		A40	A40	A63	A100	A250
		A63	A63	A100	A160	A315
		A100	A100	A160	A250	A400
		A160	A160	A250	A315	A630
		≥ 875	≥ 900	≥ 1250	≥ 1950	≥ 3450
3C90		E25	E25	E40	E63	E160
		A40	A40	A63	A100	A250
		A63	A63	A100	A160	A315
		A100	A100	A160	A250	A400
		A160	A160	A250	A315	A630
		1200	1140	1650	2485	4435
3C91	prot	≥ 875	≥ 900	≥ 1250	≥ 1950	≥ 3450
3C94	des	E25	E25	E40	E63	E160
		A40	A40	A63	A100	A250
		A63	A63	A100	A160	A315
		A100	A100	A160	A250	A400
		A160	A160	A250	A315	A630
		1200	1140	1650	2485	4435
3C96	prot	1120	1025	1475		
3F3		E25	E25	E40	E63	E160
		A40	A40	A63	A100	A250
		A63	A63	A100	A160	A315
		A100	A100	A160	A250	A400
		A160	A160	A250	A315	A630
		1000	1000	1325	2000	3550
3F35	prot	850	800	1100		
3F4	des	A100	A63	A160		
		A160	A100	A250		
		600	A160	A315		
			560	780		

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.

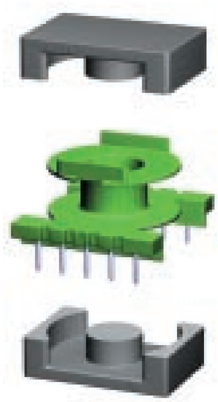


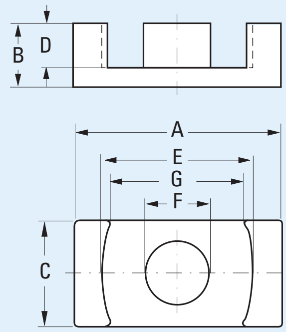
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

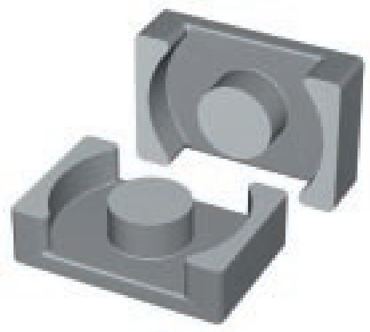
A_L tolerance: ± 3% | ± 5% | ± 8% | ± 12% | ± 25%



EQ cores



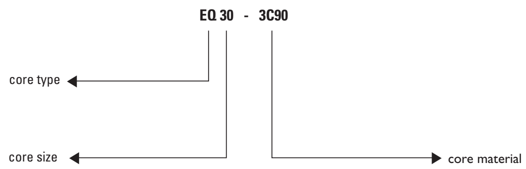


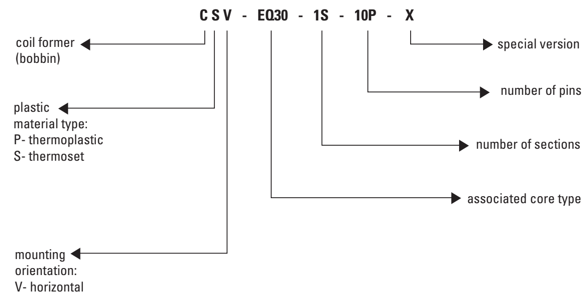


The EQ core design is derived from the ER and PQ. The EQ30 core is designed to be used in a compact AC/DC notebook adapter and DC/DC converter. It has the capability to handle a power range of 50 to 70 W (flyback topology) in an enclosed casing of a notebook adapter or 100 to 150 W in low profile DC/DC converter .
The advantages of the EQ30 core are a simple core shape, round centre pole, high A_e value (108 mm^2), a large winding window, low profile and 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	EQ30	EQ13
effective core parameters	core factor Σ I/A(mm^{-1})	0.426	0.911
	eff. volume V_e (mm^3)	4970	348
	eff. length l_e (mm)	46	17.5
	eff. area A_e (mm^2)	108	19.9
	min. area A_{min} (mm^2)	95	19.2
	mass of core set (g)	≈ 13.5	≈ 0.9
dimensions (mm)	A	30 ± 0.4	12.8 ± 0.3
	B	8 ± 0.15	2.85 ± 0.075
	C	20 ± 0.3	8.7 ± 0.25
	D	5.3 ± 0.2	1.75 ± 0.125
	E	26 ± 0.4	11.2 ± 0.3
	F	11 ± 0.2	5 ± 0.15
	G	19.45 ± 0.4	9.05 ± 0.3
coil formers	CSV	1S - 10P	





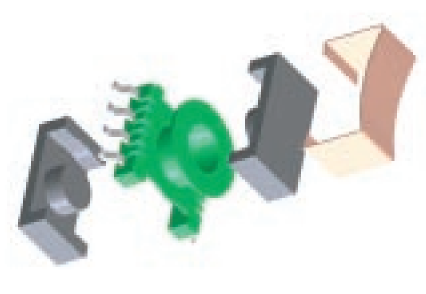
	Core type	EQ13	EQ30
core HALVES for power applications	3C90	1700	4300
	3C94 des		4300

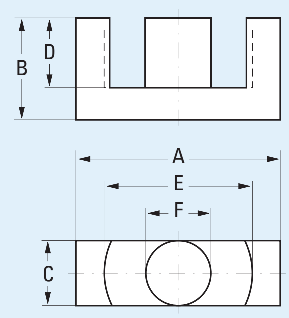
4300 — ungapped core half, A_L = 4300 measured in combination with another ungapped core half

A_L tolerance: ± 25%

Ferrite Ceramics

ER cores



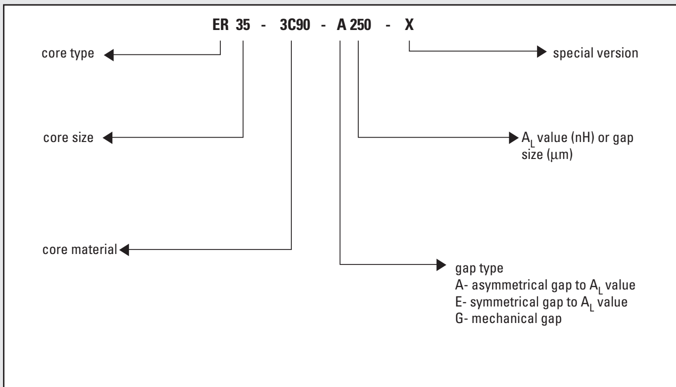


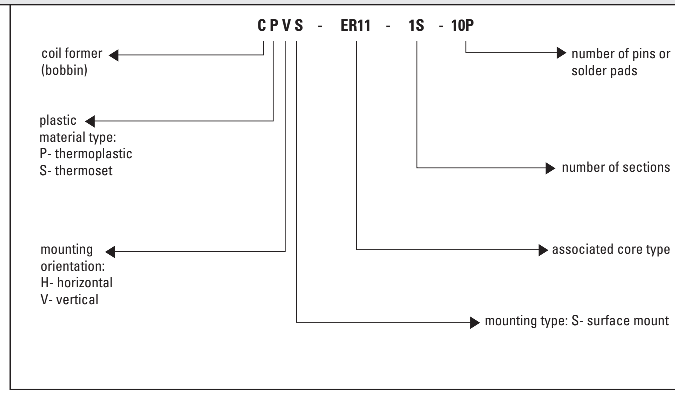
The ER core design is derived from the original E core and, like ETD and EC cores, has a round centre pole and outer legs with a radius to accomodate round coil formers.
These cores are mainly used for power transformers. The round centre pole allows the use of thicker wires while the shorter turn length 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	■	■	■			

PHILIPS





	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						

Ferrite Ceramics

ER cores

Core type		ER9.5 SETS des	ER11 SETS des	ER14.5 SETS des	ER28 HALVES	ER28L HALVES	ER35 HALVES	ER35W	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									

2400 — ungapped core half, A_L = 2400 nH measured in combination with another ungapped core half.

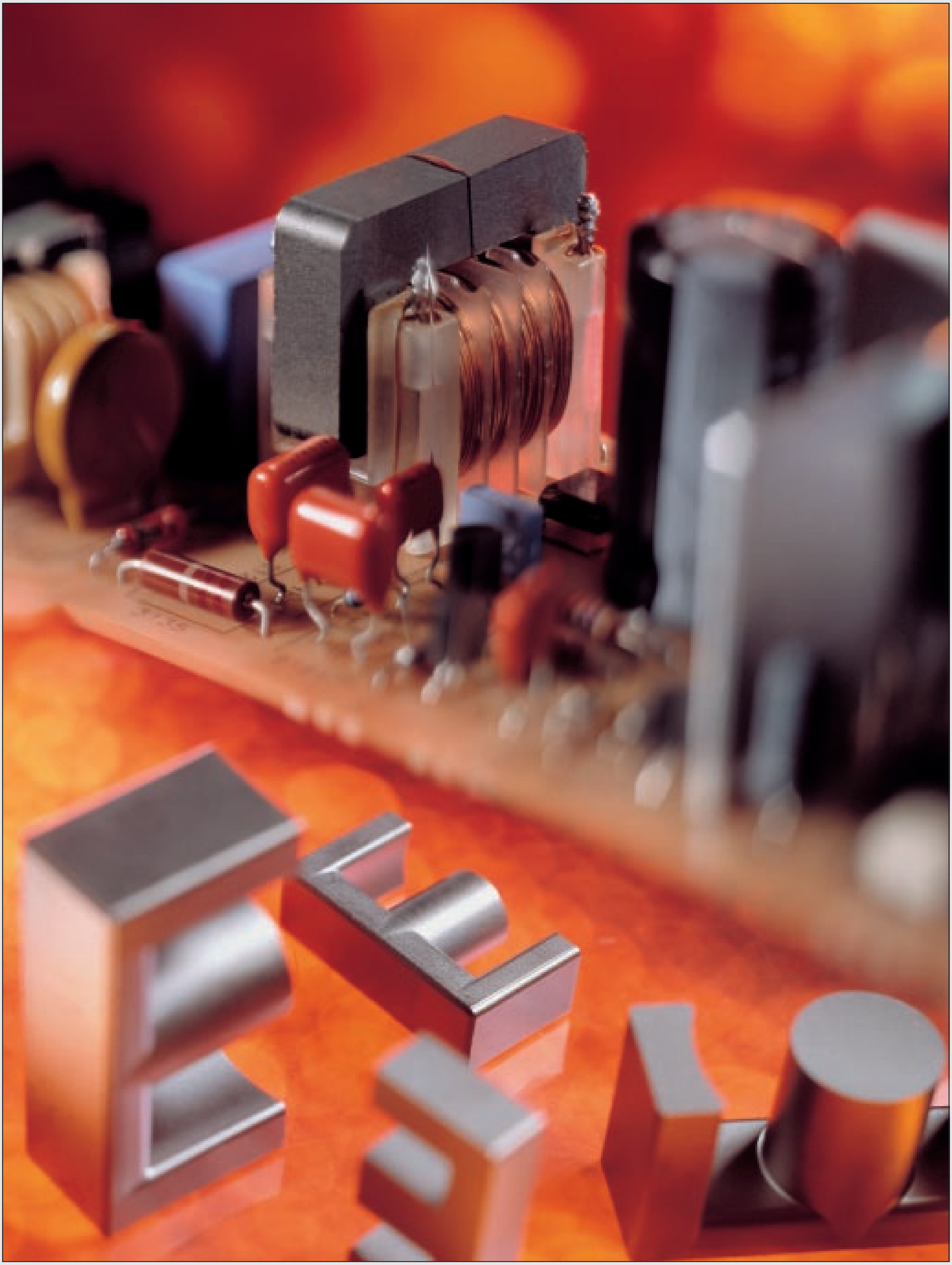
4800-S — ungapped core set, A_L = 4800 nH.

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%

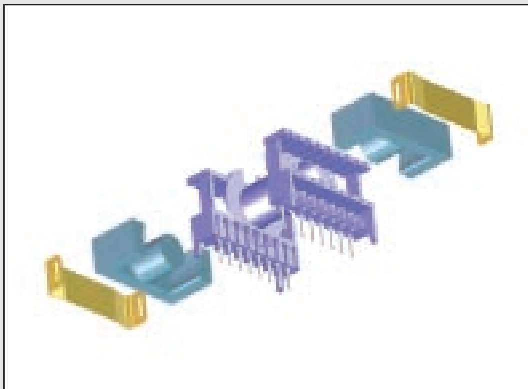
Ferrite Ceramics

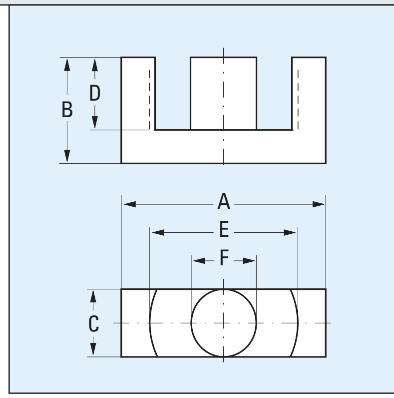
ETD cores

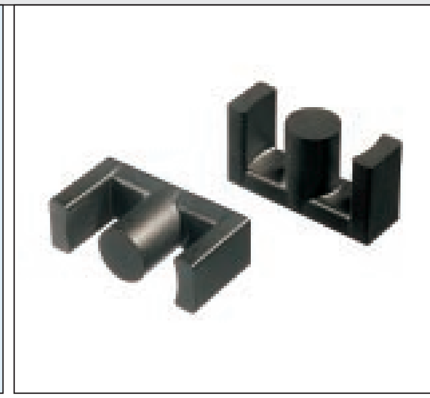


Ferrite Ceramics

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.

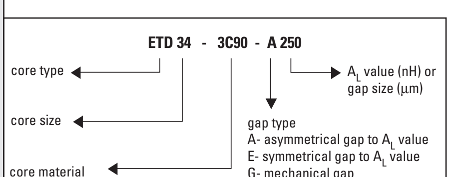
Summary:

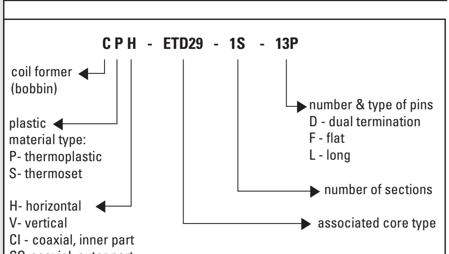
- optimized shape for AC/DC SMPS transformers up to 200 kHz
- lowest weight and volume for throughput power
- efficient mounting parts
- moderate shielding

	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	■	■	■	■	■	■	■

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

G50 — gapped core half with gap of 50 µm in centre pole.
2000 — ungapped core half. A_L = 2000 nH measured in combination with another ungapped core half.



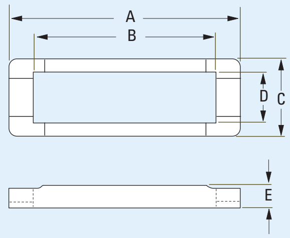


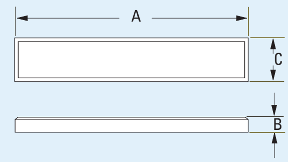
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

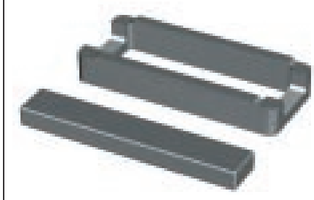
A_L tolerance: ± 25%

Ferrite Ceramics

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 :
- Slim
- 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 ± 0.15	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	■							

PHILIPS

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
core SETS for power applications: 3C94 des				

500 — ungapped core set. $A_L = 500$

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

A_L tolerance: ± 25%

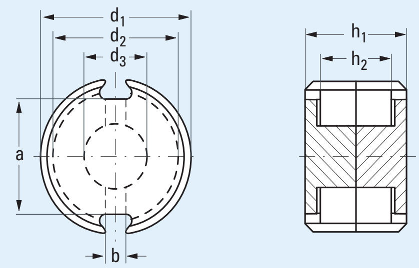
FRM20/5/15 - 3C90
- core type
- core size
- core material

BAR20/3/5.5 - 3C90
- core type
- core size
- core material

C P H S - FRM20/15 - 8S - 10P
- coil former (bobbin)
- plastic material type: P- thermoplastic, S- thermoset
- mounting orientation: H- horizontal, V- vertical
- mounting type: S- surface mount
- associated core type
- number of sections
- number of pins or solder pads

Ferrite Ceramics

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.

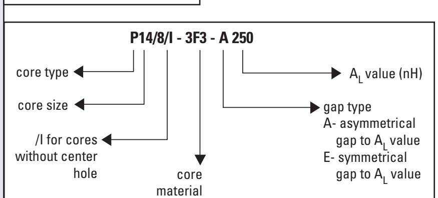
	Core type	P11/7/I	P14/8/I	P18/11/I	P22/13/I	P26/16/I
effective core parameters	core factor Σ I/A(mm^{-1})	0.860	0.700	0.560	0.450	0.360
	eff. volume V_e (mm^3)	309	628	1270	2460	4370
	eff. length l_e (mm)	16.3	21.0	26.7	33.3	39.6
	eff. area A_e (mm^2)	19.0	29.9	47.5	73.4	110
	min. area A_{min} (mm^2)	13.9	21.3	42.9	53.6	82.8
	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

remark: for coil formers and mounting parts see P cores in the Product Selection Guide "Ceramic and Thin-film Components for Signal Processing"

core SETS for general purpose transformers and power applications

Core type	P11/7/I	P14/8/I	P18/11/I	P22/13/I	P26/16/I
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.

