EP5 - a new telecom core size

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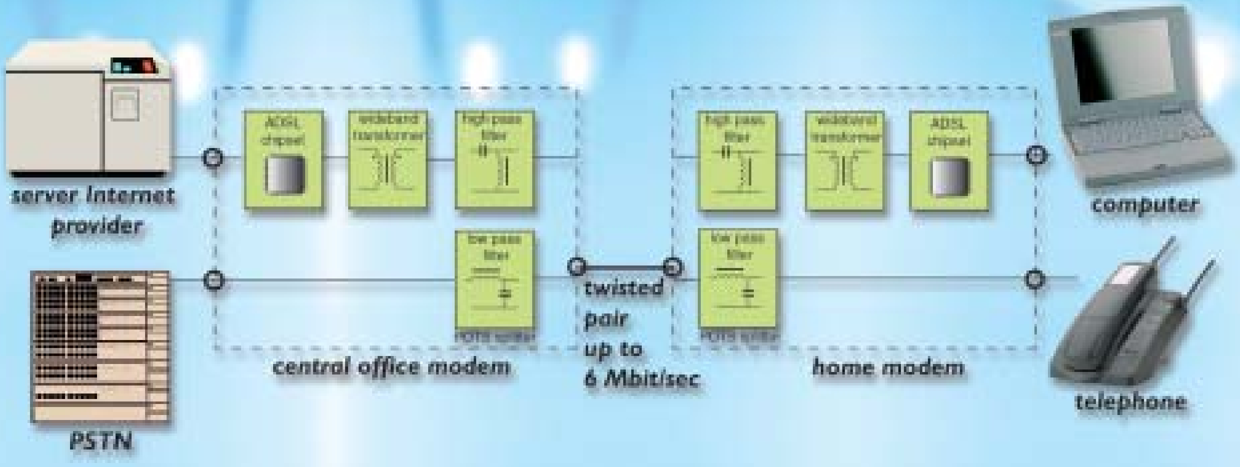
In modern Telecom applications like ISDN and DSL ferrite-cored pulse and wideband transformers play an important role. These transformers provide impedance matching and safety isolation in modems placed between networks and telephone sets or computers. Driven by miniaturization, equipment manufacturers design-in the smallest possible transformers while still fulfilling the requirements set by chip-set makers or standardization bodies like ITU-T.

For pulse transformers (ISDN) a high Lp is of prime importance to keep pulses within the prescribed mask, so cores with high A_L values in high permeability materials like our 3E6 are often used. With these cores the number of turns, and thus parasitic capacitance, is kept low for improved high frequency behavior.

In DSL applications the key design parameter is THD (Total Harmonic Distortion). It must be kept low to avoid bit errors during the translation of analog signals to digital information. The new low-THD material 3E55 is therefore ideal for use in DSL transformers and thus precision gapped products are offered.

EP cores are very popular for these designs because of their flat top for easy handling and their closed shape for excellent magnetic shielding. Up to now the EP7 core was the smallest available size in the range. For this reason, designers requiring smaller sizes had to deviate from normal practice and switch to small E cores or toroids.



New material 3E55 with improved THD properties

The THD of a ferrite component should be low under operating conditions. THD is a function of flux density (B), frequency (f) and temperature (T). To evaluate material quality with respect to THD, V_1 and V_3 have been measured with an audio analyzer on toroid samples together with their amplitude permeability μ_a. In the curves of Fig.1, 8 and 9 the behaviour of THD/μ_a as a function of B, T, and f is shown for the current high permeability ferrite 3E6 (μ_i =10.000) and for the newly developed low THD material 3E55. Values are plotted in dB-units calculated with the formula:

$20.^{10}\log (V_3 / V_1) / (\mu_a)$

As expected THD increases when the flux density level rises (Fig. 1.) This can be explained by the fact that pores and impurities inside the material act as pinning points for the domain- wall movement. At a certain magnetic field strength (H) the domain-walls jump to the next pinning point. Such irreversible jumps result in a more than linear increase of the flux density B with field H, resulting in distortion. Ferrite materials having an improved, clean homogeneous microstructure will allow a “gentle” move of the domain walls with the driving field, resulting in a more linear behaviour. The newly developed material 3E55 is optimized by raw material choice, (low impurity level), addition of dopes and improved sinter conditions.
This results in an improvement for flux densities up to 20 mT.

