



## **Inductors**

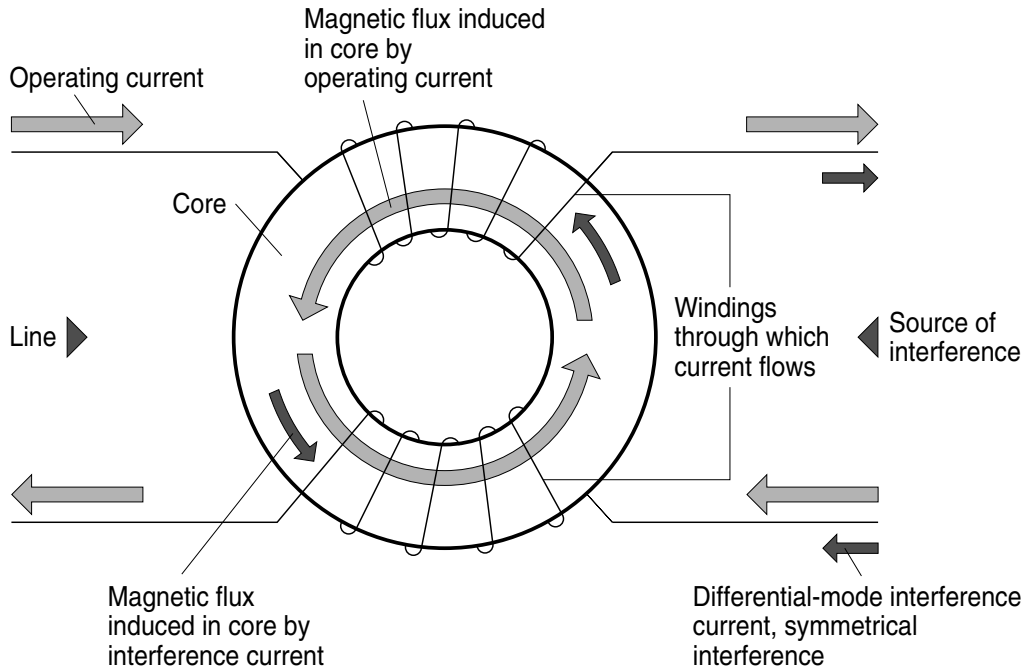
Power line chokes  
Ring core chokes with iron powder core

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## Power line chokes

### Ring core chokes with iron powder core

#### General



IND0825-B-E

Figure 1 Ring core choke with powder core  
Double choke shown as an example

Ring core chokes with iron powder core are primarily used to attenuate differential-mode interference voltages and currents in cases where the use of X capacitors is ineffective, inadequate or undesired.

In order to avoid saturation, these chokes are equipped with a closed ring core of iron powder with low permeability. They are often installed together with current-compensated chokes to improve differential-mode interference attenuation, especially at low frequencies.

Single chokes with powder core attenuate differential-mode RF interference on the connected line. Both windings of double chokes act as if they were connected in series, their effect on differential-mode interference corresponds, in practice, to roughly 3.5 times their rated inductance.

Common-mode interference is also attenuated by double chokes with powder core; maximally half the rated inductance of one winding is effective. As with I core chokes – the rated inductance is only minimally affected by operating current bias. Due to the closed core, the stray field, however, is substantially lower than that of a corresponding I core choke.

### Suppression of harmonics and PFC

Nowadays electrical devices must be designed and tested to comply with certain directives. In the European Union there are standards dealing with harmonics and power factor correction (PFC) respectively, defining limit values as well as test methods for electrical devices. In particular, the EN 61000-3-2 standard defines the limits for harmonic current emissions that electrical equipment with input current  $\leq 16$  A per phase must adhere to.

Switch-mode power electronics is the state of the art in consumer and industrial applications (i.e. SMPS, lamp ballasts, motor drives). The typical architecture of such a circuit includes a rectifier stage, which provides a DC voltage link to a semiconductor-based switching stage that is typically digitally controlled. The output is then filtered employing an inductance.