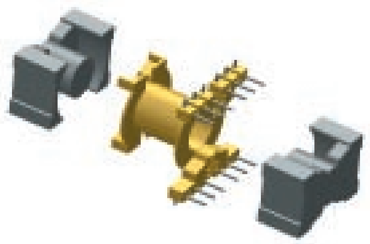


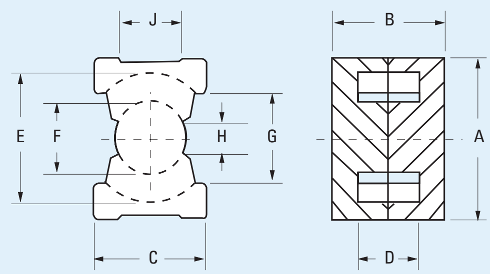
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

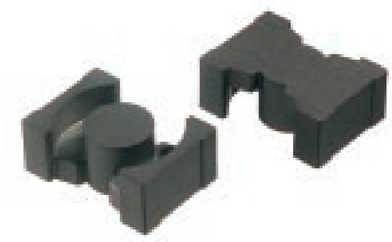
A_L tolerance: ± 3% (yellow) ± 5% (pink) ± 25% (green)

Ferrite Ceramics

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 I/A(mm^{-1})	0.600	0.726	0.380	0.456	0.335	0.459	0.481
	eff. volume V_e (mm^3)	2670	3180	6110	7210	8220	11200	14500
	eff. length l_e (mm)	40.1	48.1	48.2	57.3	52.5	71.8	83.6
	eff. area A_e (mm^2)	66.7	66.2	127	126	157	157	174
	min. area A_{min} (mm^2)	61.4	61.4	113	113	135	135	156
	mass of core set (g)	≈ 11	≈ 14	≈ 29	≈ 32	≈ 47	≈ 62	≈ 80
dimensions (mm)	A	21.3 ± 0.4		27.3 ± 0.46	27.3 ± 0.46	33 ± 0.5	33 ± 0.5	
	B	16.2 ± 0.2		20.2 ± 0.25	24.7 ± 0.25	20.6 ± 0.3	30.3 ± 0.25	
	C	14 ± 0.4		19 ± 0.45	19 ± 0.45	22 ± 0.5	22 ± 0.5	
	D	10.3 ± 0.3		11.5 ± 0.3	16.1 ± 0.3	11.5 ± 0.3	21.3 ± 0.3	
	E	18 ± 0.4		22.5 ± 0.46	22.5 ± 0.46	27.5 ± 0.5	27.5 ± 0.5	
	F	8.8 ± 0.2		12 ± 0.2	12 ± 0.2	13.5 ± 0.25	13.5 ± 0.25	
	G	12 min		15.5 min	15.5 min	19 min	19 min	
	H	4 min		6 min	6 min	5.5 min	5.5 min	
	J	7.9 min		10.5 min	10.5 min	11.6 min	11.6 min	
coil formers	CPV	1S - 14P 1S - 14PD		1S - 12P 1S - 12PD	1S - 12P 1S - 12PD	1S - 12P 1S - 12PD	1S - 12P 1S - 12PD	

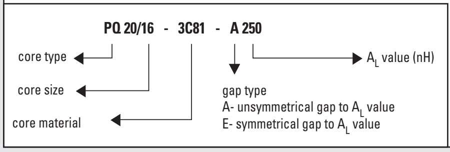
core SETS for general purpose transformers and power applicaitons

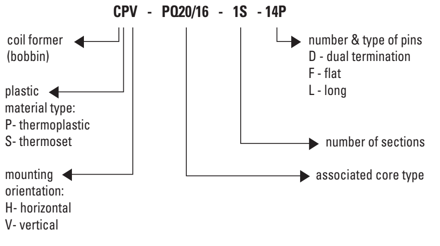
Core type		PQ20/16	PQ20/20	PQ26/20	PQ26/25	PQ32/20	PQ32/30	PQ35/35
3C81		A160	A160	E250	E250	E315	E315	E315
		A250	A250	A315	A315	A400	A400	E400
		A315	A315	A400	A400	A630	A630	A630
		A400	A400	A630	A630	A1000	A1000	A1000
		A630	A630	A1000	A1000	A1600	A1600	A1600
		4080	3580	7020	6010	7560	6570	5330
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

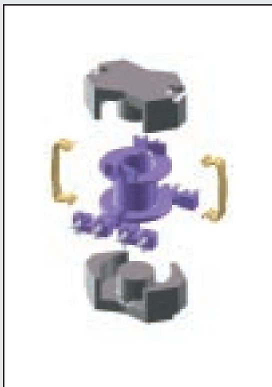
A_L tolerance: ± 3% | ± 5% | ± 25%

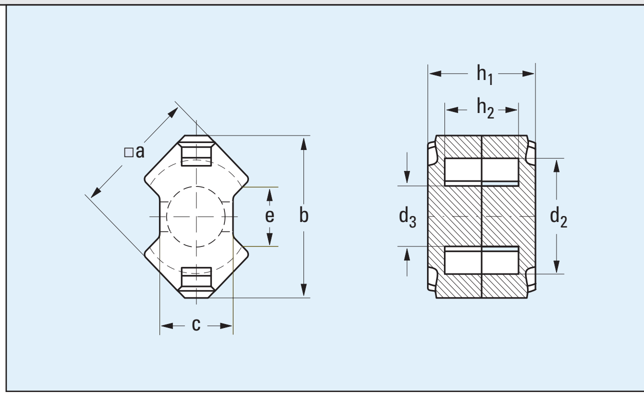




Ferrite Ceramics

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

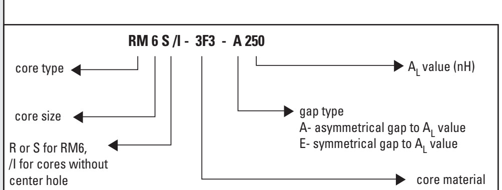
remark: coil formers CSV series with other pin configurations available on request.

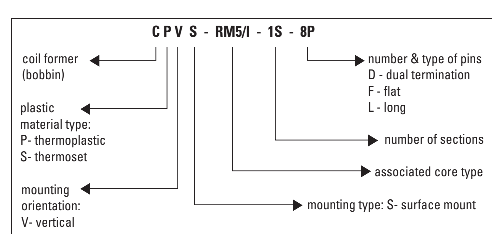
	Core type	RM4/I	RM5/I	RM6S/I	RM8/I	RM10/I	RM12/I	RM14/I
effective core parameters	core factor Σ l/A(mm^{-1})	1.69	0.935	0.784	0.604	0.462	0.388	0.353
	eff. volume V_e (mm^3)	322	574	1090	2440	4310	8340	13900
	eff. length l_e (mm)	23.3	23.2	29.2	38.4	44.6	56.6	70.0
	eff. area A_e (mm^2)	13.8	24.8	37.0	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 SETS for general purpose transformers and power applications

Core type	RM4/I	RM5/I	RM6S/I	RM8/I	RM10/I	RM12/I	RM14/I
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			

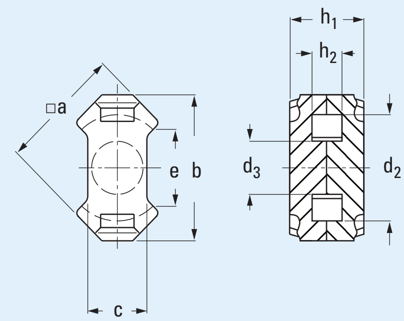
E63 — gapped core set with A_L = 63 nH, symmetrical gap (E).
A315 — gapped core set with A_L = 315 nH, asymmetrical gap (A).
2000 — ungapped core set, A_L = 2000 nH.





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%



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	> 8.4	> 9.5	> 10.9	> 12.9	> 17
	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		

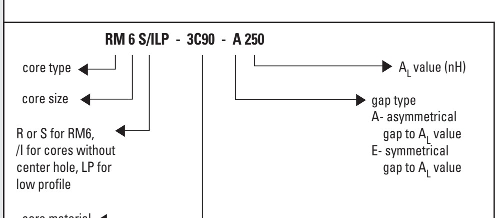
core SETS for general purpose transformers and power applications

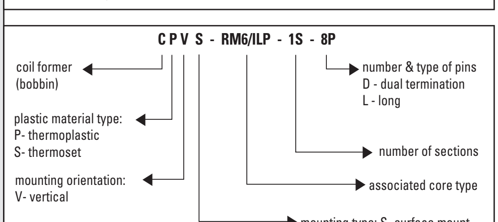
Core type	RM4/ILP des	RM5/ILP des	RM6S/ILP des	RM8/ILP des	RM10/ILP des	RM12/ILP des	RM14/ILP des
3C90	1400	2350	3175	4550	6300	8100	9400
3C94 des	1400	2350	3175	4550	6300	8100	9400
3C96 prot	1250	2100	2900	4100	5600	7200	8300
3F3	1200	2000	2700	3800	5200	6700	7700
3F35 prot	1000	1700	2200	3100			
3F4 des	750	1250	1600	2200	3000	3600	4200

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

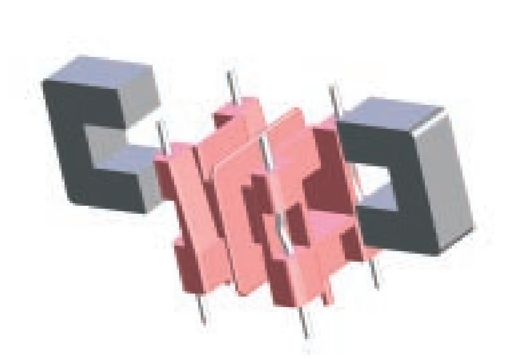
A_L tolerance: ± 25%

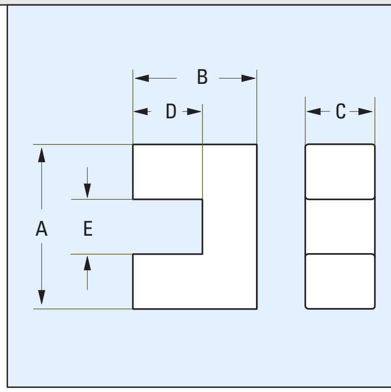


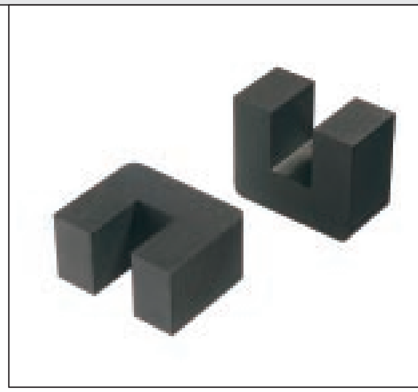


Ferrite Ceramics

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.

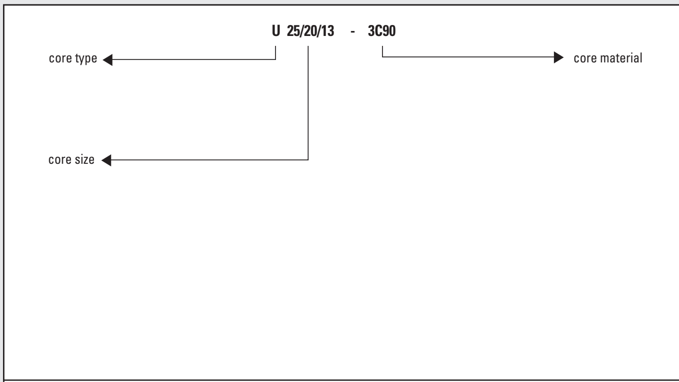
Summary:

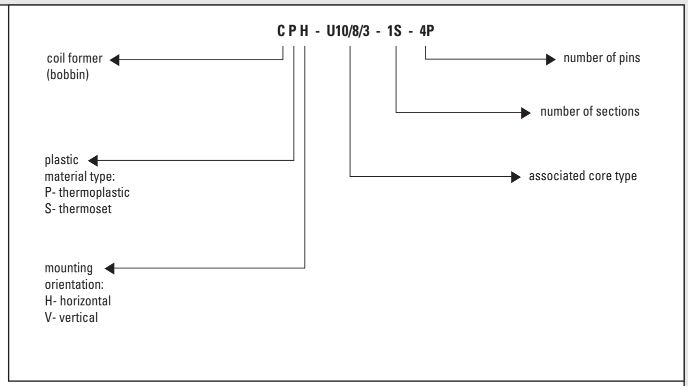
- simple, economic shape
- can be stacked for high power
- bulky sizes
- no self-shielding

	Core type	U10/8/3	U11/8/5	U15/11/6	U16/9.8/6	U20/16/7	U25/16/6 (376U250)	U25/20/13	U30/25/16
effective core parameters	core factor Σ I/A(mm^{-1})	4.74	3.20	1.60	2.07	1.21	2.07	0.850	0.690
	eff. volume V_e (mm^3)	309	501	1680	1255	3800	3380	9180	17900
	eff. length l_e (mm)	38.3	40	52	51	68	83.6	88.2	111
	eff. area A_e (mm^2)	8.07	12.5	32.3	24.6	56	40.3	104	161
	min. area A_{min} (mm^2)	7.91	12.5	32.3	22.2	56	40.3	104	161
	mass of core half (g)	≈ 0.9	≈ 1.5	≈ 4	≈ 3.6	≈ 9	≈ 8	≈ 23.5	≈ 43
dimensions (mm)	A	9.9 ± 0.3	10.5 ± 0.2	15.4 ± 0.5	15.7 ± 0.3	20.8 ± 0.6	25.4 + 0.5/ -0.4	24.8 ± 0.7	31.3 ± 0.7
	B	8.2 - 0.2	7.8 ± 0.1	11.45 ± 0.2	9.8 ± 0.3	15.6 ± 0.2	15.9 ± 0.13	19.6 ± 0.2	25.3 ± 0.2
	C	2.85 ± 0.15	5 ± 0.15	6.25 + 0.4	6 ± 0.2	7.5 ± 0.25	6.4 ± 0.13	12.7 ± 0.3	16+0.5/ -0.1
	D	5 + 0.3	5.3 ± 0.3	6.4 ± 0.35	6.1 ± 0.25	8.3 ± 0.3	9.5 ± 0.13	11.4 ± 0.4	14.9 ± 0.4
	E	4.35 ± 0.2	5.5 ± 0.2	5.4 ± 0.4	6.8 ± 0.3	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	680	1400		1900		2900	3700
	3E25		1200	3400 des	2600	4800 des	2320 sup	6300 des	
	3E26				≥ 2890				
	3E27						2320		

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%





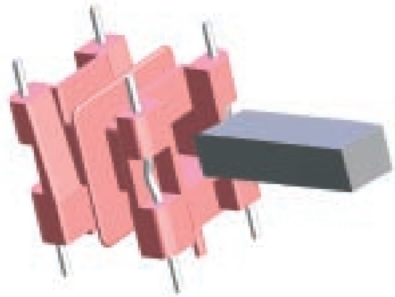
	Core type	U33/22/9 (1F30)	U67/27/14 (1F10)	U93/76/16	U93/52/30	U93/76/30	U100/57/25
effective core parameters	core factor Σ l/A(mm^{-1})	1.27	0.850	0.790	0.307	0.421	0.478
	eff. volume V_e (mm^3)	9490	35200	159000	217000	297000	199000
	eff. length l_e (mm)	110	173	354	258	354	308
	eff. area A_e (mm^2)	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						

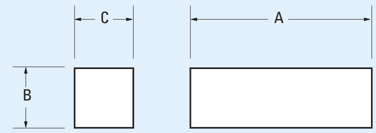
540 — A_L = 540 nH measured in combination with another ungapped core half.
A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, $T = 25°C$

A_L tolerance: ± 25%

Ferrite Ceramics

I cores





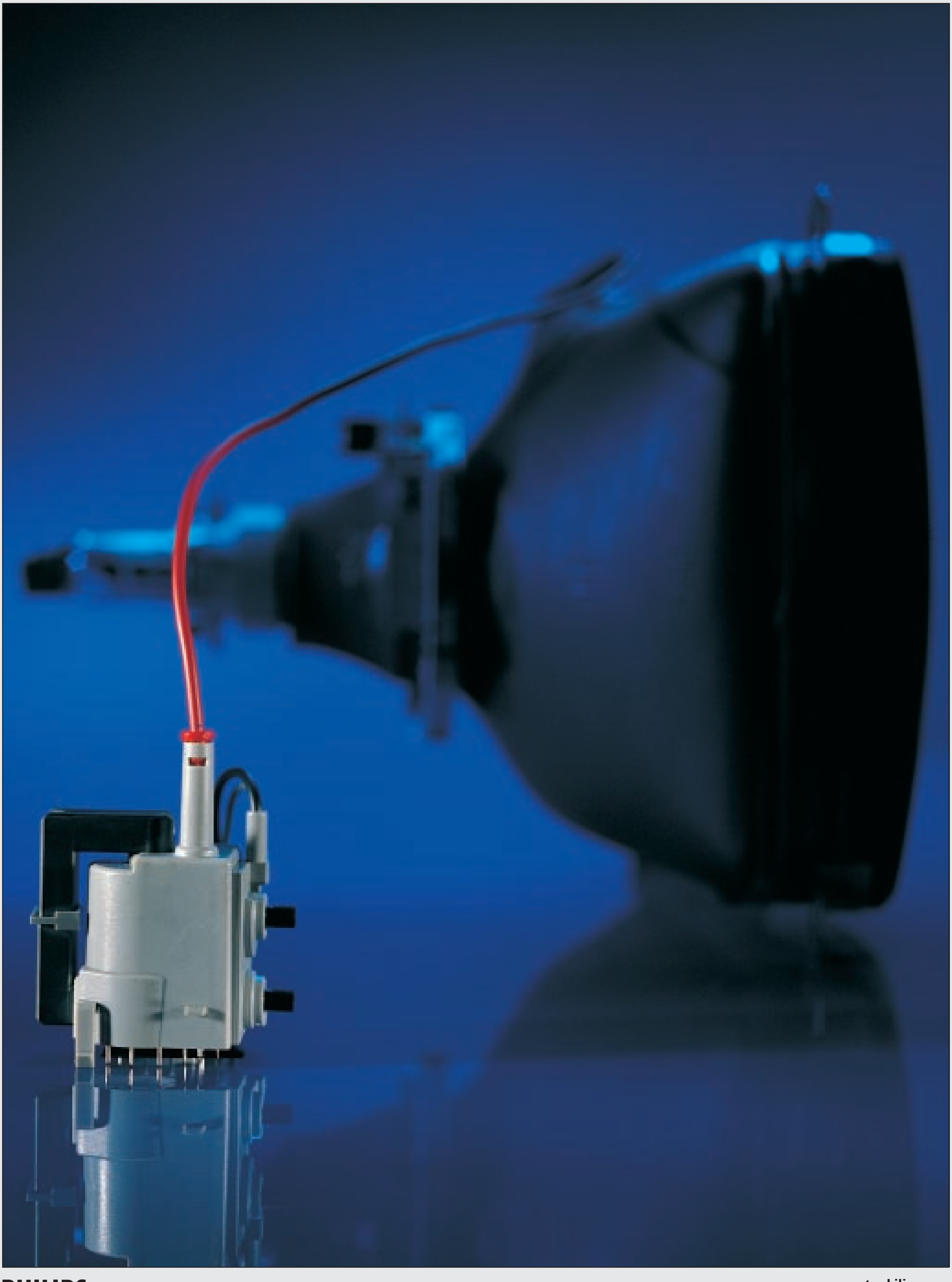
I cores are often used in combination with U-cores to build a simple transformer or inductor.
The smaller types, I 15, I 20 and I 25 fit the range of U coil formers.
This combination is suitable for easy to wind inductors in applications such as interference filters and output chokes.
As with rods, the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

I 15/3/3 - 3C90

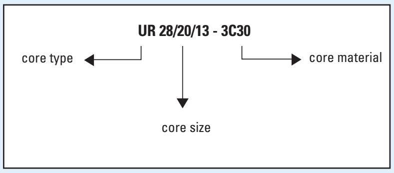
core type ← | core size ↓ | → core material

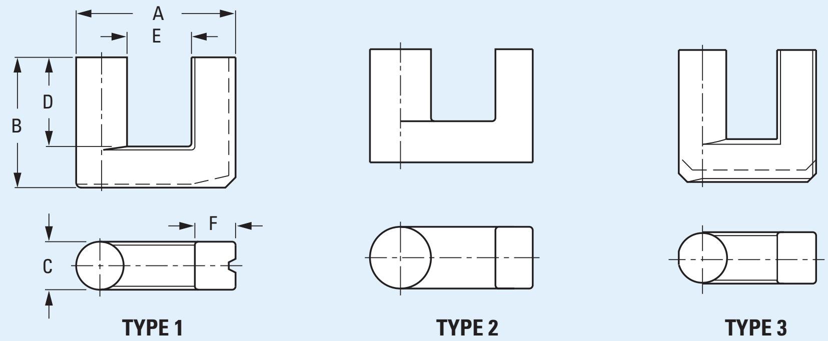


Ferrite Ceramics

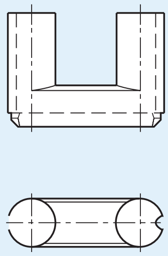
UR cores

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.

