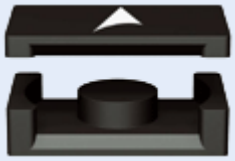
## Applications & Cases

Ferrite material N51 for switch-mode power supplies May 2006

# Recipe against energy thieves

At times of rising energy costs it is particularly important to rein in the energy guzzlers. It is often forgotten that a stereo player or TV set consumes power in standby mode. In Germany alone more than 20 billion kWh are lost each year in this mode – a figure that corresponds to roughly one and a half times the energy a large city like Berlin needs for a whole year. The consumption is so high in standby mode because ferrites have their highest efficiency under load. EPCOS now offers the N51 material that significantly reduces standby losses.

### PRODUCT PROFILE



With N51 EPCOS offers a ferrite material that reduces losses of switch-mode power supplies in standby mode.

| | |
|---|---|
| Power dissipation at 25 °C: | 407 kW/m$^3$ |
| Initial permeability: | 3000 |
| Saturation flux density: | 490 mT |

The energy consumption of electronic equipment such as TV sets or computers centers around the switch-mode power supplies – SMPS in brief. They generate the required secondary DC voltages from the power input. This conversion process simultaneously means that the losses rise as the load on the power supply increases. Thus a higher volume setting on a TV set increases the load on the power supply.

**Most of operating life in standby mode**

The reason why ferrites contribute most strongly to energy consumption in standby mode is their temperature-dependent efficiency. In general, the losses within a ferrite core initially drop as the temperature rises, to reach a minimum between 70 and 120 °C. In standby operation, when only a low load is applied, a power supply equipped with ferrite cores operates at ambient temperature, where ferrites exhibit the greatest losses and thus make the greatest contribution to losses in SMPS. This can only be minimized by taking advantage of the specific properties of the material.

In general, the losses in SMPS originate in:

- the ferrite cores
- the windings
- the power semiconductors, and
- the leads, contacts etc.

The losses listed in the last three points rise with increasing load but can be neglected in standby mode. Most equipment is operated for significantly more than half its operating life in this mode. As the total losses in standby mode are lower, no significant temperature rise takes place so the temperature of the power supply remains close to ambient. Specified limits are increasingly demanded for the standby losses of the SMPS, especially for environmental reasons. In aiming to realize these limits, development must concentrate on reducing the core losses at ambient temperature.

**Loss minima in the lower temperature range**

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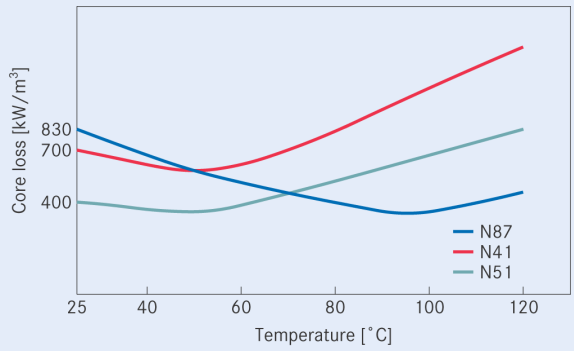
Figure 1 shows clearly that at room temperature the new material N51 is preferable to the N87 material for these applications, as its loss minimum lies in the lower temperature range. N51 exhibits lower losses than N41 both at room temperature and high temperatures. In contrast, N87 is optimized for high continuous loads. Its power dissipation minimum therefore lies in the temperature range just below 100 °C. Its typical applications are in converters that are operated at a constant high power.

**FIGURE 1:** COMPARISON OF MATERIALS




Power losses of various ferrite materials as a function of temperature

The specific losses in the core are around 700 kW/m$^3$ for the conventional material N41 under the prevailing conditions of 25 °C ambient temperature, 100 kHz frequency and a magnetic flux of 200 mT. Because current requirements are at 400 kW/m$^3$, EPCOS developed the improved material N51 (Table 1).

Optimal electrical and magnetic properties of MnZn ferrites occur at a defined temperature known as the second permeability maximum (SPM). At the SPM, the magnetic crystalline anisotropy is zero. The composition of the new material was selected such that the SPM lies close to room temperature. The critical feature of the new recipe is the ratio between bivalent and trivalent iron, which has a determining effect on the temperature-dependent magnetic crystalline anisotropy. EPCOS can produce all usual cores from the new material N51 – inclusive of special designs.

**IMPROVED MATERIAL**

| Parameter (with boundary conditions) | N41 | N51 | Unit |
|---|---|---|---|
| Initial permeability | | | |
| 10 kHz; 0,25 mT, 25 °C | 2800 | 3000 | |
| Core losses | | | |
| 100 kHz; 200 mT | | | |
| 25 °C | 693 | 407 | kW/m$^3$ |
| 100 °C | 1260 | 675 | kW/m$^3$ |
| Saturation flux density | | | |
| 10 kHz; 1200 A/m | | | |
| 25 °C | 490 | 490 | mT |
| 100 °C | 390 | 380 | mT |

Table 1: Comparing the properties of N51 and N41

**Authors:**
Somen Goswami (Senior Engineer, Material Development, EPCOS Kalyani, India) and Probal Mukherjee (Deputy General Manager and Head of Development, EPCOS Kalyani, India)

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