The single-phase bridge rectifier that is generally used in the input stage is connected to a large capacitor that smooths the pulsating voltage. However, this recharging of the capacitor causes a non-sinusoidal current flow (see also "Sine-wave chokes"). The current harmonics and the impedance of the circuitry cause voltage harmonics. These harmonics not only cause higher losses and shorten the lifetime of equipment, they are also coupled back into the mains power supply.

Harmonic distortion at lower frequencies can be reduced using an inductor connected in series with the device at power input. Single and double chokes with powder core are usually utilised for this purpose. Here, a range of well-established standard chokes featuring an iron powder ring core is offered by EPCOS. Double chokes are often more favourable, as they also provide up to 50% of the rated inductance for the suppression of common-mode interferences.

For higher powered electrical equipment, the inductance values needed for effective suppression of harmonics increase rapidly and the chokes soon become too bulky. For this reason more sophisticated active circuitry is used. The main purpose of such circuits is correction of the power factor (active PFC).

As mentioned before, the current flow caused by the rectifier stage is non-sinusoidal and not in phase with voltage. So the power factor ( $\lambda = \frac{P}{S}$ , where P is the real and S the apparent power) is lower than 1. This causes a rise of reactive power Q consumed. For this reason, power suppliers often specify a minimum value for power factor.

## Power line chokes

### Ring core chokes with iron powder core

The active power factor correction is an additional switch-mode stage, which controls the input current to be sinusoidal and in phase with input voltage, simulating a non-reactive (ohmic) load (figure 2). This results in effective reduction of harmonics and therefore, reduced size of chokes needed.

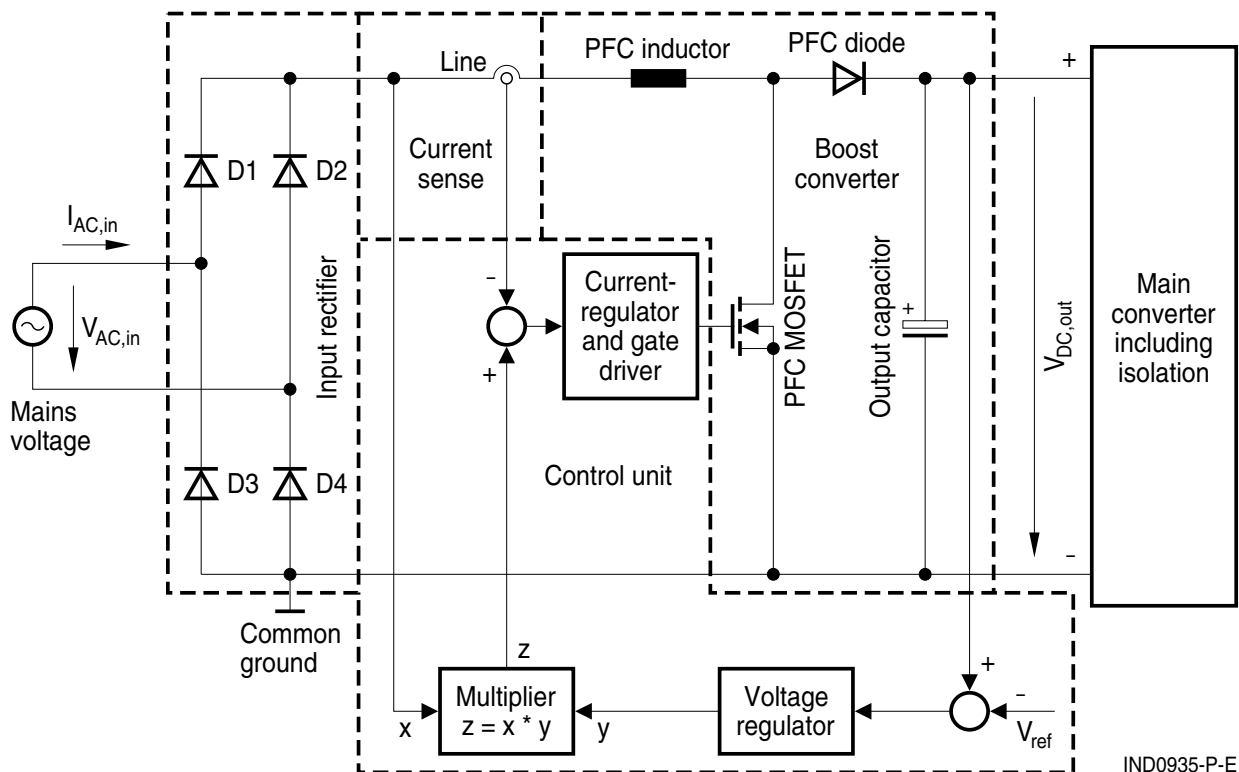


Figure 2 Modern active PFC topology [1]

[1] Reddig, M., Schlenk, M., "High efficient PFC-stage without input rectification", PCIM 2003.