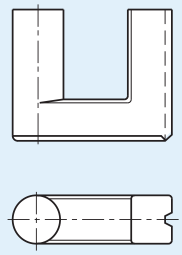




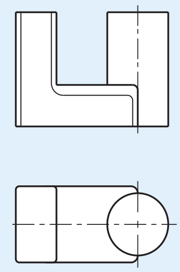
Core type	shape	dimensions (mm)						effective core parameters				
		A	B	C	D	E_{min}	F	core factor Σ I/A (mm^{-1})	eff. volume V_e (mm^3)	eff. length l_e (mm)	eff. area A_e (mm^2)	mass of core half (g)
UR20/14/13	6	19.8	13.8	12.9	10.6	9.8	3.0	2.07	2956	78.2	37.8	8
UR28/20/14	6	28.3	20.4	11.2	13.0	8.5	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



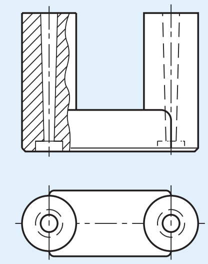
TYPE 4



TYPE 5



TYPE 6



TYPE 7

shape	product range			
	3C81 / 3F3	3C15	3C30 des	3C34 prot
6	-	-	UR20/14/13-3C30	-
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 Ceramics

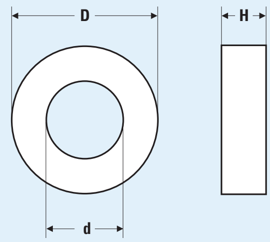
Ferrite ring cores (toroids)

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

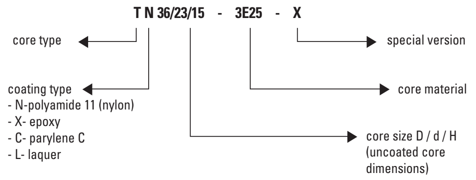


Core type	dimensions (mm)			effective core parameters				
	outside diameter D	inside diameter d	height H	core factor Σ l/A(mm^{-1})	eff. volume V_e (mm^3)	eff. length l_e (mm)	eff. area A_e (mm^2)	mass (g)
TC2.5/1.3/1.3	2.54 ± 0.1	1.27 ± 0.1	1.27 ± 0.1	7.14	4.29	5.53	0.78	0.022
TC2.5/1.5/0.8	2.5 ± 0.1	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	0.014
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
TC3.4/1.8/1.3	3.43 ± 0.13	1.78 ± 0.13	1.27 ± 0.13	7.93	7.3	7.62	0.96	0.035
TC3.4/1.8/2	3.38 ± 0.13	1.78 ± 0.13	2.06 ± 0.13	4.97	11.5	7.54	1.52	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	0.042
TC3.9/2.2/1.3	3.94 ± 0.13	2.24 ± 0.13	1.27 ± 0.13	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	0.074
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	0.040
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	0.060
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	0.070
TC5.8/3.1/1.5	5.84 ± 0.13	3.05 ± 0.13	1.52 ± 0.13	6.52	26.1	13.0	2.00	0.12
TC5.8/3.1/3.2	5.84 ± 0.13	3.05 ± 0.13	3.17 ± 0.13	3.05	55.6	13.0	4.27	0.25
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 ± 0.25	3.8 ± 0.15	2.5 ± 0.15	4.97	46.5	15.2	3.06	0.23
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 ± 0.35	4.75 ± 0.15	3.2 ± 0.15	2.89	146	20.7	7.16	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 ± 0.25	6.9 ± 0.25	5.03 ± 0.13	2.43	358	29.5	12.1	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 ± 0.25	7.67 ± 0.25	6.6 ± 0.25	2.25	434	31.2	13.9	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 ± 0.3	8.22 ± 0.18	4.95 ± 0.13	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 ± 0.43	13.47 ± 0.3	6.6 ± 0.25	2.20	1330	54.2	24.6	6.5
TX22/14/13	22.35 ± 0.43	13.47 ± 0.3	12.95 ± 0.25	1.07	2750	54.2	50.7	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 ring cores (toroids)

Core type	dimensions (mm)			effective core parameters				
	outside diameter D	inside diameter d	height H	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 (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 ± 0.65	18.75 ± 0.4	7.85 ± 0.25	2.06	2600	73.2	35.5	13
TN29/19/15	29.9 ± 0.7	18.1 ± 0.6	15.5 ± 0.6	0.978	5481	73.2	74.9	27
TN32/19/13	32.2 ± 0.8	18.1 ± 0.6	13 ± 0.5	0.99	5820	76	76.5	29
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 ± 0.7	22.75 ± 0.5	10.42 ± 0.25	1.46	5770	89.7	61.4	27
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 ± 0.7	22.75 ± 0.5	15.5 ± 0.38	0.96	8685	89.7	93.8	40
TX39/20/13	39.15 ± 0.7	19.3 ± 0.5	12.95 ± 0.38	0.76	9980	84.9	111	45
TL42/26/13	42.1 ± 1.1	25.9 ± 0.8	12.75 ± 0.5	1.076	9860	103	95.8	53
T50/30/19	50 ± 1	30 ± 0.7	19 ± 0.5	0.65	22378	120.4	186	100
TX51/32/19	51.05 ± 1.2	31.5 ± 0.64	19.3 ± 0.38	0.73	22300	125	172	100
TL55/32/18	55.8 ± 1.7	32.1 ± 1	18.3 ± 0.9	0.651	26580	131.5	202	120
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	73.91 ± 1.53	38.61 ± 0.76	12.95 ± 0.51	0.80	35200	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 ± 1.3	18.3 ± 0.35	0.700	96200	259	370	456
T107/65/25	107 ± 2	65 ± 1.3	25 ± 0.75	0.504	133000	259	514	680
T140/106/25	140 ± 3	106 ± 2	25 ± 1	0.903	161086	382	422	795



Isolation voltage

cores with polyamide and laquer coating (TN and TL)

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

cores with epoxy coating (TX):
1000 V_{DC}

cores with parylene coating (TC):
750 V_{RMS}

T = Toroid (Ring Core), TN = Toroid Nylon coated, TL = Toroid Laquered, TX = Toroid epoXy coated, TC = Toroid parylene C coated

Ferrite Ceramics

Ferrite ring cores (toroids)

Core type \ Material / Colour Code	3C81	3C90	3C11 *white*	3F3 *blue*	3F4 *beige*	3E25 *orange*	3E27 *green*	3E5 *yellow /white*	3E6 *purple /white*	3R1 *black*
TC2.5/1.3/1.3									1835 des	
TC2.5/1.5/0.8									765 des	
TC2.5/1.5/1-S									1020 des	
TC3.1/1.3/1.3						1225 des				
TC3.4/1.8/1.3							660			
TC3.4/1.8/2						1420 des				
TC3.5/1.6/1.3			862							
TC3.9/2.2/1.3							575			
TC4/2/2			1190							
TC4/2.2/1.1				260		725		1120	1315 des	
TC4/2.2/1.6				380		1050		1630	1915 des	
TC4/2.2/1.8									2130 des	
TC5.8/3.1/1.5							890			
TC5.8/3.1/3.2									4130 des	
TC5.9/3.1/3						2150				
TC6/4/2				325		890		1380	1620 des	
TC6.3/3.8/2.5				500		1390		2150	2530 des	
TN9/6/3		560		440		1340		2070[2]	2435[1] des	■
TC9.5/4.8/3.2	1200						2135		4390 des	
TN10/6/4		940 des	1750	740		2250		3470[2]	4085[2] des	
TX13/7.1/4.8	1475	1260 des		990			2750		5400 des	
TN13/7.5/5		1170 des	2200	900	460 des	2810		4340[2]	5095[2] des	■
TX13/7.9/6.4	1620	1380 des		1100		3000	3000		5900 des	
TN14/9/5		1015 des	1900	790		2430		3760[2]	4415[2] des	■
TN14/9/9		1825 des	3400	1430		4370		6760[2]	7955[2] des	
TX16/9.1/4.7	1400	1215 des					2600		5200 des	
TN16/9.6/6.3		1480 des	2700	1160		3540		5470[2]	6430[2] des	
TN19/11/10		2680 des	5000			6420				
TN19/11/15		4020 des	7500			9630				
TN20/10/7		2230 des	4150			5340		8250[2]	9685[2] des	

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

Available sizes: ■

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

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

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 / Colour Code	3C81	3C90	3C11 white	3F3 blue	3F4 beige	3E25 orange	3E27 green	3E5 yellow /white	3E6 purple /white	3R1 black
TX22/14/6.4	1650	1400 des					3055		6000 des	
TX22/14/13				2000			6110		12080 des	
TN23/14/7		1600 des	3000	1250		3820				■
TN25/15/10		2350 des	4400	1840		5620		8680[2]	10200[2] des	
TN26/15/10		2645 des	5000			6420		10000[2]		
TN26/15/20		5400 sup	10000			12800				
TN29/19/7.5		1460	2700			3550			6340 des	
TX29/19/7.6	1740						3225			
TN29/19/15						7000			12850[2] des	
TN32/19/13		2910 des	5450	2270		6950		10700[2]		
TN36/23/10		2060 des	3900							
TX36/23/10							4545		9090 des	
TX36/23/15	3670						6800		13600 des	
TN36/23/15		3090 des	5800	2420	1200	7390		11400[2]	13400[2] des	■
TX39/20/13	4700	3800 des					8720			
TL42/26/13		2690 des	5000			6425				
T50/30/19									19400 des	
TX51/32/19	4800	3980 des		3200		8850	8890		17300 des	
TL55/32/18						10620	10620			
TL58/41/18		2890 des	5400			6900				
TL63/38/25				4550		13900				
TX74/39/13	4350	3620 des		2900		8060			15775[2] des	
TL87/54/14		2930 des	5470							
T87/56/13									11190 des	
T102/66/15			5300[3] des			7900[3] des				
TL107/65/18					1354[3] des	9900 des				
T107/65/25				4485[3] des	1870[3] des					
T140/106/25						7700[3] des				

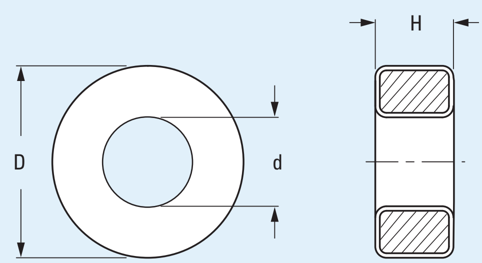
1200 — nominal A_L value (nH) measured at $\hat{B} \leq 0.1$ mT, $f \leq 10$ kHz, T = 25°C

Available sizes: ■

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

A_L tolerance: ± 20% | ± 25% | ± 30%

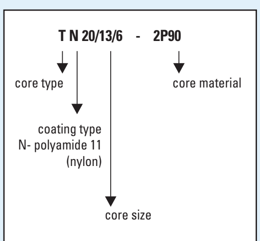
T = Toroid (Ring Core), TN = Toroid Nylon coated, TL = Toroid Laquered, TX = Toroid epoXy coated, TC = Toroid parylene C coated



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%

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	≈ 10^5	≈ 10^5	≈ 10^5	≈ 10^5	≈ 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 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.

Ferrite Ceramics

Specialty ferrites

machined ferrites

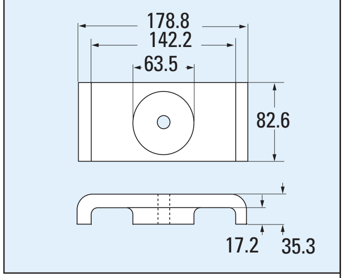
Machined ferrites and specialty shapes

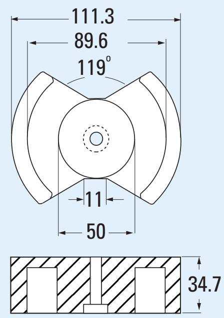
We stock blocks of most of our material grades and are able to machine all sorts of prototype cores from these blocks. Very close tolerances can be realized, if required.

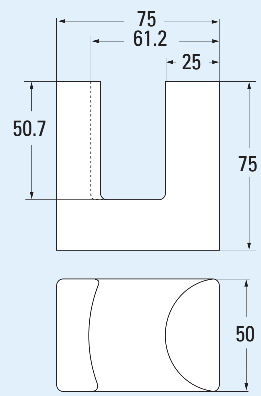
Ferrites are very hard and brittle and, therefore, difficult to work. Machining and grinding ferrites and similar materials to micron precision places stringent requirements on machines and men. To attain optimum standards requires very close cooperation between us and the manufacturers of the machines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

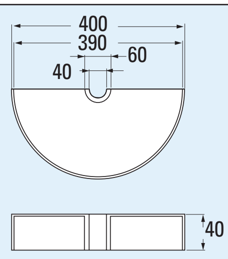
There are several reasons to go for machined ferrite cores. Sometimes samples are required on very short notice, while pressing tools are not yet available. On other occasions only a limited number of cores will be needed and it is not worthwhile to make a tool at all. Cores can be so complicated or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

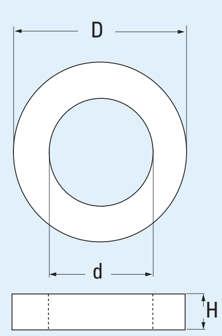
The following drawings provide a good impression of the variety of cores we have produced. For some of the cores we also have pressing tools available.





