EMC components **March 21, 2019**

Drastically reducing earth leakage currents and increasing plant availability

The individual components in variable-speed drives cause earth leakage currents that cumulatively result in the tripping of the RCD. TDK presents the EPCOS LeaXield™ leakage current filter, a novel solution which facilitates a dramatic reduction of earth leakage currents. This enables the effective use of residual current devices (RCDs) and increases plant availability.

Variable-speed drives are used in industrial installations for a variety of tasks and, as a rule, they are fed from three-phase power grids. Possible applications for LeaXield include variable-speed drives such as those in machine tools, pumps, compressors, conveyance systems, and other pluggable devices.

A complete drive system consists of an EMC input filter, the frequency converter and the motor. An equally important component that is often neglected when considering the system is the shielded cable between converter and motor which can often exceed 200 meters in length. For safety reasons, the drive systems are connected to the grid by means of residual current devices (RCDs).

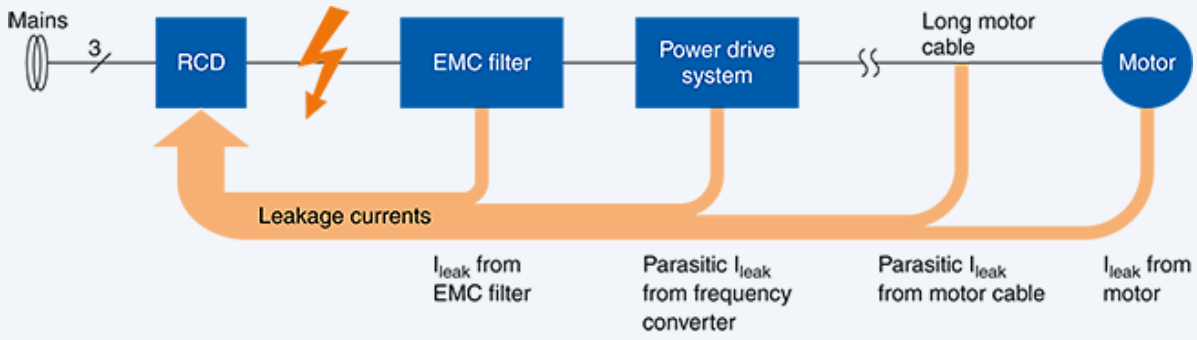


Figure 1:
In many circumstances, the aggregate of all earth leakage currents is so great that the residual current device (RCD) trips unintentionally.

A significant problem of variable-speed drives are the earth leakage currents generated during operation – in particular by the frequency converter. The level of these currents depends on the interference suppression capacitors and the parasitic capacitances to earth, the commutation of the B6 rectifier circuit and the switching cycles of the power semiconductors. In many circumstances, the aggregate of the earth leakage currents exceeds the RCD's tripping threshold (Figure 1).

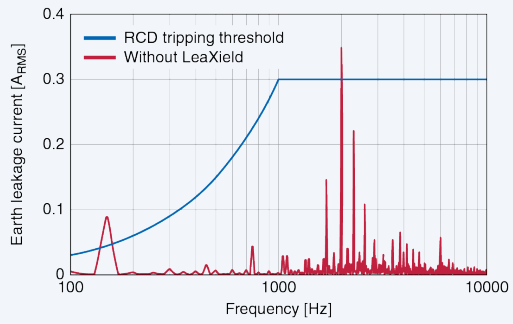


Figure 2:
Earth leakage current in the frequency range (red) relative to the RCD tripping threshold (blue). One threshold is exceeded at 2.7 kHz (variable leakage currents), and another at 150 Hz (steady leakage currents). The consequence is an unintentional tripping of the RCD.

Standard RCDs for variable-speed drives, for example, have a tripping threshold of 30 mA for currents in the frequency range up to 100 Hz, which rises significantly in the range above 100 Hz. Figure 2 shows the tripping threshold of a typical RCD, the limit being about 300 mA for frequencies in excess of 1 kHz. Variable earth leakage currents, caused by switching cycles in the frequency converter, can result in the 300 mA threshold being exceeded. This is the case, for example, at 2.7 kHz in Figure 2. Steady earth leakage currents, on the other hand, which are generated by the commuting of the B6 rectifier circuit, occur at a significantly lower frequency of between 100 Hz and 1 kHz, where the tripping threshold is also much lower. In Figure 2 the earth leakage currents at 150 Hz equal around 90 mA, which causes the RCD to be tripped in every case. Finally, there are also transient leakage currents, such as those that occur when the line voltage is being switched on or off.