Development of next-generation active PFC stages is mainly focused on increasing efficiency. A popular approach is to design PFC circuits where the number of semiconductors generating losses is reduced by eliminating the input rectifier stage by combining the diodes with switching transistors (figure 3). Such topologies often explicitly require double chokes to be used at the input. [1]

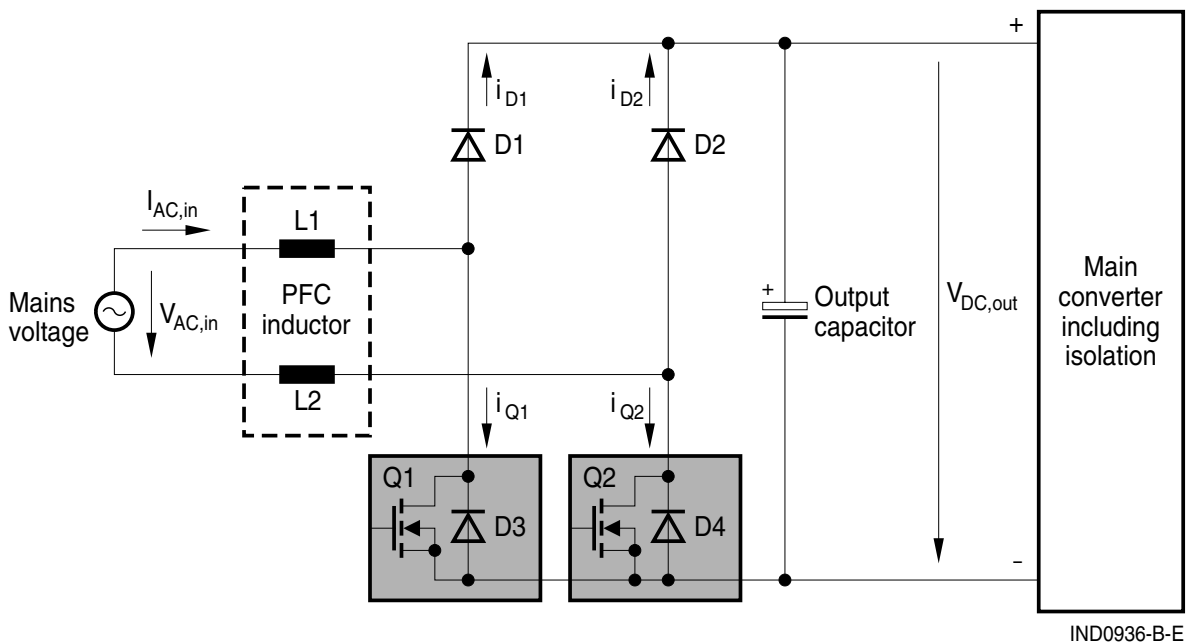


Figure 3 Basic circuit diagram of new active PFC topology [1]

Despite effective reduction of harmonics, the switch-mode PFC increases the level of high-frequency EMC interferences that must be filtered at the connection to the power line, employing components for common- and differential-mode suppression. Here, again, double powder core chokes are more advantageous, as they also help to suppress common-mode interferences.

EPCOS is offering a range of single and double chokes that can be used in small- and mid-sized switch-mode applications for EMC and harmonics suppression as well as for other filtering purposes. Chokes for higher currents, specially designed for passive reduction of harmonics, are also available on request.

For specially defined needs, like high efficiency circuits and filtering at high switching frequencies, customized chokes featuring special powder core materials are feasible on request.

[1] Reddig, M., Schlenk, M., "High efficient PFC-stage without input rectification", PCIM 2003.