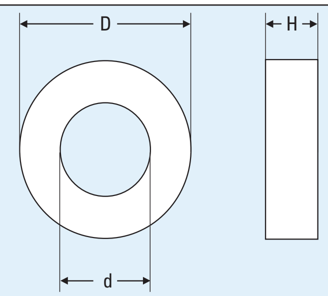






ferrites for particle accelerators

ring cores



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	♦			

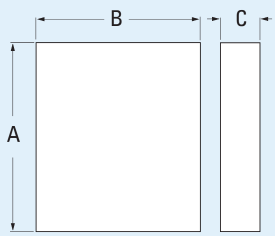
Our product range

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

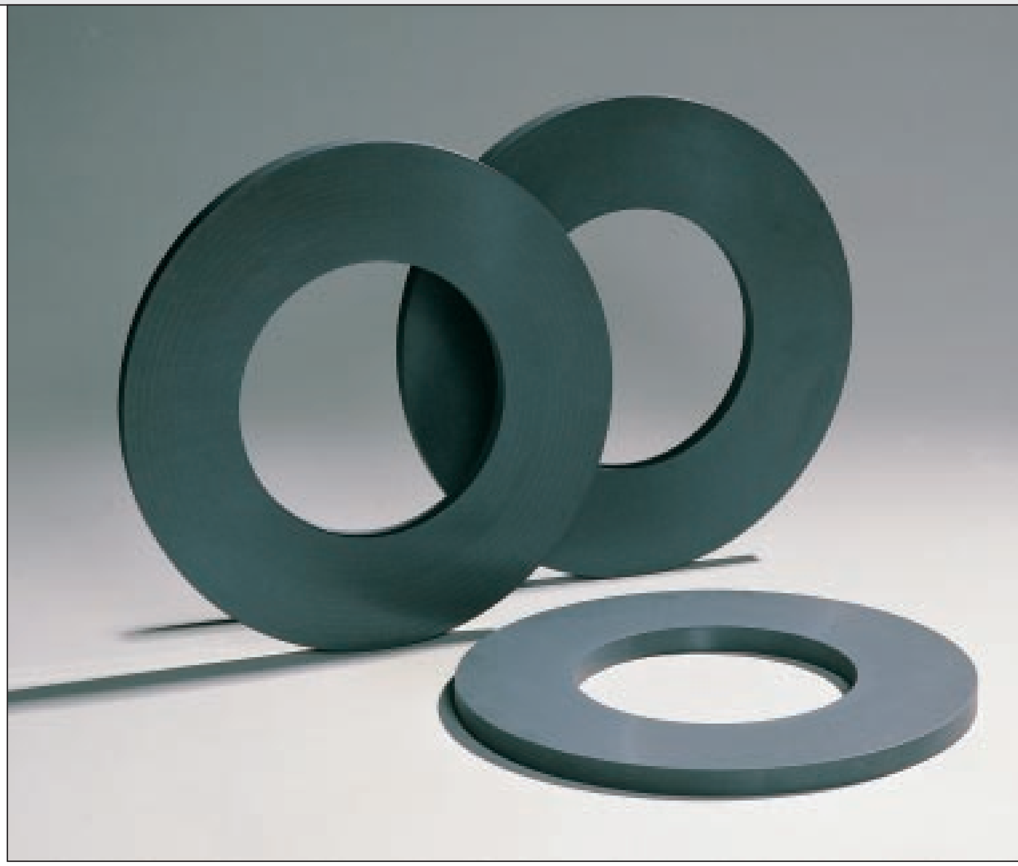
ferrites for particle accelerators

plates / blocks

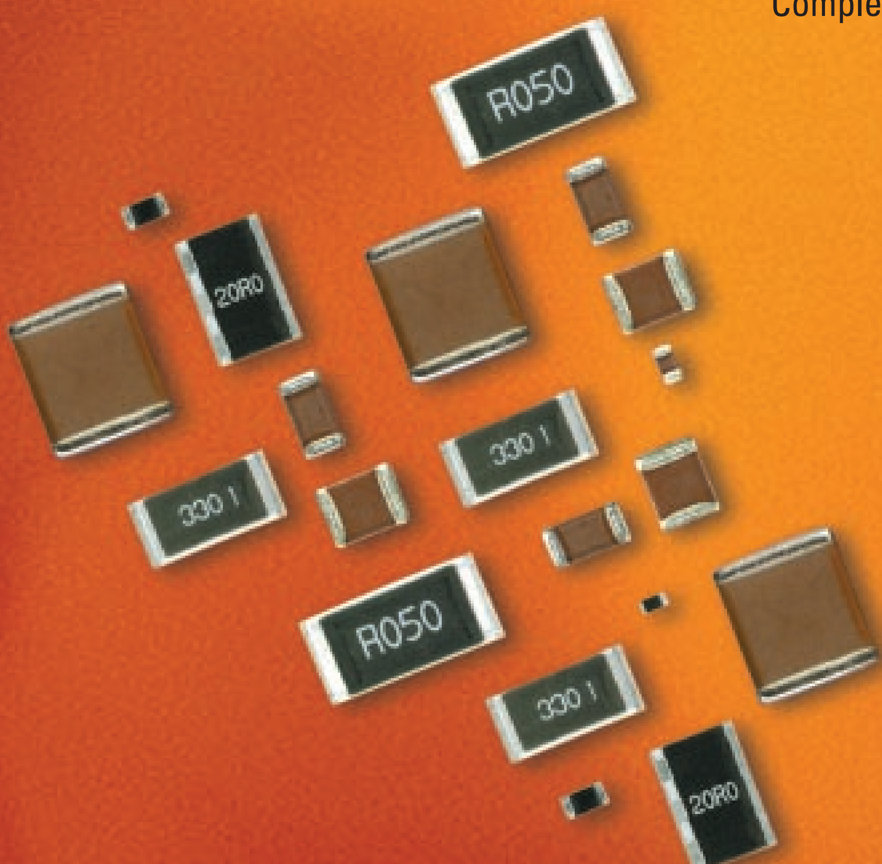


PLT80/72/19		
A	**B**	**C**
80 ± 0.3	72 ± 0.05	18.6 ± 0.1
mass (g)		
≈ 550		

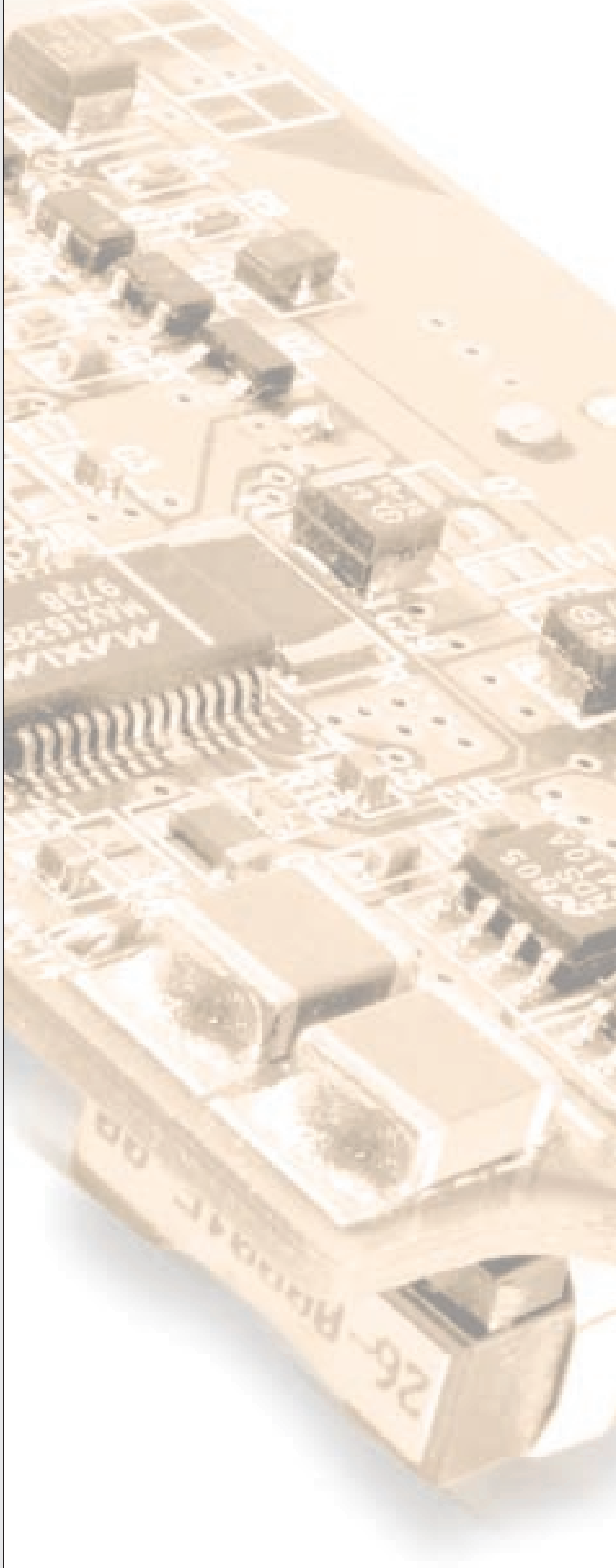
PLT100/65/25		
A	**B**	**C**
100 ± 0.3	65 - 0.3	25
mass (g)		
≈ 800		



Discrete Ceramics, SMD



Discrete Ceramics, SMD



Discrete surface-mount components for power applications

Modern trends in power supplies

Developments in modern equipment toward higher functionality and higher frequency operation coupled with ever greater levels of miniaturization are placing special demands on power supplies. In particular, advanced circuitry in today's EDP, telecommunications and multimedia equipment often require a range of precisely matched supply voltages – from 12 V down to less than 1 V. What's more, the extremely high slew rates needed to switch the latest generation of processors, often in the region of 10 A/ms, demand that power sources be located close to the processors to minimize the inductive effects of connecting wires. For power supplies, all this implies:

- multi-power distribution systems comprising a main SMPS supplying several DC/DC converters dedicated to providing specific sub-systems with the necessary operating voltages
- very high switching frequencies to enable the power supplies to react to fast load variations induced in the HF semiconductor systems
- special measures for eliminating high-frequency noise, EMI and the effects of ripple generated by the ultra-fast SMPS circuitry.

CMCs for high-frequency power applications

At the component level, these requirements have led to a dramatic increase in the use of Ceramic Multilayer Capacitors (CMCs) in place of film, tantalum and electrolytic capacitors. This is principally because the higher capacitance values formerly needed in, for example, buffering applications are no longer necessary at today's ultra-high operating frequencies. This replacement has, moreover, been facilitated by the higher capacitance values of today's CMCs, which in turn have become possible because of the trend toward lower voltage operation. Other benefits offered by CMCs include bipolarity, superior lifetime at elevated temperatures, high breakdown voltages and low ESR. Their small size and the fact that they are true surface-mount components are also major benefits, particularly in multi-power distribution systems where they allow for optimum miniaturization in the high-speed semiconductor systems.

Principal power applications for CMCs include input and output buffering in rectifier and DC/DC converter circuits, smoothing, energy storage in timing circuits, snubber circuits, DC decoupling and HF noise suppression.

Philips' range of CMCs for use in power applications includes:

- high-value, low ESR CMCs offering a cost-effective alternative to tantalum capacitors
- feedthrough CMCs with very low ESL and ESR for EMI and HF noise suppression
- high-voltage CMCs for surge protection, DC blocking and lamp ballast circuitry
- low-inductance CMCs for high-frequency coupling/decoupling networks

Chip resistors complete the range

Complementing its CMC range, Philips also offers a broad range of chip resistors specifically for power applications, including:

- precision chip resistors with low temperature coefficient for precision voltage divider and bias circuitry.
- low-ohmic power chip resistors offering resistances down to 10 mW for current sensing
- high-power chip resistors offering a broad resistance range and power ratings up to 1 W
- surge chip resistors providing exceptionally high di/dt pulse withstanding capability

Part numbering system and ordering

You can order components from this catalogue in two ways.
Both ways give logistic and packaging information.

Clear text ordering code (preferred)
This unique number is an easy-readable 15-digit code.

12-digit ordering code
This unique 12 NC number forms the basis for the Philips logistic system.

You will find details for ordering in the *Ordering* section next to each selection chart.

Minimum shipment quantities, prices and delivery details can be obtained from the Philips Components sales organization in your country or from one of our franchised distributors.

Custom-design service

Besides the products listed in this catalogue, we also offer application-specific components and a custom-design service for customers with special requirements. Please consult our local representative if you require these services.

Ni-barrier versus AgPd terminations

Almost all our CMCs are supplied with Ni-barrier terminations but AgPd terminations can be supplied on special request. A small number of products, however, mostly the larger sizes, are available only with AgPd terminations. This is clearly indicated in the ordering information of each series.

Electrode technology

Two electrode technologies are currently used in Philips CMCs:

Noble metal electrodes (NME) based on palladium with conventional ceramic materials

Base metal electrodes (BME), a newer technology based on nickel. We plan to extend our **BME** product ranges.

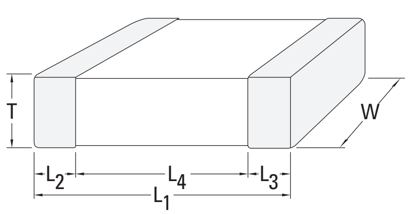
Water-based manufacturing process

Philips Components has recently introduced a revolutionary mass-manufacturing process for their Ceramic Multilayer Capacitors which is environmentally friendly, stable, safe and economical.
The process produces ceramic sheets using a water-based binder instead of the conventional, potentially harmful solvent method.

In addition, a water-based electrode paste has been developed, which achieves the same results as solvent-based pastes. This now means that Philips' CMCs are free of all organic solvents.

WATER BASED

Case size dimensions in mm and inches



Size code	mm						
	L_1	W	T_{min}*	T_{max}*	L_2, L_3 min	L_2, L_3 max	L_4 min
1005	1.0 ± 0.05	0.50 ± 0.05	0.45	0.55	0.20	0.30	0.40
1608	1.6 ± 0.10	0.80 ± 0.07	0.73	0.87	0.20	0.60	0.40
2012	2.0 ± 0.10	1.25 ± 0.10	0.50	1.35	0.25	0.75	0.55
3216	3.2 ± 0.15	1.6 ± 0.15	0.50	1.75	0.25	0.75	1.40
3225	3.2 ± 0.20	2.5 ± 0.20	0.50	1.80	0.25	0.75	1.40
4532	4.5 ± 0.20	3.2 ± 0.20	0.50	1.80	0.25	0.75	2.20
5750	5.7 ± 0.20	5.0 ± 0.20	0.50	1.80	0.25	0.75	2.90

Size code	inches						
	L_1	W	T_{min}*	T_{max}*	L_2, L_3 min	L_2, L_3 max	L_4 min
0402	0.04 ± 0.002	0.02 ± 0.002	0.018	0.022	0.008	0.012	0.016
0603	0.063 ± 0.004	0.032 ± 0.003	0.029	0.035	0.008	0.024	0.016
0805	0.079 ± 0.004	0.049 ± 0.004	0.020	0.053	0.010	0.030	0.022
1206	0.126 ± 0.006	0.063 ± 0.006	0.020	0.069	0.010	0.030	0.056
1210	0.126 ± 0.008	0.098 ± 0.008	0.020	0.072	0.010	0.030	0.056
1812	0.177 ± 0.008	0.126 ± 0.008	0.020	0.072	0.010	0.030	0.088
2220	0.224 ± 0.008	0.197 ± 0.008	0.020	0.072	0.010	0.030	0.114

* Detailed information on thickness can be found in the selection table of each series

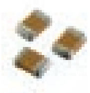
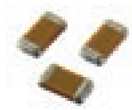
Ceramic Multilayer Capacitors

High capacitance X7R 10 V

WATER BASED

NEW

10 V

Cap.	last two digits of 12 NC	0603	0805	1206	Cap.	last two digits of 12 NC
µF 0.15	52				µF 0.15	52
0.18	53	0.8 ± 0.07			0.18	53
0.22	54		0.6 ± 0.10		0.22	54
0.27	55				0.27	55
0.33	56				0.33	56
0.39	57		0.85 ± 0.10		0.39	57
0.47	58				0.47	58
0.56	59				0.56	59
0.68	61		1.25 ± 0.10		0.68	61
0.82	62				0.82	62
1.0	63			0.85 ± 0.10	1.0	63
1.2	64				1.2	64
1.5	65				1.5	65
1.8	66			1.15 ± 0.10	1.8	66
2.2	67				2.2	67
Tape width		8 mm				Tape width

in columns : Thickness class

Thickness classes and packaging quantities

Thickness classes (mm)	8 mm tape width amount per reel				amount per bulk case	
	180 mm / 7"		330 mm / 13"			
	paper	blister	paper	blister	0603	0805
0.6 ± 0.1	4 000	-	20 000	-	-	10 000
0.85 ± 0.1	4 000	-	15 000	-	-	8 000
0.8 ± 0.07	4 000	-	15 000	-	15 000	-
1.15 ± 0.1	-	3 000	-	10 000	-	-
1.25 ± 0.1	-	3 000	-	10 000	-	5 000

Ordering information

Clear text code (preferred)

08052R105K6BB0D (example)

0805 Size code	**2R** Temp. char.	**105** Cap. in pF	**K** Tolerance	**6** Voltage	**B** Termination	**B** Packaging	**0** Marking	**D** Range identifier
0603 0805 1206	2R = X7R	105 = 1 000 000 pF i.e. the third digit signifies the multiplying factor 3 = x 1000 4 = x 10 000 5 = x 100 000	K ± 10 %	6 = 10 V	B = Ni-barrier	2 = 180 mm / 7" paper 3 = 330 mm / 13" paper B = 180 mm / 7" blister F = 330 mm / 13" blister P = bulk case	0 = no marking	D = BME

12NC

2 2 x x x x x x 5 x x x

Carrier type
- 22 blister
- 38 paper
- 54 bulk

Rated voltage - Termination
- 24 10 V; Ni-barrier

Size code
- 6 0603
- 0 0805
- 1 1206

Capacitance value (see selection chart)

Tolerance code
- 6 ± 10%

Packaging
- 1 reel ∅ 180 mm; 7"
- 5 reel ∅ 330 mm; 13"
- 4 bulk case

Ceramic Multilayer Capacitors

High capacitance Y5V 10 V

	10 V			
NEW				

Cap.	last two digits of 12 NC	0603	0805	1206	Cap.	last two digits of 12 NC
µF 1.0	63	0.8 ± 0.07		0.85 ± 0.10	nF 1 000	63
1.5	65				1 500	65
2.2	67		1.25 ± 0.10		2 200	67
3.3	69	in columns : Thickness class		1.15 ± 0.10	3 300	69
4.7	72				4 700	72
6.8	74			1.60 ± 0.15	6 800	74
10.0	76				10 000	76
Tape width		8 mm				Tape width

Thickness classes and packaging quantities

Thickness classes (mm)	8 mm tape width amount per reel				amount per bulk case	
	180 mm / 7"		330 mm / 13"			
	paper	blister	paper	blister	0603	0805
0.8 ± 0.07	4 000	-	15 000	-	15 000	-
0.85 ± 0.10	4 000	-	15 000	-	-	-
1.15 ± 0.10	-	3 000	10 000	10 000	-	-
1.25 ± 0.10	-	3 000	10 000	10 000	-	5 000
1.60 ± 0.15	-	2 000	7 000	7 000	-	-

Ordering information

Clear text code (preferred)

06032F105Z24BB0D (example)

0603	**2F**	**105**	**Z**	**6**	**B**	**B**	**0**	**D**
Size code	Temp. char.	Cap. in pF	Tolerance	Voltage	Termination	Packaging	Marking	Range identifier
0603 0805 1206	2F = Y5V	105 = 1 000 000 pF i.e. the third digit signifies the multiplying factor 5 = x 100 000 6 = x 1 000 000	Z = –20 % / +80%	6 = 10 V	B = Ni-barrier	2 = 180 mm / 7" paper 3 = 330 mm / 13" paper B = 180 mm / 7" blister F = 330 mm / 13" blister P = bulk case	0 = no marking 2 = 2-character marking in North America only	D = BME

12NC

2 2 x x   x x   x   x 9 x x x

Carrier type
- 22 blister
- 38 paper
- 54 bulk

Rated voltage - Termination
- 24 10 V Ni-barrier

Size code
- 6 0603
- 0 0805
- 1 1206

Capacitance value (see selection chart)

Tolerance code
- 8 –20 % / +80%

Packaging
- 1 reel ∅ 180 mm; 7"
- 5 reel ∅ 330 mm; 13"
- 4 bulk case

WATER BASED

	50 V
NEW	

Cap.	last two digits of 12 NC	1206
pF 47	32	
100	36	
220	41	0.8 ± 0.1
330	43	
470	45	
1000	49	
Tape width		8 mm

Thickness class and packaging quantities

Thickness classes (mm)	8 mm tape width amount per reel
	180 mm / 7"
	paper
0.8 ± 0.1	4000

Ordering information

12NC

22xx xxx x1xxx

Carrier type
55 paper

Rated voltage - Termination
23 50 V; Ni-barrier

Size
1 1206 Feedthrough

Capacitance value
(see selection chart)

Tolerance
5 ± 5%
6 ± 10%

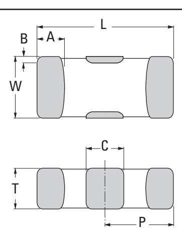
Packaging
1 reel ∅ 180 mm / 7"
0 bulk (1000 units)

Clear text code (preferred)

1206CG102J9B20F (example)

1206 Size code	**CG** Temp. char.	**102** Cap. in pF	**J** Tolerance	**9** Voltage	**B** Termination	**2** Packaging	**0** Marking	**F** Range identifier
1206	CG = NP0	102 = 1000 pF i.e. the third digit signifies the multiplying factor 0 = x 1 1 = x 10 2 = x 100	J ± 5 % K ± 10 %	9 = 50 V	B = Ni-barrier	2 = 180 mm / 7" paper A = bulk (1000 units)	0 = no marking	F = feed-through

Mechanical data



Case Size		L	W	T	A	B	C	P
3216	mm	3.20 ± 0.20	1.6 ± 0.20	0.80 ± 0.10	0.50 ± 0.20	0.30 ± 0.15	0.90 ± 0.20	1.60 ± 0.15
1206	inches	0.126 ± 0.008	0.063 ± 0.008	0.032 ± 0.004	0.02 ± 0.008	0.012 ± 0.006	0.036 ± 0.008	0.063 ± 0.006

Ceramic Multilayer Capacitors

Feedthrough X7R 16 V, 25 V, 50 V

16 V

NEW

Cap.	last two digits of 12 NC	1206
pF 680 000	61	
820 000	62	Thickness class 1.20 ± 0.15
1 000 000	63	
Tape width		8 mm

Thickness classes and packaging quantities

Thickness class (mm)	8 mm tape width amount per reel
	180 mm / 7" / blister
1.20 ± 0.15	3000

25 V / 50 V

NEW

Cap.	last two digits of 12 NC	25 V 1206	50 V 1206
pF 4700	32		
5600	33		
6800	34		0.80 ± 0.1
8200	35		
10 000	36		
12 000	37		
15 000	38		
18 000	39		
22 000	41		
27 000	42		
33 000	43	0.80 ± 0.1	
39 000	44		
47 000	45		
56 000	46		
68 000	47		
82 000	48		
100 000	49		
Tape width		8 mm	

in columns : Thickness class

Thickness classes and packaging quantities

Thickness class (mm)	8 mm tape width amount per reel
	180 mm / 7" / paper
	1206
0.80 ± 0.1	4000

Ordering information

Clear text code (preferred)

12062R104K9BB0F (example)

1206	2R	104	K	9	B	B	0	F
Size code	Temp. char.	Cap. in pF	Tolerance	Voltage	Termination	Packaging	Marking	Range identifier
1206	2R = X7R	104 = 100 000 pF i.e. the third digit signifies the multiplying factor 2 = x 100 3 = x 1000 4 = x 10 000 5 = x 100 000	K ± 10 % M ± 20 %	7 = 16 V 8 = 25 V 9 = 50 V	B = Ni-barrier	B = 180 mm / 7" blister 2 = 180 mm / 7" paper A = bulk (1000 units)	0 = no marking	F = feed-through

12NC

2 2 x x x x x x 6 x x x

Carrier type
- 50 blister
- 55 paper

Rated voltage - Termination
- 53 16 V; Ni-barrier
- 52 25 V; Ni-barrier
- 22 50 V; Ni-barrier