In the temperature behaviour of every ferrite a minimum for THD/ma is noticed. This minimum coincides with the point where the permeability versus temperature shows a (secondary) maximum denoted as Tsm. At this temperature the an isotropy and therefore hysteresis losses are minimal. To the left and right of this temperature the THD usually increases sharply. Changes in chemical composition of the material will shift the curie temperature Tc and the Tsm of the material. Materials optimized for THD show low values over a substantial temperature range and not for one or two specific temperatures. The optimum is found by placing the Tc slightly above 100 ˚C and the Tsm at about 5˚C.
Fig. 3 shows the improvement in THD performance over the temperature range for 3E55 compared to 3E6.

These results are based on measurements on toroids. For the THD in core sets not only the properties of the pure material but also the condition of the mating surfaces in the core set determine the overall distortion in the product. Bad planarity or grinding grooves will cause magnetic flux concentrations, which increases the distortion level, especially when the surfaces are directly in contact with each other.
Coarse- and fine-ground samples show inferior distortion compared to lapped samples. However this difference disappears when an airgap is introduced by putting a spacer between the core halves.

Ferrite material properties

The curves clearly show the differences in material characteristics between "normal" high permeability ferrites and the new low distortion material 3E55. Notice the improved behaviour of THD at low flux densities and as a function of temperature. However, at room temperature and higher flux densities (B > 30 mT), the differences between 3E55 and 3E6 are not significant.

Fig.1 THD/μ_a - B measured at 10 kHz and 20˚C

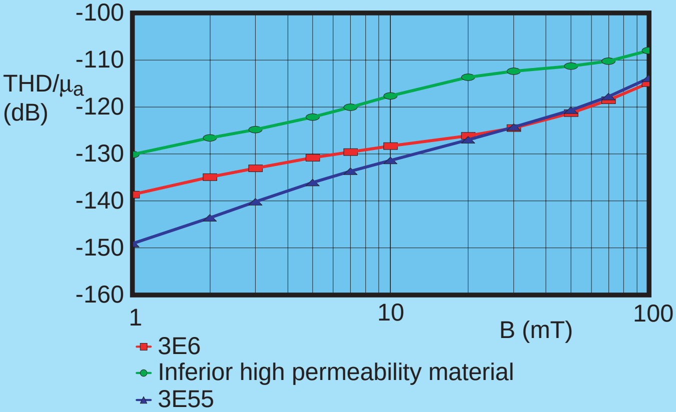


Fig.2 μ_i-T curve

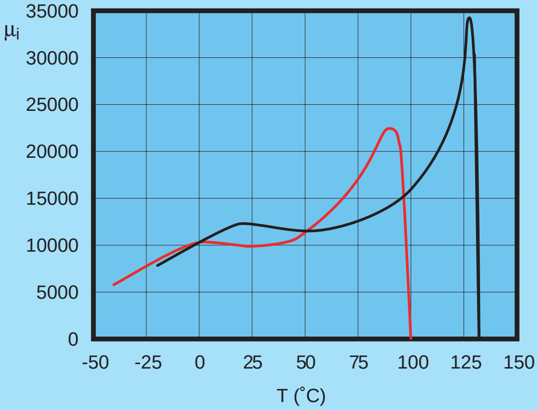
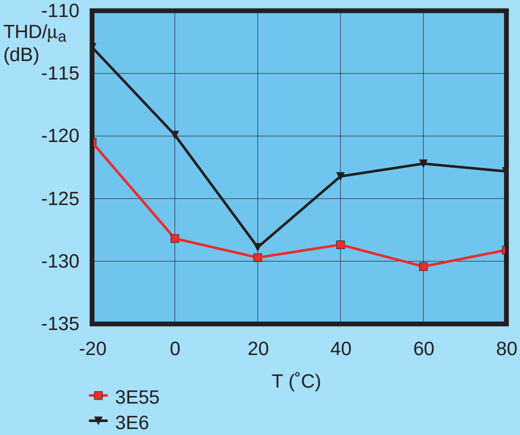
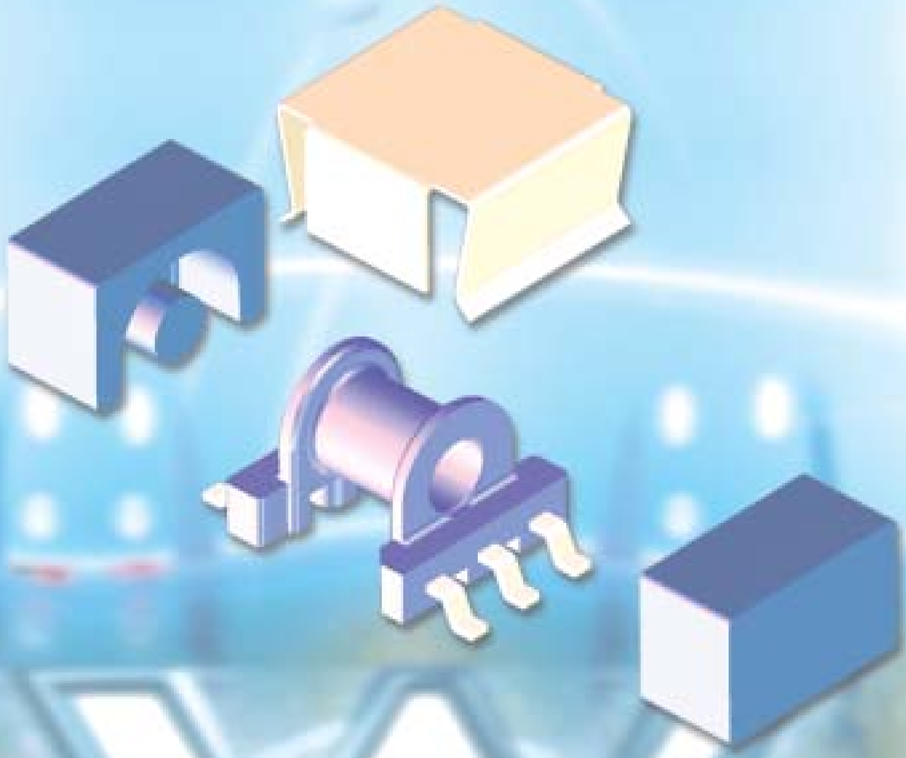


