

## Eliminate RF leakage currents from drives

High-frequency radio frequency (RF) leakage currents in drive-powered systems can be eliminated by using special filters.

### Key concepts

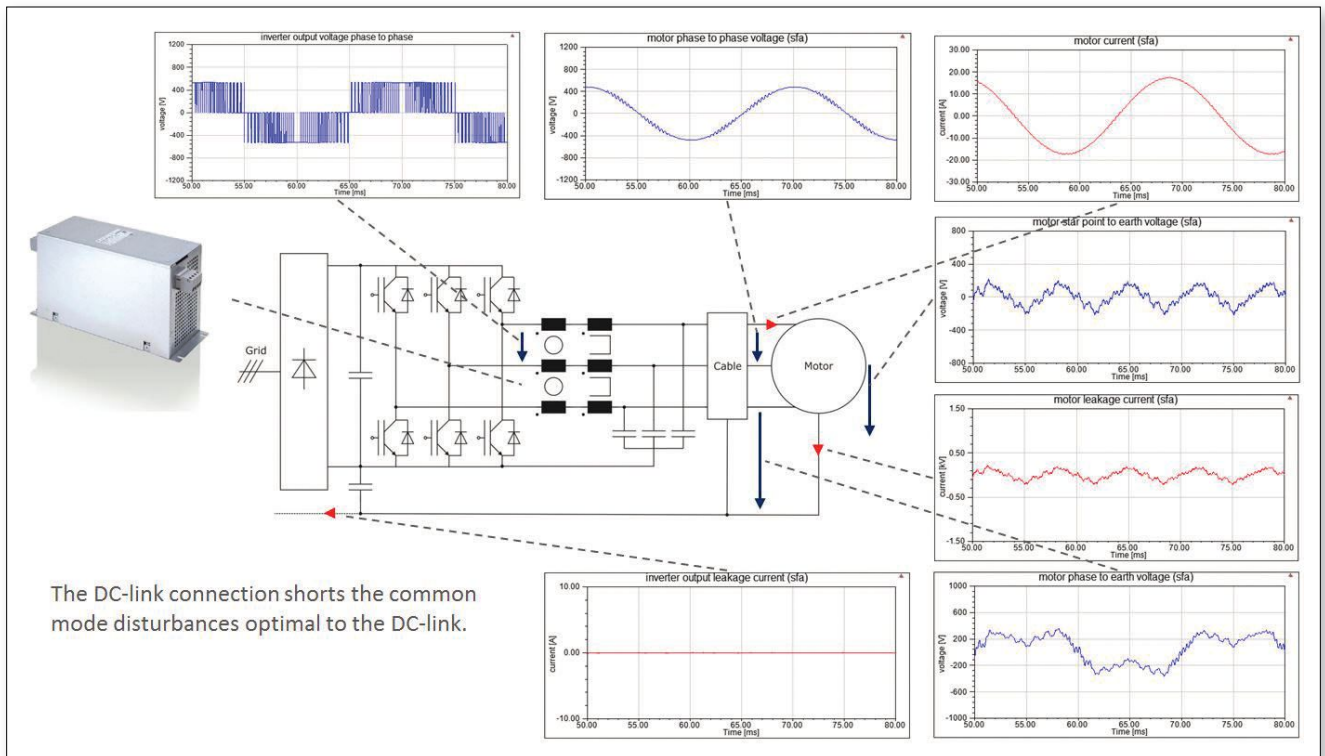


- Get better performance by using intelligent automation.
- All-pole sine filters combine a standard sine-wave filter with an additional step for reducing the common mode.
- Pulsed currents can be caused by the motor bearings when the shaft is better connected to the ground rather than the motor housing.

Using pulse-width modulation, drives' output reaches variable speeds and torques, but also brings some undesired effects such as leakage, bearing currents, and additional thermal losses. A drive is unable to create a 100% symmetrical three-phase system in which common-mode parts are almost zero. In particular, common-mode parts require attention, because these voltages memorize corresponding currents to earth. With increasing motor cable lengths and sizes of motors used, the parasitic capacitance to ground increases. Manufacturers try to improve this by using specific constructions, but this could be done in a limited range only. For an efficient elimination of common-mode disturbances, additional filter technologies have to be used to reduce output interferences to almost zero.