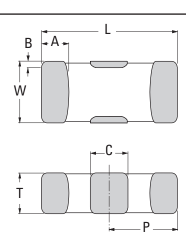
Size
- 1 1206 Feedthrough

Capacitance value (see selection chart)

Tolerance
- 6 ± 10%
- 7 ± 20%

Packaging
- 1 reel ∅ 180 mm; 7"
- 0 bulk (1000 units)

Mechanical data

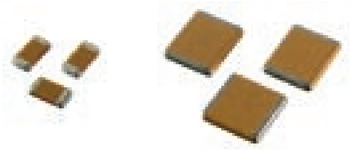


Case Size		L	W	T	A	B	C	P
3216	mm	3.20 ± 0.20	1.6 ± 0.20	0.7 to 1.35	0.50 ± 0.20	0.30 ± 0.15	0.90 ± 0.20	1.60 ± 0.15
1206	inches	0.126 ± 0.008	0.063 ± 0.008	0.028 to 0.053	0.02 ± 0.008	0.012 ± 0.006	0.036 ± 0.008	0.063 ± 0.006

Ceramic Multilayer Capacitors

High voltage NP0 1 kV, 2 kV, 3 kV, 4 kV, noble metal electrode

WATER BASED

		1 kV			NEW 2 kV	3 kV		NEW 4 kV	
									
Cap.	last two digits of 12 NC	**1206**	**1812**	**2220**	**1206**	**1808**	**1812**	**1808**	**1812**
pF 10	23								
12	24							1.2 to 2.0	
15	25								
18	26								
22	27					1.2 to 1.75			1.2 to 2.0
27	28								
33	29						1.2 to 1.75		
39	31								
47	32				0.9 to 1.3				
56	33								
68	34								
82	35					1.0 to 1.3			
100	36								
120	37								
160	38						1.0 to 1.3		
180	39								
220	41	0.9 to 1.3							
270	42								
330	43		0.5 to 1.0						
390	44								
470	45								
560	46			0.5 to 1.0					
680	47								
820	48								
1000	49								
1200	51		0.9 to 1.3						
1500	52								
1800	53								
2200	54								
2700	55			0.9 to 1.3					
3300	56								
Tape width		8 mm	12 mm		8 mm	12 mm		12 mm	

Thickness classification and packaging quantities

Thickness classes (mm)	8 mm tape width amount per reel		12 mm tape width amount per reel		
	∅180 mm / 7" blister	∅330 mm / 13" blister	∅180 mm / 7" blister		
	1206	1206	1808	1812	2220
0.5 to 1.0	-	-	-	2000	1500
0.9 to 1.3	3000	10 000	-	1500	1500
1.0 to 1.3	-	-	1500	1500	-
1.2 to 1.75	-	-	1000	1000	-
1.2 to 2.0	-	-	1000	1000	-

Ordering information

Clear text code (preferred)

1206CG220JFBB00 (example)

1206	**CG**	**220**	**J**	**F**	**B**	**B**	**0**	**0**
Size code	Temp. char.	Cap. in pF	Tolerance	Voltage	Termination	Packaging	Marking	Range identifier
1206 1808 1812 2220	CG = NP0	220 = 22 pF i.e. the third digit signifies the multiplying factor 0 = x 1 2 = x 100 1 = x 10	J ± 5 % K ± 10 %	E = 1 kV F = 2 kV G = 3 kV H = 4 kV	B = Ni-barrier	B = 180 mm / 7" blister F = 330 mm / 13" blister A = bulk (1000 units)	0 = no marking	0 = conv. ceramic

12NC

2 2 x x x x x x 1 x x x

Carrier type
- 22 blister (1206)
- 54 bulk (1206)
- 50 blister (1808 / 1812)
- 56 bulk (1808 / 1812)

Voltage
- 00 1 kV
- 01 2 kV
- 04 3 kV
- 50 4 kV

Size
- 1 1206
- 3 1808
- 4 1812
- 5 2220

Packaging
- 1 reel ∅ 180 mm / 7"
- 5 reel ∅ 330 mm / 13"
- 0 bulk (1000 units)

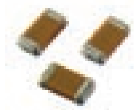
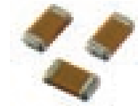
Tolerance
- 5 ± 5%
- 6 ± 10%

Capacitance value (see selection chart)

WATER BASED

Ceramic Multilayer Capacitors

High voltage X7R 1 kV, 2 kV, noble metal electrode

		1 kV			NEW 2 kV	
						
Cap.	last two digits of 12 NC	**1206**	**1808**	**1812**	**1808**	**1812**
pF 470	18	0.9 to 1.3				
560	19	0.9 to 1.3				
680	21	0.9 to 1.3				
820	22	0.9 to 1.3				
1000	23	0.9 to 1.3	1.2 to 1.75	1.2 to 1.75	1.2 to 2.0	1.2 to 2.0
1200	24	0.9 to 1.3	1.2 to 1.75	1.2 to 1.75	1.2 to 2.0	1.2 to 2.0
1500	25	0.9 to 1.3	1.2 to 1.75	1.2 to 1.75	1.2 to 2.0	1.2 to 2.0
1800	26	0.9 to 1.3	1.2 to 1.75	1.2 to 1.75	1.2 to 2.0	1.2 to 2.0
2200	27	0.9 to 1.3	1.2 to 1.75	1.2 to 1.75	1.2 to 2.0	1.2 to 2.0
2700	28	0.9 to 1.3	1.2 to 1.75	1.2 to 1.75		1.2 to 2.0
3300	29	0.9 to 1.3	1.2 to 1.75	1.2 to 1.75		1.2 to 2.0
3900	31	0.9 to 1.3		1.2 to 1.75		1.2 to 2.0
4700	32			1.2 to 1.75		1.2 to 2.0
5600	33			1.2 to 1.75		
6800	34			1.2 to 1.75		
8200	35			1.2 to 1.75		
10 000	36			1.2 to 1.75		
Tape width		8 mm	12 mm		12 mm	

in columns : Thickness class

Thickness classes and packaging quantities

Thickness classes (mm)	8 mm tape width amount per reel		12 mm tape width amount per reel	
	180 mm / 7"/ blister	330 mm / 13"/ blister	180 mm / 7"/ blister	
	1206	1206	1808	1812
0.9 to 1.3	3000	10 000	-	-
1.2 to 1.75	-	-	1000	1000
1.2 to 2.0	-	-	1000	1000

Ordering information

Clear text code (preferred)

12062R102KEBB00 (example)

1206 Size code	**2R** Temp. char.	**102** Cap. in pF	**K** Tolerance	**E** Voltage	**B** Termination	**B** Packaging	**0** Marking	**0** Range identifier
1206 1808 1812	2R = X7R	102 = 1000 pF i.e. the third digit signifies the multiplying factor 1 = x 10 2 = x 100 3 = x 1000	K ± 10 % M ± 20 %	E = 1 kV F = 2 kV	B = Ni-barrier	B = 180 mm / 7" blister F = 330 mm / 13" blister A = bulk (1000 units)	0 = no marking	0 = conv. ceramic

12NC

22xx xxx x6xxx

Carrier type
- 22 blister (1206)
- 54 bulk (1206)
- 50 blister (1808 / 1812)
- 56 bulk (1808 / 1812)

Voltage
- 00 1 kV
- 02 2 kV

Size
- 1 1206
- 3 1808
- 4 1812

Capacitance value (see selection chart)

Tolerance
- 6 ± 10%
- 7 ± 20%

Packaging
- 1 reel ∅ 180 mm / 7"
- 5 reel ∅ 330 mm / 13"
- 0 bulk (1000 units)

Ceramic Multilayer Capacitors

X7R 50 V, Low inductance

NEW

Cap.	last two digits of 12 NC	50 V **0612**
pF 10 000	36	
12 000	37	
15 000	38	Thickness class: 0.85 ± 0.1
18 000	39	
22 000	41	
Tape width		8 mm

Ordering information

12NC 22xx xxx x6xxx

Carrier type
- 50 blister
- 55 paper tape

Rated voltage - Termination
- 06 50 V Ni-barrier

Size code
- 0 0612 low inductance

Capacitance value (see selection chart)

Tolerance code
- 6 ± 10%

Packaging
- 1 reel ∅ 180 mm; 7"
- 5 reel ∅ 330 mm; 13"

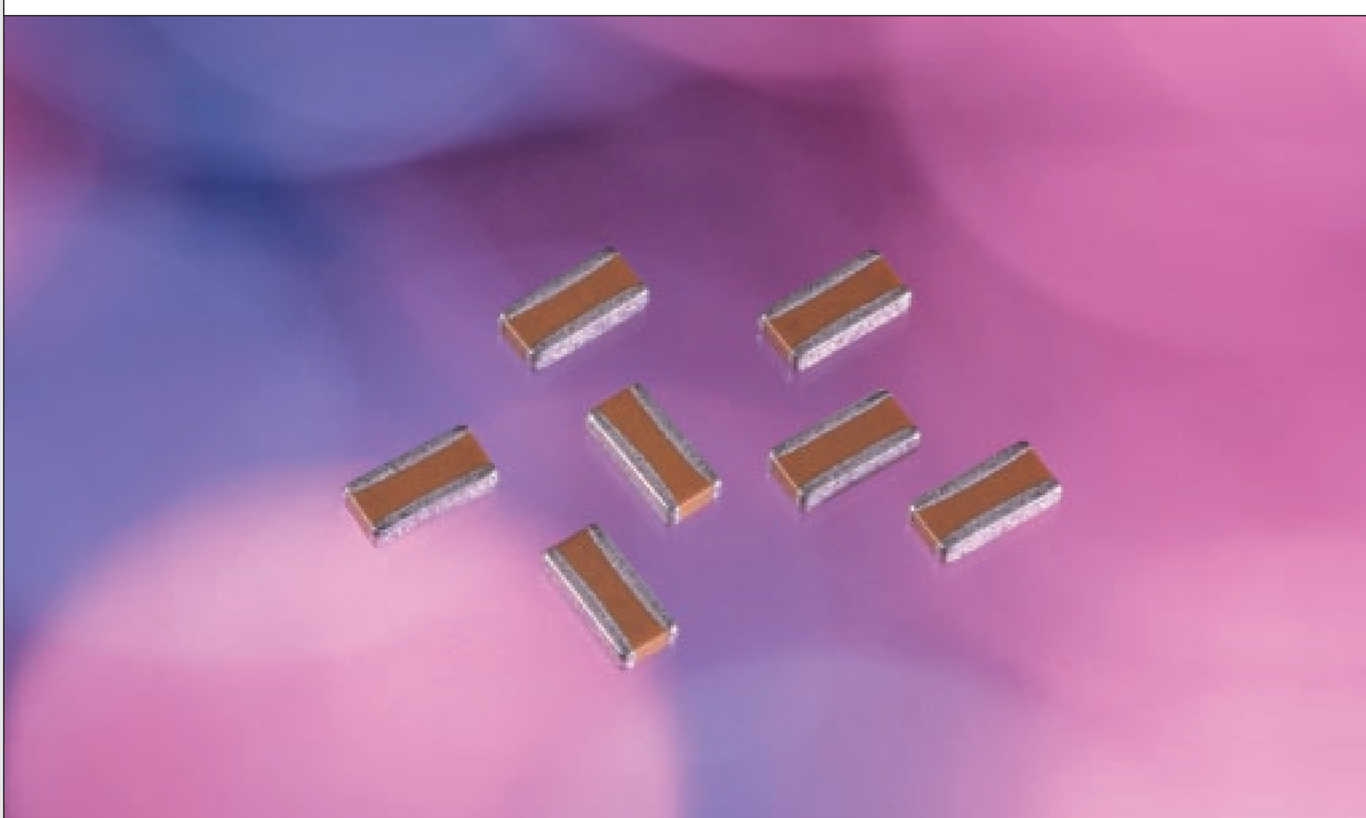
Clear text code (preferred)

06122R223K9BB0L (example)

0612 Size code	**2R** Temp. char.	**223** Cap. in pF	**K** Tolerance	**9** Voltage	**B** Termination	**B** Packaging	**0** Marking	**L** Range identifier
0612	2R = X7R	223 = 22 000 pF i.e. the third digit signifies the multiplying factor 3 = x 1000	K ± 10 %	9 = 50 V	B = Ni-barrier	2 = 180 mm / 7" paper 3 = 330 mm / 13" paper B = 180 mm / 7" blister F = 330 mm / 13" blister	0 = no marking	L = low inductance

Thickness classes and packaging quantities

Thickness classes (mm)	**8 mm tape width amount per reel**			
	180 mm / 7"		330 mm / 13"	
	paper	blister	paper	blister
0.85 ± 0.10	4000	4000	15 000	10 000



Ceramic Multilayer Capacitors

Complete CMC program

WATER BASED

Class 1 NP0

	NP0 16 V		NP0 25 V					NP0 50 V (note)							NP0 100 V					NP0 200 V				NP0 500 V			NP0 1 kV			NP0 2 kV	NP0 3 kV		NP0 4 kV		
Capacitance	0402	0603	0402	0603	0805	1206	1210	0402	0603	0805	1206	1210	1812	2220	0603	0805	1206	1210	1812	0805	1206	1210	1812	1206	1210	1812	1206	1812	2220	1206	1808	1812	1808	1812	Capacitance
pF 0.47								●	●	●	●																								pF 0.47
I E 12								●	●	●	●																								I E 12
3.9								●	●	●	●																								3.9
4.7								●	●	●	●																								4.7
5.6								●	●	●	●																								5.6
6.8								●	●	●	●																								6.8
8.2								●	●	●	●																								8.2
10								●	●	●	●				●	●	●			●	●			●							●	●	●	●	10
12								●	●	●	●				●	●	●			●	●			●							●	●	●	●	12
15								●	●	●	●				●	●	●			●	●			●							●	●	●	●	15
18								●	●	●	●				●	●	●			●	●			●							●	●	●	●	18
22								●	●	●	●				●	●	●			●	●			●						●	●	●	●	●	22
27								●	●	●	●				●	●	●			●	●			●						●	●	●		●	27
33								●	●	●	●				●	●	●			●	●			●						●	●	●		●	33
39								●	●	●	●				●	●	●			●	●			●						●	●	●		●	39
47								●	●	●	●				●	●	●			●	●			●	●					●	●	●		●	47
56								●	●	●	●				●	●	●			●	●			●	●					●		●			56
68								●	●	●	●				●	●	●			●	●			●	●					●		●			68
82								●	●	●	●				●	●	●			●	●			●	●					●		●			82
100								●	●	●	●				●	●	●			●	●			●	●			●	●	●		●			100
120								●	●	●	●				●	●	●			●	●			●	●		●	●	●						120
150								●	●	●	●				●	●	●			●	●			●	●		●	●	●						150
180								●	●	●	●				●	●	●			●	●			●	●		●	●	●						180
220			▲					●	●	●	●				●	●	●			●	●			●	●		●	●	●						220
270	●		▲						●	●	●				●	●	●			●	●			●	●		●	●	●						270
330	●		▲						●	●	●				●	●	●			●	●			●	●		●	●	●						330
390	●								●	●	●				●	●	●			●	●			●	●		●	●	●						390
470	●								●	●	●				●	●	●			●	●			●	●			●	●						470
560									●	●	●				●	●	●			●	●			●	●			●	●						560
680									●	●	●				●	●	●				●			●	●			●	●						680
820				●					▲	●	●					●	●				●			●	●			●	●						820
1000				●					▲	●	●	●				●	●				●			●	●			●	●						1000
1200				●					▲	●	●	●				●	●				●				●			●	●						1200
1500				●						●	●	●				●	●				●				●			●	●						1500
1800		●								●	●	●				●	●					●			●				●						1800
2200		●								●	●	●	●			●	●					●				●			●						2200
2700		●								●	●	●	●			●	●					●				●			●						2700
3300		●			●					▲	●	●	●				●					●				●			●						3300
3900					●					▲	●	●	●				●						●												3900
4700					●					▲	●	●	●				●						●												4700
5600										▲	●	●	●				●						●												5600
6800											●	●	●				●																		6800
8200						●					▲	●	●					●																	8200
10 000						●					▲	●	●	●				●																	10 000
12 000							●				▲	▲	●	●					●																12 000
15 000							●				▲	▲	●	●					●																15 000
18 000							●					▲	●	●					●																18 000
22 000							●					▲	●	●					●																22 000
27 000													▲	●																					27 000
33 000													▲	●																					33 000
39 000														●																					39 000
47 000														●																					47 000
56 000														▲																					56 000
68 000														▲																					68 000
82 000														▲																					82 000
100 000														▲																					100 000

Quick reference data

Dielectric : EIA/IEC, CECC		COG/NP0/CG
Rated voltage		16 V, 25 V, 50/63 V, 100 V, 200 V, 500 V, 1 kV, 2 kV, 3 kV, 4 kV
Tolerance	C < 10 pF	± 0.1 pF, ± 0.25 pF, ± 0.5 pF
	C ≥ 10 pF	± 1%, 2%, 5%, 10%
Tan δ	C < 10 pF	$\leq 10 (\frac{3}{C} + 0.7) \times 10^{-4}$; max: 30×10^{-4}
	C ≥ 10 pF	$\leq 10 \times 10^{-4}$
Insulation resistance		> 100 GΩ or R x C > 1000 sec.
Temperature coefficient		
0805, 1206	C < 10 pF	0 ± 150 ppm/K
0402, 0603	C < 10 pF	0 ± 30 ppm/K
	C ≥ 10 pF	0 ± 30 ppm/K
Climatic category		55/125/56
Measuring voltage		1 Vrms
Measuring frequency		
	C ≤ 1000 pF	1 MHz
	C > 1000 pF	1 kHz