Fig.3 THD/μ_a - T at 10 kHz and 10 mT





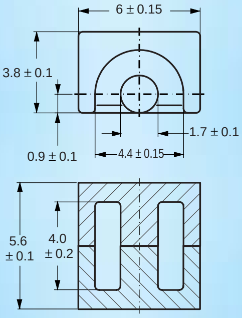
The new EP5 design, complete with SMD bobbin and clip satisfies the need for smaller pulse transformers. They are available in the high permeability material 3E6 for pulse transformers and in the new low harmonic distortion material 3E55 for DSL wideband applications.

Even though the EP5 has half the volume of an EP7 it is suitable to build pulse transformers which comply to CCITT (G.703).

Direct replacement for E5.3 cores

EP5 can serve as a direct replacement for a wideband transformer based on E5.3 because their bobbins have the same footprint. Advantages of the EP5 design compared to E5.3 are: improved magnetic shielding due to the closed core shape, higher A_L values and a larger winding area. Furthermore, it can be shown that the EP core shape intrinsically has a superior THD performance. This is explained in more detail in our Application Note "The use of Ferrite Cores in DSL wideband Transformers" (9398 088 00111).

The EP5 product range



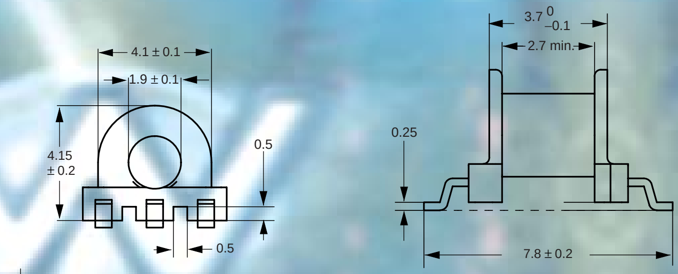
CORE SETS

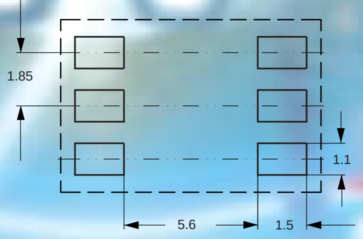
Effective core parameters

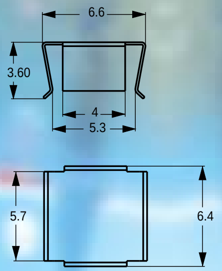
SYMBOL	PARAMETER	VALUE	UNIT
$\Sigma(l/A)$	core factor (C1)	3.20	mm^{-1}
V_e	effective volume	28.7	mm^3
l_e	effective length	9.70	mm
A_e	effective area	3.00	mm^2
A_{min}	minimum area	2.27	mm^2
m	mass of core set	≈ 0.5	g

Core sets

MATERIAL	A_L (nH)	EFFECTIVE PERMEABILITY (μ_e)	AIRGAP (μm)	TYPE NUMBER
3E55	16 ± 3%	≈ 41	≈ 320	EP5-3E55-A16
	25 ± 3%	≈ 64	≈170	EP5-3E55-A25
	40 ± 5%	≈102	≈ 90	EP5-3E55-A40
	63 ± 8%	≈160	≈ 50	EP5-3E55-A63
	2000 +40/-30%	≈ 5100	≈ 0	EP5-3E55
3E6	2200 +40/-30%	≈ 5600	≈ 0	EP5-3E6







Clip for EP5
Material: CrNi steel
thickness 0,15 mm.