When aggregated, the stated parts of leakage current result in an unintentional shutdown of the system which, in industrial plants, can cause costly production downtimes.

Until now, there has not been a comprehensive solution for dealing with the different causes of leakage currents. Attempts are often made to vary the overall capacitance to earth in the system. By switching off the filter capacitor in the converter, for example, it is possible to reduce the 150 Hz portion of the leakage current. This does however mean that in many cases the electromagnetic compatibility is no longer guaranteed. If, on the other hand, the capacitances of the Y-capacitors in the EMC filter are reduced, the proportion of the clock-frequency leakage current will increase despite the lower 50 Hz leakage current.

Although the use of an isolating transformer offers a technical solution, cost and installation space restrictions sometimes render this impossible. Doing without the RCD is by no means an alternative, because this is a safety risk and harbors considerable potential for hazards and accidents. The methods described are unsatisfactory in both technical and economic terms.

LeaXield sets new standards for the reduction of leakage currents

The EPCOS LeaXield leakage current filter has been developed in order to compensate leakage currents. It is inserted in the circuit between the RCD and the EMC line filter.

Figure 3 shows the circuit diagram. To measure the residual current across the three phases, a current sensor is integrated in the LeaXield. By means of an operation amplifier, a correspondingly 180° phase-shifted current with identical amplitude is then generated, which is capacitively coupled to the respective phases.

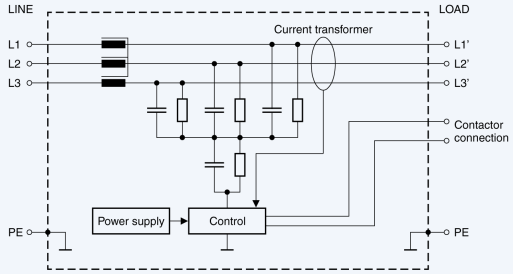


Figure 3:
A 180° phase-shifted current is capacitively coupled to the respective phases. By means of the current sink thus created, the leakage currents are returned to the source. With the optional contactor connections, the LeaXield module is already prepared for operation before the leakage current flows.

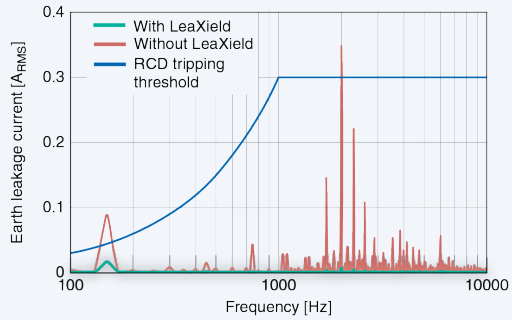
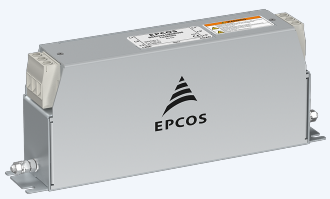


Figure 4:
The unfiltered leakage currents (red) are dramatically attentuated (green) by using the LeaXield and fall well below the RCD tripping threshold. This prevents an unintentional tripping of the RCD.

The leakage currents are fed back into the system by means of the current sink thus created. This prevents them from flowing through the RCD and tripping it unintentionally.

LeaXield can compensate for earth leakage currents of up to 1 A. The compensation effect extends over a wide frequency range from 150 Hz to about 30 kHz. In Figure 4 an unfiltered leakage current (red) in the spectral range is compared with a leakage current (green) that is filtered through the LeaXield. The latter is far below the RCD tripping threshold, thereby preventing unintentional tripping of the RCD.



Thanks to its compact dimensions of just 270 mm x 60 mm x 119 mm, LeaXield is also ideal for retrofitting into existing systems. Furthermore, as no external voltage supply is necessary for operation, the installation costs are low.

For the first time, therefore, LeaXield offers a compact and cost-effective solution for the compensation of leakage currents across a broad frequency range. This permits the use of a residual current device and consequently raises the plant availability.

Technical data of EPCOS LeaXield

Rated voltage V_R	[V AC]	305 / 530 (50 Hz)
Rated current I_R max.	[A]	50
Maximum leakage current $I_{LK,load}$	[A]	1
Frequency range	[Hz]	150 to 30000
Dimensions	[mm]	270 x 60 x 119
Conformity		CE
Ordering code		B84233A1500R000