● = Standard technology, noble metal electrode type
▲ = Compact technology, noble metal electrode type

note: Compact series meet IEC 60063

Class 2 X7R

Capacitance	X7R 10 V			X7R 16 V				X7R 25 V							X7R 50 V (note)							X7R 50 V LI	X7R 100 V				X7R 200 V				X7R 500 V			X7R 1 kV			X7R 2 kV		Capacitance
	0603	0805	1206	0402	0603	0805	1206	0402	0603	0805	1206	1210	1812	2220	0402	0603	0805	1206	1210	1812	2220	0612	0805	1206	1210	1812	0805	1206	1210	1812	1206	1210	1812	1206	1808	1812	1808	1812	
pF 100															•	•■																							nF 0.1
120															•	•■						LI																	0.12
150															•	•■																							0.15
180															•	•■	•■						•				•												0.18
220															•	•■	•■	•■					•	•			•												0.22
270															•	•■	•■	•■					•	•			•												0.27
330															•	•■	•■	•■					•	•			•												0.33
390															•	•■	•■	•■					•	•			•												0.39
470															•	•■	•■	•■					•	•			•				•			•					0.47
560															•	•■	•■	•■					•	•			•				•			•					0.56
680															•	•■	•■	•■					•	•			•	•			•			•					0.68
820															•	•■	•■	•■					•	•			•	•			•			•					0.82
1000															•	•■	•■	•■					•	•			•	•			•			•	•	•	•	•	1
1200															•	•■	•■	•■					•	•			•	•			•			•	•	•	•	•	1.2
1500															•	•■	•■	•■					•	•			•	•			•			•	•	•	•	•	1.5
1800															•	•■	•■	•■					•	•			•	•			•			•	•	•	•	•	1.8
2200															•	•■	•■	•■					•	•			•	•			•			•	•	•	•	•	2.2
2700															•	•■	•■	•■					•	•			•	•				•		•	•	•		•	2.7
3300								•							•	•■	•■	•■					•	•			•	•				•		•	•	•		•	3.3
3900								•								•■	•■	•■					•	•			•	•				•		•		•		•	3.9
4700				•				•								•■	•■	•■					•	•			•	•				•				•		•	4.7
5600				•												•■	•■	•■					•	•			•	•				•				•			5.6
6800				•												•■	•■	•■					•	•			•	•				•				•			6.8
8200				•												•■	•■	•■					•	•			•	•				•				•			8.2
10 000				•					•■	•■						•■	•■	•■	•■			•	•	•				•					•			•			10
12 000				•					•■	•■						•■	•■	•■	•■			•	•	•				•					•						12
15 000				•					•■	•■						•■	•■	•■	•■			•	•	•				•					•						15
18 000				•					•■	•■						•■	•■	•■	•■			•	•	•				•											18
22 000				•	•■				•■	•■						■	•■	•■	•■			•	•	•				•	•										22
27 000					•■				•■	•■							•■	•■	•■				•	•				•	•										27
33 000					•■					•■							•■	•■	•■					•					•										33
39 000					•■					•■							•■	•■	•■					•					•										39
47 000					•■	•■				•■							•■	•■	•■					•	•				•	•									47
56 000					•■	•■				•■							•■	•■	•■					•	•				•	•									56
68 000					•■	•■				•■							•■	•■	•■					•	•					•									68
82 000					•■	•■				•■							•■	•■	•■					•	•					•									82
100 000					•■	•■				•■	•■						•■	•■	•■	•■				•	•	•				•									100
120 000						•■				▲	•■							•■	•■	•■					•	•				•									120
150 000	■					•■					•■							•■	•■	•■					•	•													150
180 000	■					•■					•■							•■	•■	•■						•													180
220 000	■	■				•■	•■				•■	•■						•■	•■	•■	•■					•													220
270 000		■				•■	•■				•■	•■							▲	•■	•■					•													270
330 000		■				•■	•■				•■	•■							▲	•■	•■					•													330
390 000		■				•■	•■				▲	•■							▲	•■	•■																		390
470 000		■				•■	•■				▲	•■							▲	•■	•■																		470
560 000		■					•■					▲								▲	•■																		560
680 000		■					•■					▲								▲	•■																		680
820 000		■					•■					▲	▲							▲	•■																		820
1 000 000		■	■				•■					▲	▲							▲	•■																		1000
1 200 000			■										▲								▲																		1200
1 500 000			■										▲								▲																		1500
1 800 000			■										▲								▲																		1800
2 200 000			■											▲							▲																		2200
2 700 000														▲																									2700
3 300 000														▲																									3300
3 900 000														▲																									3900
4 700 000														▲																									4700

Quick reference data

Dielectric : EIA/IEC, CECC	X7R/ 2R1
Rated voltage	10 V, 16 V, 25 V, 50/63 V, 100 V, 200 V, 500 V, 1 kV, 2 kV
Tolerance	± 5%, 10%, 20%
Tan δ V rated ≥ 25 V V rated ≤ 16 V	≤ 2.5% ≤ 3.5%
Insulation resistance: noble metal electrode type base metal electrode type	 > 100 GΩ or R x C > 1000 sec. R x C > 500 sec.
Temperature characteristics	± 15%
Climatic category	55/125/56
Ageing per time decade	typical 1%
Measuring voltage Measuring frequency	1 Vrms 1 kHz

• = Standard technology, noble metal electrode type
■ = Standard technology, base metal electrode type
▲ = Compact technology, noble metal electrode type

LI = Low Inductance
note: Compact series meet IEC 60063

Ceramic Multilayer Capacitors

Complete CMC program

WATER BASED

Class 2 Y5V and Z5U

	Y5V 10 V			Y5V 16 V				Y5V 25 V			Y5V 50 V			Z5U 25 V		Z5U 50 V		
Capacitance	0603	0805	1206	0402	0603	0805	1206	0603	0805	1206	0603	0805	1206	0603	1206	0805	1206	1210
µF 0.010				■				■			■	■		■		■	■	
0.012														■		■	■	
0.015				■				■			■	■		■		■	■	
0.018														■		■	■	
0.022				■				■			■	■		■		■	■	
0.027														■		■	■	
0.033				■				■			■	■		■		■	■	
0.039														■		■	■	
0.047				■				■			■	■		■		■	■	
0.056														■		■	■	
0.068				■				■			■	■		■		■	■	
0.082														■		■	■	
0.10				■				■	■	■	■	■	■	■		■	■	■
0.12																■	■	■
0.15					■				■	■		■	■			■	■	■
0.18																■	■	■
0.22					■				■	■		■	■			■	■	■
0.27																	■	■
0.33					■				■	■		■	■				■	■
0.39																	■	■
0.47					■	■				■			■		■		■	■
0.56															■			■
0.68						■				■			■		■			■
0.82															■			■
1.0	■		■			■	■			■			■		■			■
1.2																		
1.5			■			■	■											
1.8																		
2.2		■	■			■	■											
2.7																		
3.3		■	■				■											
3.9																		
4.7			■				■											
5.6																		
6.8			■															
8.2																		
10			■															

Quick reference data

Dielectric : EIA/IEC, CECC	Y5V/2F4	Z5U/2E6
Rated voltage	10 V, 16 V, 25 V, 50 V	25 V, 50 V
Tolerance	± 20%, -20%/+80%	± 20%, -20%/+80%
Tan δ	all 25 & 50 V, except 0603 100 nF and 1206 1 µF ≤ 5% 0603 100 nF and 1206 1 µF ≤ 7% all 16 V ≤ 9%	≤ 4%
Insulation resistance: base metal electrode type	R x C > 100 sec.	R x C > 100 sec.
Temperature characteristic	+30% at -25°C to -80% at 85°C	+22%/-56%
Climatic category	25/085/56	10/085/21
Ageing per time decade	typical 7%	typical 3%
Measuring voltage Measuring frequency	1 Vrms 1 kHz	0.5 Vrms 1 kHz

● = Standard technology, noble metal electrode type
■ = Standard technology, base metal electrode type

Class 2 C-Array

	X7R 16 V	X7R 25 V	X7R 50 V	Y5V 25 V
Capacitance	4x 0603	4x 0603	4x 0603	4x 0603
pF 220			●	
270			●	
330			●	
390			●	
470			●	
560			●	
680			●	
820			●	
1000			●	
1200			●	
1500			●	
1800			●	
2200			●	
2700			●	
3300			●	
3900			●	
4700			●	
5600			●	
6800			●	
8200			●	
10 000	● ■	●	●	■
12 000	●	●		■
15 000	● ■	●		■
18 000	●	●		■
22 000	● ■	●		■
27 000	●	●		■
33 000	● ■	●		■
39 000	● ■	●		■
47 000	● ■	●		■
56 000	●			■
68 000	● ■			■
82 000	●			■
100 000	● ■			■

Class 1 C-Array

	NP0 50/63 V
Capacitance	4x 0603
pF 22	●
27	●
33	●
39	●
47	●
56	●
68	●
82	●
100	●
120	●
150	●
180	●
220	●
270	●
330	●
390	●
470	●
560	●
680	●
820	●
1000	●

Class 1 Narrow tolerance

	NP0 50 V			
Capacitance	0402	0603	0805	1206
pF 0.47	●	●	●	●
I E 12	●	●	●	●
3.9	●	●	●	●
4.7	●	●	●	●
5.6	●	●	●	●
6.8	●	●	●	●
8.2	●	●	●	●
10	●	●	●	●
12	●	●	●	●
15	●	●	●	●
18	●	●	●	●
22	●	●	●	●
27	●	●	●	●
33	●	●	●	●
39	●	●	●	●
47	●	●	●	●
56	●	●	●	●
68	●	●	●	●
82	●	●	●	●
100	●	●	●	●
120	●	●	●	●
150	●	●	●	●
180	●	●	●	●
220	●	●	●	●
270		●	●	●
330		●	●	●
390		●	●	●
470		●	●	●
560		●	●	●
680		●	●	●
820			●	●
1000			●	●
1200			●	●
1500			●	●
1800			●	●
2200			●	●
2700			●	●
3300				●
3900				●
4700				●
5600				●
6800				●

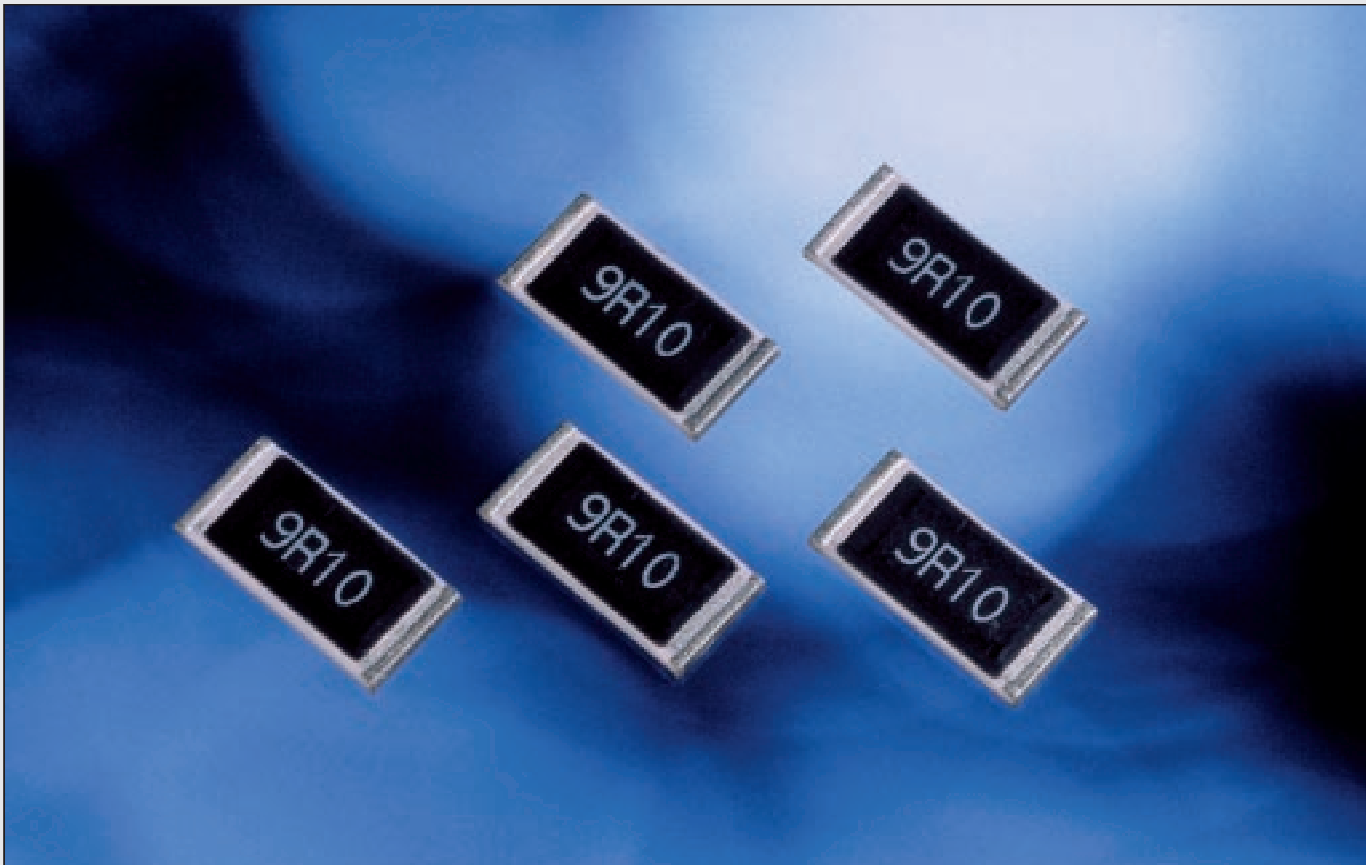
Class 1 Microwave

	NP0 50 V		
Capacitance	0603	0805	1206
pF 0.47	●	●	●
I E 12	●	●	●
3.9	●	●	●
4.7	●	●	●
5.6	●	●	●
6.8	●	●	●
8.2	●	●	●
10	●	●	●
12	●	●	●
15	●	●	●
18	●	●	●
22	●	●	●
27	●	●	●
33	●	●	●
39	●	●	●
47	●	●	●
56		●	●
68		●	●
82		●	●
100			●
120			●

Series	Description	Termination	Series	Description	Termination
2222 24 . .5	X7R 10 V	Ni-barrier	2238 91 . .6	X7R 25 V, NME	Ni-barrier
2222 24 . .9	Y5V 10 V	Ni-barrier	2238 91 . .9	Y5V 25 V	Ni-barrier
2222 57	NP0 50 V, Microwave	Ni-barrier	2238 93 . .1	NP0 200 V	Ni-barrier
2222 58 . .5	X7R 50 V	Ni-barrier	2238 93 . .6	X7R 200 V, NME	Ni-barrier
2222 58 . .6	X7R 50 V, NME	Ni-barrier	2238 95	X7R 16 V, Compact	Ni-barrier
2222 58 . .9	Y5V 50 V	Ni-barrier	2238 97 . .1	NP0 500 V	Ni-barrier
2222 595 .6	X7R 50 V, NME (size 2220)	AgPd	2238 97 . .6	X7R 500 V, NME	Ni-barrier
2222 60 . .1	NP0 100 V	Ni-barrier	2250 00 . .1	NP0 1 kV	Ni-barrier
2222 60 . .6	X7R 100 V, NME	Ni-barrier	2250 00 . .6	X7R 1kV, NME	Ni-barrier
2222 615 .1	NP0 100 V (size 2220)	AgPd	2250 01 . .1	NP0 1kV	AgPd
2222 62 . .8	Z5U 25 V or 50 V	Ni-barrier	2250 04 . .1	NP0 3kV	Ni-barrier
2222 78 . .1	NP0 16 V	Ni-barrier	2250 06 . .6	Low Inductance X7R 50 V	Ni-barrier
2222 78 . .5	X7R 16 V	Ni-barrier	2250 10 . .5	C-Array X7R 16 V	Ni-barrier
2222 78 . .6	X7R 16 V, NME	Ni-barrier	2250 10 . .6	C-Array X7R 16 V, NME	Ni-barrier
2222 78 . .9	Y5V 16 V	Ni-barrier	2250 12 . .6	C-Array X7R 25 V, NME	Ni-barrier
2222 86	NP0 50 V	Ni-barrier	2250 12 . .9	C-Array Y5V 25 V	Ni-barrier
2222 866	NP0 50 V (size 2220)	AgPd	2250 14 . .1	C-Array NP0 50 / 63 V	Ni-barrier
2222 87 . .6	X7R 25 V, Compact	Ni-barrier	2250 14 . .6	C-Array X7R 50 V, NME	Ni-barrier
2222 877 .0	NP0 25 V, Compact (size 0402)	Ni-barrier	2254 24 . .5	X7R 10 V	Ni-barrier
2222 885	X7R 25 V, Compact (size 2220)	Ni-barrier	2254 24 . .9	Y5V 10 V	Ni-barrier
2222 89 . .0	NP0 50 V / 63 V, Compact	Ni-barrier	2254 57	NP0 50 V, Microwave	Ni-barrier
2222 89 . .6	X7R 50 V / 63 V, Compact	Ni-barrier	2254 58 . .5	X7R 50 V	Ni-barrier
2222 90 . .0	NP0 50 V / 63 V, Compact	AgPd	2254 58 . .6	X7R 50 V, NME	Ni-barrier
2222 905 .6	X7R 50 V / 63 V, Compact	AgPd	2254 58 . .9	Y5V 50 V	Ni-barrier
2222 91 . .1	NP0 25 V	Ni-barrier	2254 60 . .1	NP0 100 V	Ni-barrier
2222 91 . .5	X7R 25 V	Ni-barrier	2254 60 . .6	X7R 100 V, NME	Ni-barrier
2222 91 . .6	X7R 25 V, NME	Ni-barrier	2254 62 . .8	Z5U 50 V	Ni-barrier
2222 91 . .9	Y5V 25 V	Ni-barrier	2254 78 . .1	NP0 16 V	Ni-barrier
2222 93 . .1	NP0 200 V	Ni-barrier	2254 78 . .5	X7R 16 V	Ni-barrier
2222 93 . .6	X7R 200 V, NME	Ni-barrier	2254 78 . .6	X7R 16 V, NME	Ni-barrier
2222 95	X7R 16 V, Compact	Ni-barrier	2254 78 . .9	Y5V 16 V	Ni-barrier
2222 964	X7R 16 V, Compact (size 1812)	AgPd	2254 86	NP0 50 V	Ni-barrier
2222 97 . .1	NP0 500 V	Ni-barrier	2254 87	X7R 25 V, Compact	Ni-barrier
2222 97 . .6	X7R 500 V, NME	Ni-barrier	2254 877	X7R 25 V, Compact (size 0402)	Ni-barrier
2238 24 . .5	X7R 10 V	Ni-barrier	2254 89 . .0	NP0 50 V / 63 V, Compact	Ni-barrier
2238 24 . .9	Y5V 10 V	Ni-barrier	2254 89 . .6	X7R 50 V/ /63 V, Compact	Ni-barrier
2238 57	NP0 50 V, Microwave	Ni-barrier	2254 91 . .1	NP0 25 V	Ni-barrier
2238 58 . .5	X7R 50 V	Ni-barrier	2254 91 . .5	X7R 25 V	Ni-barrier
2238 58 . .6	X7R 50 V, NME	Ni-barrier	2254 91 . .6	X7R 25 V, NME	Ni-barrier
2238 58 . .9	Y5V 50 V	Ni-barrier	2254 91 . .9	Y5V 25 V	Ni-barrier
2238 60 . .1	NP0 100 V	Ni-barrier	2254 93 . .1	NP0 200 V	Ni-barrier
2238 60 . .6	X7R 100 V, NME	Ni-barrier	2254 93 . .6	X7R 200 V, NME	Ni-barrier
2238 62 . .8	Z5U 25 V or 50 V	Ni-barrier	2254 95	X7R 16 V, Compact	Ni-barrier
2238 78 . .1	NP0 16 V	Ni-barrier	2255 06 . .6	Low Inductance X7R 50 V	Ni-barrier
2238 78 . .5	X7R 16 V	Ni-barrier	2255 10 . .5	C-Array X7R 16 V	Ni-barrier
2238 78 . .6	X7R 16 V, NME	Ni-barrier	2255 10 . .6	C-Array X7R 16 V, NME	Ni-barrier
2238 78 . .9	Y5V 16 V	Ni-barrier	2255 12 . .6	C-Array X7R 25 V, NME	Ni-barrier
2238 86	NP0 50 V	Ni-barrier	2255 12 . .9	C-Array Y5V 25 V	Ni-barrier
2238 87	X7R 25 V, Compact	Ni-barrier	2255 14 . .1	C-Array NP0 50 / 63 V	Ni-barrier
2238 877	NP0 25 V, Compact (size 0402)	Ni-barrier	2255 14 . .6	C-Array X7R 50 V, NME	Ni-barrier
2238 89 . .0	NP0 50 V / 63 V, Compact	Ni-barrier	2256 04 . .1	NP0 3 kV	Ni-barrier
2238 89 . .6	X7R 50 V / 63 V, Compact	Ni-barrier	2256 00 . .6	X7R 1 kV, NME	Ni-barrier
2238 91 . .1	NP0 25 V	Ni-barrier	2256 06 . .6	Low Inductance X7R 50 V	Ni-barrier
2238 91 . .5	X7R 25 V	Ni-barrier			