General data for EP5 bobbin with 6 soldering pads

	SPECIFICATION
Coil former material	Liquid crystal polymer (LCP), glass reinforced, flame retardant in accordance with UL 94V-0; UL file number E54705(M)
Pin material	copper-tin alloy (CuSn), tin-lead alloy (SnPb) plated
Maximum operating temperature	155 °C, IEC 85 class F
Resistance to soldering heat	*"IEC 68-2-20",* Part 2, Test Tb, method 1B: 350°C, 3.5 s
Solderability	*"IEC 68-2-20",* Part 2, Test Ta, method 1: 235°C, 2 s

Winding data for EP5 bobbin with 6 soldering pads

NUMBER OF SECTIONS	WINDING AREA (mm^2)	MINIMUM WINDING WIDTH (mm)	AVERAGE LENGTH OF TURN (mm)	TYPE NUMBER
1	1.89	2.7	10.5	CPHS-EP5-1S-6P

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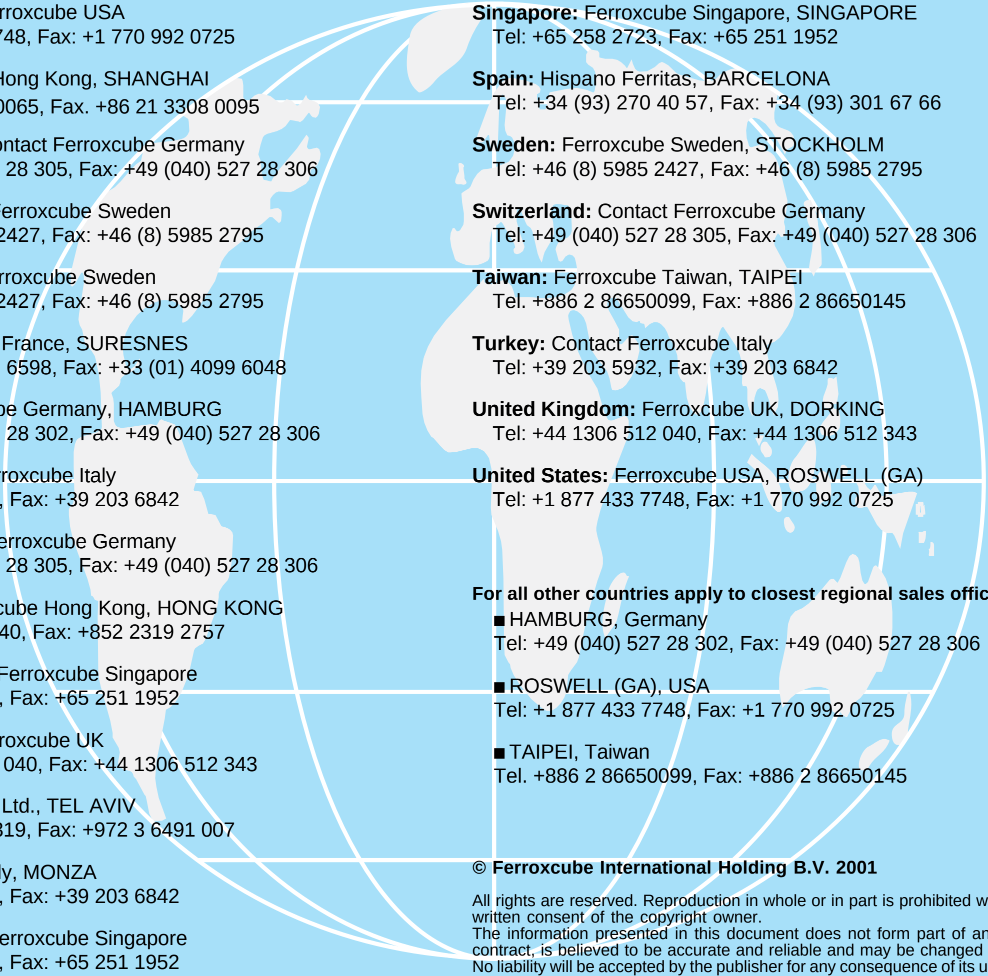

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