

## Applications & Cases



Flat transformers for modular switch-mode power supplies

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## The future is flat

TV sets are becoming flatter than ever. The German electronics group Loewe is at the forefront of this trend. Loewe has managed to reduce the previously usual thickness of its new Reference series of LCD TV sets by almost half from 100/120 mm to only 60 mm. This was done not only by using state-of-the-art displays with LED backlighting as well as flat loudspeakers – but also by optimizing the insertion height of the power supply.

The depth of a TV set used to be determined by the picture tube, while the critical factor today is the switch-mode power supply and the components it contains – especially the transformers. Thanks to the consistent evolution of a concept developed for the lighting industry, EPCOS has now succeeded in reducing the insertion height of a 100-W transformer from 50 to 15 mm. The transformer was simultaneously optimized especially for high efficiency state-of-the-art power supplies.

### State-of-the-art concepts for power supplies

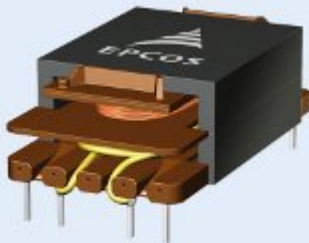
Conventional flyback or forward converters are frequently still being used in the power range between 100 and 500 W. In view of their comparatively high switching losses, these topologies rarely reach efficiencies greater than 85 percent. In a 400-W power unit, this means that a power loss of about 60 W must be dissipated via heat sinks and the circuit board. As a result, such conventional power units are expensive to manufacture and take up considerable space.

Loewe consequently uses state-of-the-art LLC topology in the power units of its extremely flat premium TV sets. LLC designates the three key components that perform the function of the oscillating circuit: the magnetization inductance ( $L_m$ ) of the transformer, its stray inductance ( $L_s$ ) and the resonance capacitor (C). To minimize the switching losses in the MOSFET power semiconductor, the voltage in an LLC switch-mode power supply is switched with zero voltage switching (ZVS). In all power classes of its modular power supplies, Loewe uses a PFC stage in front of the LLC converter. This not only improves the angle of current flow but also supplies the converter with an effectively stabilized input voltage.

In view of the low switching losses of this circuit, heat sinks are not needed; the heat is dissipated purely via the board. This simplifies the manufacture of the power supplies and reduces costs.



FIGURE 1: FLAT TRANSFORMERS



The primary and secondary windings of the new transformers for switch-mode power supplies are accommodated in their own chambers and stacked on top of each other to save space.

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### Product development in close coordination with Loewe

Already four weeks after the first inquiry from Loewe, EPCOS supplied the first prototypes of its extremely flat transformer. On the basis of these prototypes, in close coordination with the Product Development and Product Marketing Departments of EPCOS, Loewe developed the specifications for two 100-W transformers with different transformation ratios as well as for a PFC transformer, all of them optimally matched for the requirements of its new generation of premium TV sets.

The windings are stacked over each other in an extremely flat configuration (Fig. 1) to ensure that each of the new EPCOS two-chamber transformers with an insertion height of only 15 mm can transform significantly more than 100 W. The special EPCOS E26 core ensures a good coupling and a comparatively low leakage field at switching frequencies between 50 and 200 kHz.

The transformer's coil former satisfies the requirements of the highest insulation class and is accordingly listed in CTI group 1 or as PLC 0. The separation of the primary and secondary windings as well as the voltage strength of the coil former ensure a high dielectric strength of 3000 V AC despite the compact dimensions of the transformer. Because the components also satisfy all European and German protection requirements on power-supply transformers, they bear the VDE test mark. The table below gives an overview of the key specifications of the transformers.

**Table: OVERVIEW OF TECHNICAL DATA OF THE NEW TRANSFORMER**

	Transformer T4506	Transformer T4505	PFC transformer T4580
Dimensions (H x W x T)	15.5 x 27.5 x 47.5 mm <sup>3</sup>		14.5 x 27.0 x 42.5 mm <sup>3</sup>
Inductance (primary-side)	37.0 to 43.0 µH	50.8 to 59.2 µH	900 µH ± 15%
Winding resistance (primary side)	max. 0.30 Ω	max. 0.30 Ω	max. 0.60 Ω
DC resistance (secondary side)	max. 50 mΩ	max. 50 mΩ	--
Transfer ratio	9:4:4	12:4:4	64.5:3:5
Breakdown strength (winding w.r.t. core)	1500 V AC	1500 V AC	1500 V AC
Breakdown strength (primary/secondary)	3000 V AC	3000 V AC	--

“In conjunction with state-of-the-art power supply topologies, these transformers allow efficiencies significantly greater than 95 percent to be reached,” explains Bernhard Roellgen from the EPCOS Product Development Magnetics. Low power losses not only improve the energy balance of the TV set. In the power class up to 500 W, heat sinks can be obviated for the power semiconductors in the power supply unit, thus reducing manufacturing costs and permitting very flat designs. A major contribution to these is made by the open, vacuum-impregnated design of the transformers, which are placed directly onto the circuit board via their solder pins.

The coordination of the project with the power supply development activities at Loewe, the development of the transformers in Munich and their manufacture in China was a demanding task. To ensure that the new transformers could go into series production at the EPCOS plant in Hongqi/ China, project-specific tools were manufactured in coordination with Loewe and were then further adapted during the circuit development process at Loewe and the product development stage at EPCOS. “Throughout the simultaneous development of the switch-mode power supply at Loewe and the flat transformer at EPCOS we were able to significantly shorten the path to a series component and thus optimize the development costs to the benefit of the customer,” says Uwe Ernst, Product Marketing Manager Transformers in Munich.

### Lighting technology as innovation driver

EPCOS originally developed the basic concept with flat stacked windings for use in the electronic ballasts of energy-saving lamps. The magnetic properties of the transformer were optimized for this purpose using a sophisticated computer simulation in order to minimize the magnetic loop and thus obtain high efficiency with compact flat dimensions. In view of the large volumes involved, the lighting industry in general is considered an innovation driver in this sector. Components for lighting technology must also operate reliably at high operating temperatures and be quickly available – even in large volumes.

## Partner for modular power supplies

For use in the power supply unit of a premium TV set, however, the flat winding concept had to be suitably adapted and optimized for modular power supply concepts. Furthermore, it was necessary to ensure a reliable electrical isolation. One of Loewe's development aims was to use a modular circuit design with the same components to implement various classes of power supplies in the range from 200 to 500 W. Thanks to the new components, there is now no longer any need for a specific transformer for each power class: if more power is needed, several of the new transformers are simply connected together.

Together with the new transformers, EPCOS now supplies all complex inductors as well as a large part of the film capacitors for the power supplies of the new, extremely flat premium TV sets from Loewe.