Fixed Resistors

General information



Standard series of values in a decade according to IEC 63

E6 series:	10	15	22	33	47	68						
E12 series:	10	12	15	18	22	27	33	39	47	56	68	82
E24 series:	10	11	12	13	15	16	18	20	22	24	27	30
	33	36	39	43	47	51	56	62	68	75	82	91
E48*/E96 series:	**100**	102	**105**	107	**110**	113	**115**	118	**121**	124	**127**	130
	133	137	**140**	143	**147**	150	**154**	158	**162**	165	**169**	174
	178	182	**187**	191	**196**	200	**205**	210	**215**	221	**226**	232
	237	243	**249**	255	**261**	267	**274**	280	**287**	294	**301**	309
	316	324	**332**	340	**348**	357	**365**	374	**383**	392	**402**	412
	422	432	**442**	453	**464**	475	**487**	499	**511**	523	**536**	549
	562	576	**590**	604	**619**	634	**649**	665	**681**	698	**715**	732
	750	768	**787**	806	**825**	845	**866**	887	**909**	931	**953**	976

* E48 values in bold are the alternate values of E96

Ordering information 12 NC

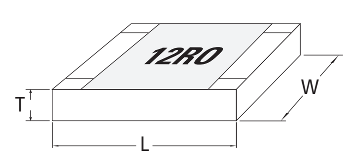
The first 8 or 9 digits of the 12 digit catalogue number are given under "Ordering information Preferred types" (see following pages)
The remaining 4 or 3 digits represent the resistance value with the last digit indicating the multiplier as shown in the table

Last digit of 12 NC	
Resistance	Last digit
0.01 to 0.0976 Ω	0
0.1 to 0.976 Ω	7
1 to 9.76 Ω	8
10 to 97.6 Ω	9
100 to 976 Ω	1
1 to 9.76 kΩ	2
10 to 97.6 kΩ	3
100 to 976 kΩ	4
1 to 9.76 MΩ	5
10 to 68 MΩ	6

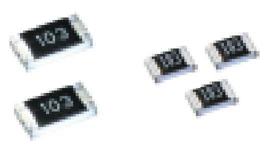
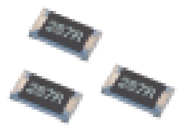
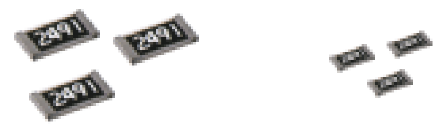
Examples:

0.01	Ω	=	0100 or 100
0.1	Ω	=	0107 or 107
1	Ω	=	1008 or 108
33	kΩ	=	3303 or 333
10	MΩ	=	1006 or 106

Case size dimensions



Size code	L (mm)	W (mm)	T (mm)	Mass (g)
0402	1.0	0.5	0.35	0.05
0603	1.6	0.8	0.45	0.4
0805	2.0	1.25	0.55	0.55
1206	3.2	1.6	0.55	1.0
1218	3.05	4.6	0.55	3.0
2010	5.0	2.5	0.55	2.5
2512	6.4	3.1	0.55	4.25

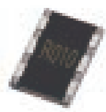
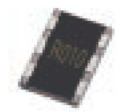
	Precision		High precision		Ultra high precision, high stability			
								
Series	**RC02G**	**RC12G**	**RC03G**	**RC 13G**	**MPC 01**		**MPC 11**	**MPC 21**
Case size	**1206**	**0805**	**1206**	**0805**	**1206**		**0805**	**0603**
Tolerance	1%		0.5%		0.1%			
Power P_{70}	0.25 W	0.125 W	0.25 W	0.125 W	0.125 W		0.1 W	0.063 W
Temp range	-55 to 155 °C		– 55 to 125 °C		– 55 to 125 °C			
U_{max}	200 V	150 V	200 V	150 V	150 V		100 V	75 V
E-Series	E24/E96	E24/E96	E24/E96	E24/E96	E24/E96 and others		E24/E96 and others	E24/E96
Resistance range including temperature coefficient (TC) 0 Ω, 0.1 Ω, 1 Ω, 10 Ω, 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ, 10 MΩ	90 Ω TC 50 2.74 MΩ	90 Ω TC 50 2.74 MΩ	90 Ω TC 100 250 Ω TC 50 2.74 MΩ	90 Ω TC 50 2.74 MΩ	10 Ω TC 50 51 Ω TC 25 1 MΩ	100 Ω TC 10 249 kΩ	TC 50 33 Ω TC 25 1 MΩ	100 Ω TC 25 332 kΩ
Remarks	thick film technology				thin film technology			

Ordering information Preferred types

Series	**RC02G**	**RC12G**	**RC03G**	**RC 13G**	**MPC 01**		**MPC 11**	**MPC 21**
Range	E24, 1% 5000	E24, 1% 5000	E24, 90 Ω-2.74 MΩ	E24, 90 Ω-2.74 MΩ	E24, 10 Ω-1 MΩ		E24, 10 Ω-1 MΩ	E24, 100 Ω-332 kΩ
Quantity	reel	reel	5000	5000	5000		5000	5000
Packing	plastic tape	plastic tape	reel plastic tape	reel plastic tape	reel plastic tape		reel plastic tape	reel plastic tape
Cat. number	2322 723 6....	2322 733 6....	2322 725 2....	2322 738 2....	2322 740 3....* 2322 741 3....**	2322 781 3....***	2322 744 3....	2322 747 3....
Note	* TC 50, ** TC 25, *** TC10	See page 90 for E24 values, the last 4 or 3 digits of the catalogue number and size information						

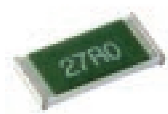
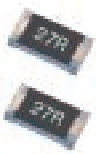
Fixed Resistors

Power, low ohmic

	Power, low ohmic				
				NEW 	NEW 
Series	**PRC 201**	**PRC 111**	**PRC 221**	**LPRC 201**	**LPRC 221**
Case size	**1218** (3.0x4.6 mm)	**2010** (5.0x2.5 mm)	**2512** (6.4x3.1 mm)	**1218** (3.0x4.6 mm)	**2512** (6.4x3.1 mm)
Tolerance	5%, 2%	1%	5%, 2%	1%	5%, 2%	1%	5%, 1%	5%, 1%
Power P_{70}	1 W	0.5 W	1 W	1 W	1 W
Temp range	-55 to 155 °C	-55 to 125 °C	-55 to 125 °C	-55 to 155 °C	-55 to 125 °C
U_{max}	200 V	200 V	250 V	200 V	250 V
E-Series	E24/E96	E24/E96	E24/E96	E24	E24
Resistance range incl. temperature coefficient (TC) 0 Ω 0.01 Ω 0.1 Ω 1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ 1 MΩ 10 MΩ	5%, 2%: 0.02 Ω; 1%: 0.1 Ω TC 2000 to TC 250 0.99 Ω	5%, 2%: 0.01 Ω; 1%: 0.02 Ω TC 1500 to TC 75 0.99 Ω	5%, 2%: 0.01 Ω; 1%: 0.02 Ω TC 1500 to TC 75 0.99 Ω	0.008 Ω TC 200 to TC 300 0.019 Ω	0.02 Ω TC 200 to TC 300 0.099 Ω
Remarks	terminations on the long side improve heat transfer and reduce stresses			terminations on the long side improve heat transfer and reduce stresses	

Ordering information Preferred types

Series	**PRC 201**	**PRC 111**	**PRC 221**	**LPRC 201**	**LPRC 221**
Range	E24, 5% 0.02 Ω - 0.99 Ω	E24, 5% 0.01 Ω - 0.99 Ω	E24, 5% 0.01 Ω - 0.99 Ω	E24 0.008 Ω - 0.019 Ω	E24 0.02 Ω - 0.099 Ω
Quantity	5000	4000	4000	5000	4000
Packing	reel blister tape	reel blister tape	reel blister tape	reel blister tape	reel blister tape
Cat. number	2322 735 60...	for ordering contact your local Philips sales representative		5% 2322 801 60... 1% 2322 801 7....	5% 2322 802 60... 1% 2322 802 7....
Note	See page 90 for E24 values, the last 4 or 3 digits of the catalogue number and size information				

	Power			Surge
				NEW 
Series	**PRC 201**	**PRC 111**	**PRC 221**	**SRC 01**
Case size	**1218** (3.0x4.6 mm)	**2010** (5.0x2.5 mm)	**2512** (6.4x3.1 mm)	**1206** (3.2x1.6 mm)
Tolerance	5% | 1%	5%, 2% | 1%	5%, 2% | 1%	5% | 2%
Power P_{70}	1 W	0.5 W	1 W	0.25 W
Temp range	-55 to 155 °C	-55 to 125 °C	-55 to 125 °C	-55 to 155 °C
U_{max}	200 V	200 V	250 V	200 V
E-Series	E24	E24 | E96	E24 | E96	E24
Resistance range incl. temperature coefficient (TC) (0 Ω, 0.01 Ω, 0.1 Ω, 1 Ω, 10 Ω, 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ, 10 MΩ)	1 Ω; TC 200; TC 100; 1 MΩ	Jumper 2322 760 90003; 1 Ω; TC 300; 5 Ω; TC 200; 10 Ω; TC 100; TC 200; 10 MΩ	Jumper 2322 762 90000; 1 Ω; TC 300; 5 Ω; TC 200; 10 Ω; TC 100; TC 200; 10 MΩ	1 Ω; TC 200; 100 kΩ
Remarks	terminations on the long side improve heat transfer and reduce stresses			

Ordering information Preferred types

Series	PRC 201	PRC 111	PRC 221	SRC01
Range	E24, 5% 1 Ω - 1 MΩ	E24, 5% 1 Ω - 1 MΩ	E24, 5% 1 Ω - 1 MΩ	E24, 5%, 2% 1 Ω - 100 kΩ
Quantity	5000	4000	4000	5000
Packing	reel blister tape	reel blister tape	reel blister tape	reel paper tape
Cat. number	2322 735 60...	2322 760 60...	2322 762 60...	5% 2350 550 10... 2% 2350 550 11...
Note	See page 90 for E24 values, the last 4 or 3 digits of the catalogue number and size information			

Fixed Resistors

Complete resistor program

General Purpose / Precision Resistors

	SMD				R-Array (note)			R-Network
	Thick film							
	1206	0805	0603	0402	4 x 0603	4 x 0402	1606	1206
5%, 2%	RC01	RC11	RC21	RC31				
5%					ARV241 ARC241	ARV341 ARC341	8R Array (ARF381)	8R Network (RNA310)
1% (TC 200)				RC32				
1% (TC 100)	RC02H	RC12H	RC22H		ARC242			
1% (TC 50)	RC02G	RC12G						

TC = Temperature Coefficient

Power / Power, low ohmic Resistors

	SMD			
	Thick film			
	Power		Power, low ohmic	
P_{nom} at 70 °C	5%, 1%	5%, 2%, 1%	5%, 2%, 1%	5%, 1%
0.5 Watt		PRC111	PRC111	
1 Watt	PRC201	PRC221	PRC201 PRC221	LPRC201 LPRC221

High / Ultra-High Precision Resistors

			High precision		Ultra-high precision
			Thick film	Thin film	Thin film
			0.5%	0.5%	0.1%
SMD	1206	TC 50	RC03G		
		TC 25		TFR01	MPC01
	0805	TC 50	RC13G		
		TC 25		TFR11	MPC11
	0603	TC 25		TFR21	MPC21
	0402	TC 25		TFR31	
	0201	TC 25		TFR41	

Application Specific Resistors

	SMD		
	1206	0805	0603
High ohmic / High voltage	HRC01	HRC11	HRC21
Low ohmic	LRC01 (5%) LRC02 (1%)	LRC11	
Fusible (non flammable)	FRC01		
Surge	SRC01		
Trimmable	RC02TR	RC12TR	RC22TR

note: ARV : conVex type termination
ARC : conCave type termination

Piezoelectric Ceramics

Piezoelectric Ceramics

General information

The nature of piezoelectric ceramics

Piezoelectricity is the general term to describe the property exhibited by certain crystals of becoming electrically polarized when stress is applied to them. Quartz is a good example of a piezoelectric crystal. If stress is applied to such a crystal, it will develop an electric moment proportional to the applied stress.

This is the direct piezoelectric effect. Conversely, if it is placed in an electric field, a piezoelectric crystal changes its shape slightly. This is the inverse piezoelectric effect.

An important group of piezoelectric materials are the piezoelectric ceramics, of which PXE (Philips trade mark) is an example. These are polycrystalline ferroelectric materials with the perovskite crystal structure. They have the general formula ABO_3, in which A denotes a large divalent metal ion such as Pb and B denotes a small tetravalent metal ion such as Zr or Ti.

PXE can be fashioned into components of almost any shape and size. As well as being strongly piezoelectric, PXE is hard, chemically inert and unaffected by humid environments.

PXE ceramics are solid solutions of lead titanate ($PbTiO_3$) and lead zirconate ($PbZrO_3$), modified by additives, a group of piezoceramics generally known as PZT. They are available in several grades distinguished by their electrical and physical properties to meet particular requirements.

In a ferroelectric crystal, each cell of the crystal lattice spontaneously polarizes along one of the allowed directions. This spontaneous polarization disappears at a critical temperature (the Curie temperature), above which the crystal becomes paraelectric.

A PXE ceramic may be regarded as mass of minute crystallites, randomly oriented. After it has been sintered,the ceramic material will be isotropic and will exhibit no piezoelectric effect because of this random orientation. The ceramic may be made piezoelectric in any chosen direction by a poling treatment which involves exposing it to a strong electric field. When the field is removed, the dipoles remain locked in formation (i.e. making it anisotropic), as well as making it permanently piezoelectric. This poling treatment is usually the final stage of PXE component manufacture.

A PXE component will usually have metal electrodes deposited on its surface perpendicular to its poling axis.

Application areas

The piezoelectric effect is used in many interesting applications throughout industry.

- Conversion of mechanical into electrical energy (generators), e.g. spark igniters, solid-state batteries.
- Conversion of mechanical force into electrical signals (sensors), e.g. acceleration sensor, knock sensor.
- Conversion of electrical signals into mechanical displacement (actuators), e.g. pneumatic valves, fuel-injection valves, selection box for textile machines, inkjet printers.
- Conversion of electrical into mechanical energy (transducers), e.g. buzzers, echo-sounders, ultrasonic cleaning, atomizers, ultrasonic motor.

Piezoelectric Ceramics

Material properties

Electrical connections

An electrical contact can be made by soldering, glueing or clamping wires to the silver, nickel or gold electrodes.

Soldering

The electrode surface should be free from grease and dust.When tarnished, an india rubber eraser may be used to lightly clean the silver.

Suggested soldering method:

- soldering iron: standard 25 to 50 W type with copper bit
- soldering iron temperature: 300 to 350°C for silver electrodes and 400°C for nickel electrodes
- preferred solder: Sn/Pb 60/40, with slightly activated resin, e.g.. 'Fluitin' (SnPb 60/1532); 'Billiton' (SnPb 60/RS4); or 'Multicore' (SnPb 60/366)
- soldering time: 1 to 3 s
- standard wire diameter: 0,3 mm, or fine-stranded flex

The soldering time should be kept as short as possible; otherwise, the disc or plate may be partly depolarized (to an extent dependent upon temperature and time).

Safety and environmental aspects

Environmental aspects of piezoceramics

Our piezoceramic products generally consist of one or more layers of ceramic materials (PXE) covered with metal electrodes.
The chemical composition of the range of PXE grades is Pb(ZrTi) Ox (lead titanate zirconate) with some minor dopants of, for example La. Sr or Fe.
More exactly PXE5 has the following main composition (weight percent)

PbO	66%
ZrO_2	21%
TiO_2	11%

Silver (Ag) electrodes have a thickness of some microns (μm) whereas nickel (Ni), electrodes, combined with some chromium (Cr) have a thickness of about 0,5 μm. Materials and electrodes contain no measurable amounts of cadmium (Cd).