Better performance and efficiency can be achieved by introducing intelligent communication systems. Using such electrical network communication also means the use of high-frequency (HF) signals at low-voltage levels. Establishing stable communication in conjunction with variable speed drives can become a challenge, especially, if interfering currents get into grounding through parasitic capacitances of motor and shielded wires.

This becomes easy to understand, if the equivalent circuit diagram of the drive and its accessories are taken into account. Based on disproportional behavior of impedance and capacitance, HF currents can get into low-impedance grounding systems very easily, and many different interactions may appear, which also can affect communication by superimposing signals.



The DC-link connection, pictured here, shorts the common mode. All graphics and images courtesy: Block USA

## Reduction of differential disturbances (phase-phase)

The first possible reduction of differential interference can be achieved by the use of a motor choke as a first-order filter. This additional inductance influences  $dv/dt$  and voltage peaks positively. However, there is always the risk of resonance between the reactor and cable capacities, which may also cause an adverse condition. With the enlargement of the inductor with resistive and capacitive elements to a  $dv/dt$  filter, the performance of the single reactor can be further increased. Thus,  $dv/dt$  and voltage peaks at the motor are reduced even further.

With a suitable design of  $L$  and  $C$  to reduce the differential components outside of the fundamental frequency, up to 95% of the voltage can be reached. [Editor's note:  $L$  stands for inductance.  $C$  refers to NEMA design C, a two-cage rotor design.] Thus, the connected motor is operated with approximately sinusoidal-voltage, which contributes to a reduction of noise and temperature development. Nevertheless, due to the nonsymmetrical form of the voltage, common-mode components remain virtually unchanged.

## Elimination of common-mode components

Common-mode can only be effectively filtered when the interference currents can flow back over a short distance to their source. Since this should happen directly at the drive, the dc-link has to be accessible to connect (dc-). Thus, it is ensured that the spread of these shares are reduced to a minimum over the motor cable, the motor itself, and the downstream system is free from high-frequency currents. Technically, all-pole sine filters combine a standard sine-wave filter with an additional step for reducing the common-mode, so that both parts are lowered to a minimum. Communication routes remain free from interference, and the motors used are driven with a reduction in additional radio frequency (RF) loads.

## Additional example: bearing currents

Direct effects of such RF currents are bearing currents at the motor. When the motor is operating at sinusoidal voltage, a shaft voltage is induced. This wave voltage, corresponding to the fundamental, is superimposed due to saturation effects with its third harmonic. If the peak value of the ripple voltage stays below 500 mV, no further protective action is generally required.

Excesses in the wave voltage value and occurring circulating currents in the motor



**Pulsed currents** can be caused by the motor bearings when the shaft is better connected to the ground than the motor housing. This is often the case when the motor equipped with a conductive clutch is mechanically connected to the particular application, and the motor housing has a lower earth connection.

can cause damage to the bearings in a short time. Isolating the bearings is sufficient as a rule to prevent their damage by such currents over the long term. When operating behind a drive, common-mode voltages are becoming the source of bearing currents. Depending on switching frequency and  $dv/dt$ , the shaft voltage can now have peaks of up to 10 V, which causes a breakdown of the lubricating film inside the bearing and leads to damage after a certain period.

Furthermore, pulsed currents can be caused by the motor bearings when the shaft is better connected to the ground than the motor housing. This is often the case when the motor equipped with a conductive clutch is mechanically connected to the particular application, and the motor housing has a lower earth connection. By using an SFA filter, voltages supplied by the inverter are corrected to a sinusoidal shape so that no relevant voltage spikes can occur and potential bearing damage is eliminated. **ce**

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## Consider this...

Use a filter to reduce RF leakage.



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