General warnings

- With strong acids, the metals chromium, nickel and silver may be partially extracted. Other metals may also be extracted on a smaller scale, due to their very strong chemical bonds.
- In a fire, at temperature higher than 800°C, lead oxide will evaporate from the products.
- Dispose as industrial, chemical or special waste depending on local rules and circumstances.

	property and symbol	PXE 5	PXE 52	PXE 59	PXE 21	PXE 41	PXE 42	PXE 43	unit
thermal data	Curie temperature	285	165	360	270	315	325	300	°C
	specific heat	420	420	420	420	420	420	420	J/kg K
	thermal conductivity	1.2	1.2	1.2	1.2	1.2	1.2	1.2	W/m K
mechanical data	density ρ_m	7.8	7.8	7.9	7.8	7.9	7.8	7.8	10^3 kg/m^3
	compliance								
	s^E_{33}	18	20	18	19	15	15	13	10^{-12}/Pa
	s^E_{11}	15	16	16	15	12	13	11	10^{-12}/Pa
	s^E_{55}	39	-	45	-	37	-	-	10^{-12}/Pa
	Poisson's ratio σ	0.3	0.3	0.35	0.3	0.3	0.3	0.3	
	mechanical quality factor for radial mode Q^E_m	75	65	80	75	1200	750	1000	
	frequency constants								
	N^E_p	1975	1925	1970	2000	2175	2200	2350	Hz m or m/s
	$N^D_3 = 1/2\upsilon^D_3$	1850	1800	2060	1900	2000	2015	2050	Hz m or m/s
	$N^E_1 = 1/2\upsilon^E_1$	1450	1400	1400	-	1620	-	-	Hz m or m/s
	$N^E_5 = 1/2\upsilon^E_5$	930	-	900	-	950	-	-	Hz m or m/s
	compressive strength	> 600	> 600	> 600	> 600	> 600	> 600	> 600	10^6 Pa
	tensile strength	80	80	100	80	80	80	80	10^6 Pa

Properties measured on discs of dimensions ∅16 x 1 at 21 °C, 24 hours after poling

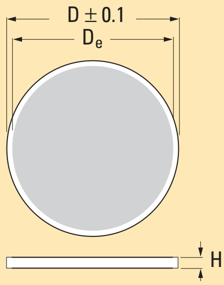
	property and symbol	PXE 5	PXE 52	PXE 59	PXE 21	PXE 41	PXE 42	PXE 43	unit
electrical data	**relative permittivity** (**ε_o= 8.85 x 10^{-12} F/m**)								
	$\varepsilon_{33}^{T}/\varepsilon_o$	2100	3900	1850	2000	1225	1325	1000	
	$\varepsilon_{11}^{T}/\varepsilon_o$	1800	3300	1650	-	1400	-	-	
	resistivity ρ	5	1	5	5	1	1	1	10^{10} Ωm
	time constant $\rho\varepsilon_{33}^{T}$ **(25°C)**	> 300	> 500	> 100	> 25	> 7	-	-	minute
	dielectric loss factor tan δ	20	16	17	15	2.5	3.5	2	10^{-3}
electro-mechanical data	**coupling factor**								
	k_p	0.68	0.70	0.66	0.64	0.64	0.61	0.53	
	k_{33}	0.75	0.80	0.71	0.74	0.74	0.70	0.66	
	k_{31}	0.38	0.39	0.37	0.37	0.38	0.34	0.30	
	k_{15}	0.66	-	0.68	-	0.70	-	-	
	piezoelectric charge constants								
	d_{33}	500	700	460	450	325	315	230	10^{-12} C/N or m/V
	d_{31}	– 215	– 280	– 195	– 200	– 150	– 130	– 100	10^{-12} C/N or m/V
	d_{15}	515	-	550	-	480	-	-	10^{-12} C/N or m/V
	piezoelectric voltage constants								
	g_{33}	24	20	28	25	30	27	27	10^{-3} Vm/N or m^2/C
	g_{31}	– 10	– 10	– 13	– 12	– 12	– 11	– 11	10^{-3} Vm/N or m^2/C
	g_{15}	33	-	37	-	39	-	-	10^{-3} Vm/N or m^2/C
time stability (%)	**coupling factor** k_p	– 0.5	– 0.6	– 0.1	– 1.5	– 1.5	– 2.5	– 2.0	relative change per time decade (days)
	permittivity ε_{33}^{T}	– 1.0	– 1.0	– 2	– 2.0	1.0	– 6.0	– 4.5	
	frequency constant N_p^E	0.5	0.3	0.1	0.5	0.5	1.5	1.0	
	quality factor Q_m^E	-	–3.0	0.1	-	10.0	-	-	
	dielectric loss factor tan δ	-	-	– 0.1	-	– 10	-	-	

Properties measured on discs of dimensions ∅16 x 1 at 21 °C, 24 hours after poling

Piezoelectric Ceramics

Discs

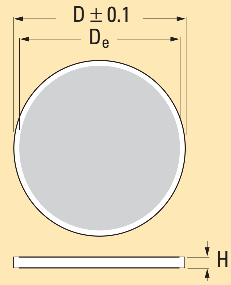
discs with nickel electrodes



type number	D (mm)	D_e (mm)	H (mm)	Cap. (pF)
DSC5/0.3-PX5-N	5	5.0 ± 0.1	0.3 ± 0.03	1220 ± 25%
DSC5/0.5-PX5-N	5	5.0 ± 0.1	0.5 ± 0.03	750 ± 25%
DSC5/1-PX5-N	5	5.0 ± 0.1	1.0 ± 0.03	375 ± 25%
DSC5/2-PX5-N	5	5.0 ± 0.1	2.0 ± 0.1	185 ± 25%
DSC10/0.2-PX5-N	10	9.0 ± 0.3	0.2 ± 0.03	5900 ± 25%
DSC10/0.5-PX5-N	10	9.0 ± 0.3	0.5 ± 0.03	2360 ± 25%
DSC10/1-PX5-N	10	9.5 ± 0.3	1.0 ± 0.03	1390 ± 25%
DSC10/2-PX5-N	10	9.5 ± 0.3	2.0 ± 0.1	700 ± 25%
DSC10/3-PX5-N	10	9.5 ± 0.3	3.0 ± 0.1	460 ± 25%
DSC10/5-PX5-N	10	9.5 ± 0.3	5.0 ± 0.1	280 ± 25%
DSC16/0.2-PX5-N	16	15.0 ± 0.3	0.2 ± 0.03	17000 ± 25%
DSC16/0.5-PX5-N	16	15.5 ± 0.3	0.5 ± 0.03	6800 ± 25%
DSC16/1-PX5-N	16	15.5 ± 0.3	1.0 ± 0.03	3620 ± 25%
DSC16/2-PX5-N	16	15.5 ± 0.3	2.0 ± 0.1	1800 ± 25%
DSC16/3-PX5-N	16	15.5 ± 0.3	3.0 ± 0.1	1200 ± 25%
DSC20/0.2-PX5-N	20	19.0 ± 0.3	0.2 ± 0.03	27000 ± 25%
DSC20/0.5-PX5-N	20	19.5 ± 0.3	0.5 ± 0.03	10800 ± 25%
DSC20/1-PX5-N	20	19.5 ± 0.3	1.0 ± 0.03	5700 ± 25%
DSC20/2-PX5-N	20	19.5 ± 0.3	2.0 ± 0.1	2850 ± 25%
DSC25/0.2-PX5-N	25	24.0 ± 0.3	0.2 ± 0.03	42925 ± 25%
DSC25/0.5-PX5-N	25	24.5 ± 0.3	0.5 ± 0.03	17200 ± 25%
DSC25/1-PX5-N	25	24.5 ± 0.3	1.0 ± 0.03	9000 ± 25%
DSC25/2-PX5-N	25	24.5 ± 0.3	2.0 ± 0.1	4500 ± 25%

remark: Other grades and sizes are available on request. The positive pole is marked.

discs with silver electrodes



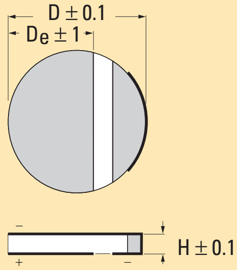
type number	D (mm)	D_e (mm)	H (mm)	Cap. (pF)
DSC5/0.3-PX5-S	5	= D	0.3 ± 0.03	1220 ± 25%
DSC5/0.5-PX5-S	5	= D	0.5 ± 0.03	750 ± 25%
DSC5/1-PX5-S	5	= D	1.0 ± 0.03	375 ± 25%
DSC5/2-PX5-S	5	= D	2.0 ± 0.1	185 ± 25%
DSC10/0.5-PX5-S	10	9 ± 0.3	0.5 ± 0.03	2360 ± 25%
DSC10/1.0-PX5-S	10	= D	1.0 ± 0.03	1460 ± 25%
DSC10/2-PX5-S	10	= D	2.0 ± 0.1	730 ± 25%
DSC10/3-PX5-S	10	= D	3.0 ± 0.1	490 ± 25%
DSC10/5-PX5-S	10	= D	5.0 ± 0.1	290 ± 25%
DSC16/0.5-PX5-S	16	15 ± 0.3	0.5 ± 0.03	6800 ± 25%
DSC16/1-PX5-S	16	= D	1.0 ± 0.03	3735 ± 25%
DSC25/0.5-PX5-S	25	24 ± 0.3	0.5 ± 0.03	17200 ± 25%
DSC25/1-PX5-S	25	= D	1.0 ± 0.03	9125 ± 25%
DSC25/2-PX5-S	25	= D	2.0 ± 0.1	4560 ± 25%
DSC32/14-PX41-S-T	31.75 ± 0.5	-	≈ 14.3[1)]	650 ± 25%
DSC25/10-PX41-S-T	25.4 ± 0.5	-	≈ 10.2[2)]	550 ± 25%
DSC25/1-PX42-S	25.0 ± 0.1	-	1 ± 0.1	5750 ± 25%
DSC25/2-PX42-S	25.0 ± 0.1	-	2 ± 0.1	2870 ± 25%
DSC38/3-PX42-S	38.0 ± 0.5	-	3 ± 0.1	4430 ± 25%
DSC38/6-PX42-S	38.0 ± 0.5	-	6 ± 0.1	2215 ± 25%
DSC50/3-PX42-S	50.0 ± 1.0	-	3 ± 0.1	7670 ± 25%
DSC50/6-PX42-S	50.0 ± 1.0	-	6 ± 0.1	3835 ± 25%

Remark: Other grades and sizes are available on request. The positive pole is marked.

1) Tuned for 151 kHz

2) Tuned for 200 kHz

discs with linear wrap-around electrode



DSC10/1/WL-PX5-S

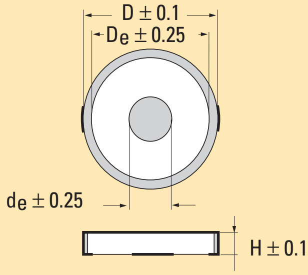
D (mm)	D_e (mm)	H (mm)
10	6.5	1
capacitance (pF)		
1000 ± 25%		

DSC16/1/WL-PX5-S

D (mm)	D_e (mm)	H (mm)
16	10	1
capacitance (pF)		
2600 ± 25%		

These discs are designed for connecting both electrodes from one side by means of a wrap-around electrode as shown. They are therefore particularly suitable for bonding to flat substrates where electrical connection to both sides is difficult.Other grades and sizes are available on request.

discs with round wrap-around electrode



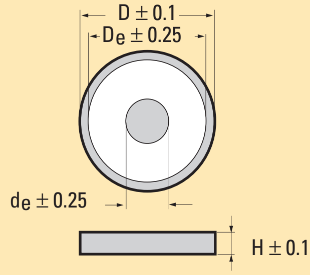
DSC20/0.9/WR-PX42-S

D (mm)	D_e (mm)	d_e (mm)	H (mm)
20	17	7	0.85
capacitance (pF)			
730 ± 20%			

DSC20/1.2/WR-PX42-S

D (mm)	D_e (mm)	d_e (mm)	H (mm)
20	17	7	1.2
capacitance (pF)			
520 ± 20%			

discs with round wrap-around electrode



DSC16/2/WR-PX5-G

D (mm)	D_e (mm)	d_e (mm)	H (mm)
16	13.1	7	2
capacitance (pF)			
490 ± 20%			

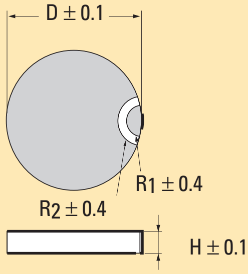
DSC25/2/WR-PX5-G

D (mm)	D_e (mm)	d_e (mm)	H (mm)
25	22.7	8	2
capacitance (pF)			
640 ± 20%			

DSC25.4/2/WR-PX5-G

D (mm)	D_e (mm)	d_e (mm)	H (mm)
25.4	22.7	8	2
capacitance (pF)			
640 ± 20%			

discs with circular wrap-around electrode



DSC16/1/WC-PX5-S

D (mm)	R1 (mm)	R2 (mm)	H (mm)
16	2.6	3.6	1
capacitance (pF)			
3350 ± 25%			

DSC20/1/WC-PX5-S

D (mm)	R1 (mm)	R2 (mm)	H (mm)
20	3	4	1
capacitance (pF)			
5230 ± 25%			

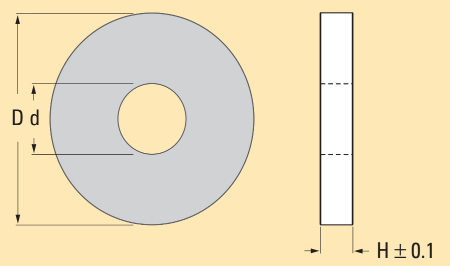
DSC25/1/WC-PX5-S

D (mm)	R1 (mm)	R2 (mm)	H (mm)
25	3	4	1
capacitance (pF)			
8200 ± 25%			

Piezoelectric Ceramics

Rings and high-power actuators

rings

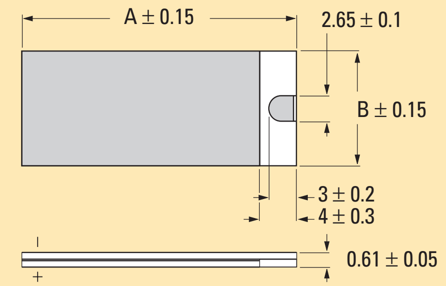


Type number	D (mm)	d (mm)	H (mm)	Capacitance (pF)
RNG10/5/2-PX5-S	10 ± 0.1	5.0 ± 0.15	2	550 ± 25%
RNG12/6/1-PX59-S	12 ± 0.1	6.0 ± 0.15	1	1200 ± 25%
RNG12/6/1.5-PX59-S	12 ± 0.1	6.0 ± 0.15	1.5	865 ± 25%
RNG10/5/2-PX42-S	10 ± 0.1	5.0 ± 0.15	2	340 ± 25%
RNG15/6/3-PX42-S	15 ± 0.1	6.0 ± 0.15	3	580 ± 25%
RNG15/8/2-PX42-S	15 ± 0.1	8.0 ± 0.15	2	740 ± 25%
RNG20/6/5-PX42-S	20 ± 0.4	6.0 ± 0.15	5	670 ± 25%
RNG25/10/4-PX42-S	25 ± 0.5	10.0 ± 0.2	4	1200 ± 25%
RNG25/10/5-PX42-S	25 ± 0.5	10.0 ± 0.2	5	965 ± 25%
RNG25/10/6-PX42-S	25 ± 0.5	10.0 ± 0.2	6	800 ± 25%
RNG38/13/4-PX42-S	38 ± 0.6	12.7 ± 0.3	4	2950 ± 25%
RNG38/13/6-PX42-S	38 ± 0.6	12.7 ± 0.3	6	1970 ± 25%
RNG38/13/6.4-PX42-S	38 ± 0.6	12.7 ± 0.3	6.35	1870 ± 25%
RNG38/19/4-PX42-S	38 ± 0.6	19.0 ± 0.4	4	2490 ± 25%
RNG38/19/6.4-PX42-S	38 ± 0.6	19.0 ± 0.4	6.35	1570 ± 25%
RNG50/20/5-PX42-S	50 ± 1.0	20.0 ± 0.4	5	3865 ± 25%
RNG50/20/6-PX42-S	50 ± 1.0	20.0 ± 0.4	6	3220 ± 25%
RNG50/20/6.4-PX42-S	50 ± 1.0	20.0 ± 0.4	6.35	3040 ± 25%
RNG10/5/2-PX43-S	10 ± 0.1	5.0 ± 0.15	2	260 ± 25%
RNG15/8/2-PX43-S	15 ± 0.1	8.0 ± 0.15	2	530 ± 25%
RNG20/6/5-PX43-S	20 ± 0.4	6.0 ± 0.15	5	500 ± 25%
RNG25/10/4-PX43-S	25 ± 0.5	10.0 ± 0.2	4	910 ± 25%
RNG25/10/5-PX43-S	25 ± 0.5	10.0 ± 0.2	5	730 ± 25%
RNG25/10/6-PX43-S	25 ± 0.5	10.0 ± 0.2	6	610 ± 25%
RNG38/13/4-PX43-S	38 ± 0.6	12.7 ± 0.3	4	2220 ± 25%
RNG38/13/6-PX43-S	38 ± 0.6	12.7 ± 0.3	6	1480 ± 25%
RNG38/13/6.4-PX43-S	38 ± 0.6	12.7 ± 0.3	6.35	1400 ± 25%
RNG50/20/5-PX43-S	50 ± 1.0	20.0 ± 0.5	5	2910 ± 25%
RNG50/20/6-PX43-S	50 ± 1.0	20.0 ± 0.5	6	2425 ± 25%

Our standard range of rings has silver electrodes. The polarization is axial and the positive electrode is marked. Other sizes and grades are available on request.

Bimorph elements

parallel bimorph elements



Type number	A (mm)	B (mm)	Cap. (pF)[1]	F_r MIN. (Hz)	Defl. (μm)[2]
BIMP15/6/0.6-PX5-N	15	6	9000	2200	85 ± 20%
BIMP20/6/0.6-PX5-N	20	6	13000	1000	195 ± 20%
BIMP25/6/0.6-PX5-N	25	6	16500	500	335 ± 20%
BIMP30/6/0.6-PX5-N	30	6	20000	350	525 ± 20%
BIMP35/6/0.6-PX5-N	35	6	24000	240	750 ± 20%
BIMP15/12/0.6-PX5-N	15	12	18000	2200	85 ± 20%
BIMP20/12/0.6-PX5-N	20	12	25000	1000	195 ± 20%
BIMP25/12/0.6-PX5-N	25	12	33000	500	335 ± 20%
BIMP30/12/0.6-PX5-N	30	12	40000	350	525 ± 20%
BIMP35/12/0.6-PX5-N	35	12	48000	240	750 ± 20%

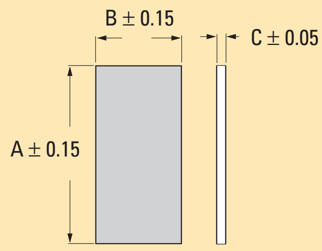
A range of rectangular parallel bimorph elements in grade PXE 5.The electrodes are nickel-plated and the inner electrode is accessible through a small cut-out in the upper plate. Parallel bimorphs are especially recommended for use as actuators.

Remark: Bimorphs in other sizes and materials or with intermediate metal layers are available on request

1) The capacitance between the central electrode and the interconnected outer electrodes

2) Deflection peak-to-peak at 300 V peak-to-peak (± 150 V) with free length is A - 5mm
Bimorph not mechanically loaded

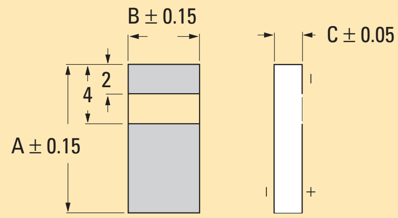
square and rectangular plates



type number	A (mm)	B (mm)	C (mm)	capacitance (pF)
nickel electrodes				
PLT4/4/0.3-PX5-N	4	4	0.3	990 ± 20%
PLT6/6/0.3-PX5-N	6	6	0.3	2230 ± 20%
PLT8/4/0.3-PX5-N	8	4	0.3	1980 ± 20%
PLT8/8/0.3-PX5-N	8	8	0.3	3960 ± 20%
PLT10/10/0.3-PX5-N	10	10	0.3	6200 ± 20%
PLT12/4/0.3-PX5-N	12	4	0.3	2970 ± 20%
PLT12/6/0.3-PX5-N	12	6	0.3	4460 ± 20%
PLT12/6/0.5-PX5-N	12	6	0.5	2670 ± 20%
PLT12/6/1.0-PX5-N	12	6	1.0	1340 ± 20%
PLT12/12/0.3-PX5-N	12	12	0.3	8920 ± 20%
silver electrodes				
PLT12/6/0.5-PX5-S	12	6	0.5	2670 ± 20%
PLT12/6/1-PX5-S	12	6	1	1340 ± 20%
PLT12/6/1.3-PX5-S	12	6	1.25	1070 ± 20%
PLT16/12/1-PX5-S	16	12	1	3500 ± 20%

The material grade in the tables is PXE 5, but other grades and sizes are available on request (any thickness between 0.2 and 3.0 mm is possible). The positive pole is marked.

plates with wrap-around electrodes



type number	A (mm)	B (mm)	C (mm)	capacitance (pF)
PLT10/4/1/W-PX5-S	10	4	1	480 ± 25%
PLT10/4/2/W-PX5-S	10	4	2	240 ± 25%
PLT10/5/1/W-PX5-S	10	5	1	600 ± 25%
PLT10/5/2/W-PX5-S	10	5	2	300 ± 25%
PLT15/5/2/W-PX5-S	15	5	2	550 ± 25%

These plates have provision for connecting both electrodes from one side by means of a wrap-around electrode as shown. They are therefore particularly suitable for bonding to flat substrates where electrical connection to both sides is difficult. The material is PXE 5, but other grades and sizes are available on request.