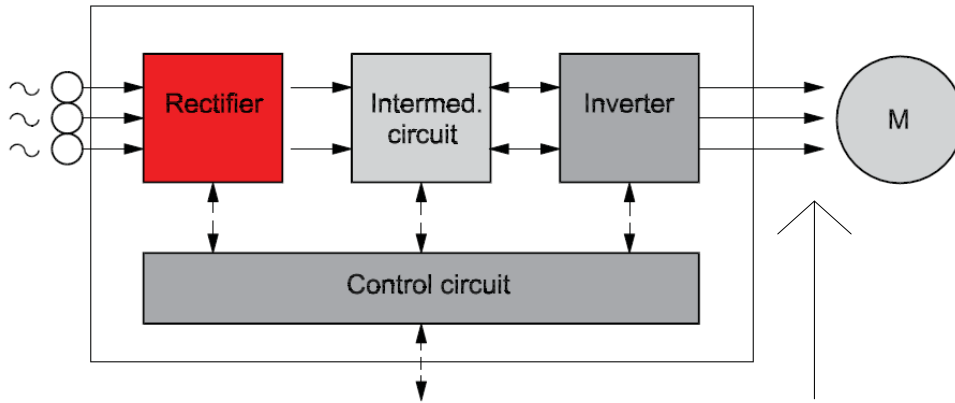
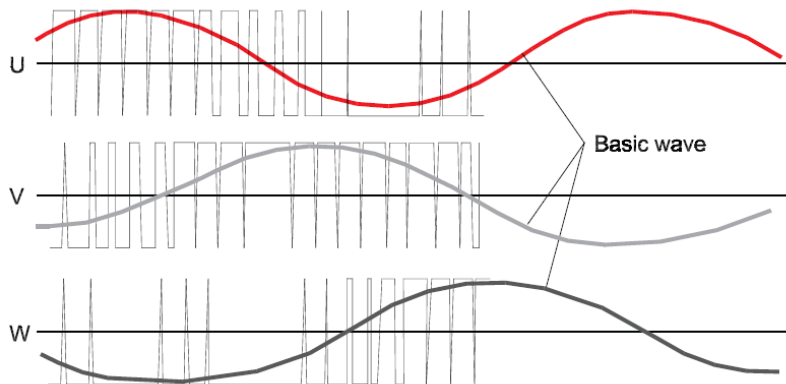


EMC/EMI challenges in electric drives applications

Frequency converter basics



PWM signal, high voltage and "fast" switching
400V drive: $\approx 550\text{Vpp}$, $\approx 150\text{ns}$



PWM signal direct to machine is still the most common approach due to price and space advantages

Disadvantage: PWM signal emits a high noise level into the surroundings

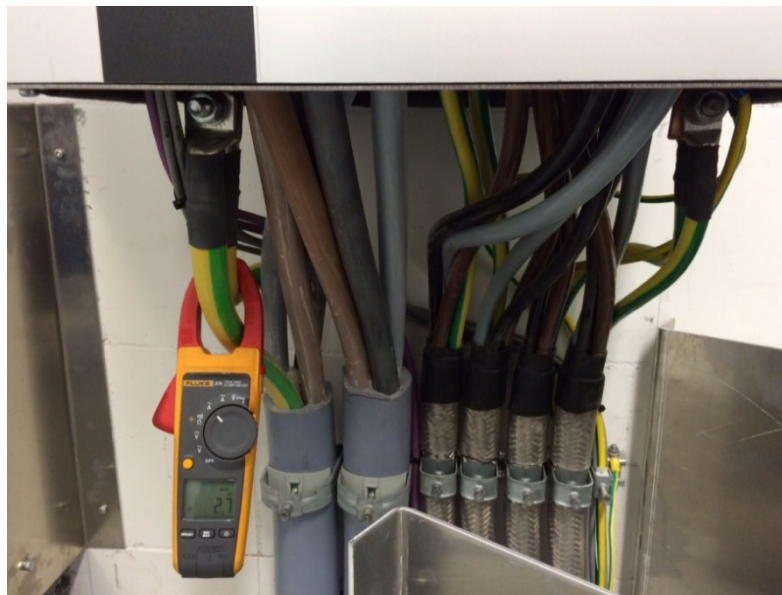
EMC directive + high noise emission: ☹️☹️☹️

Real life + high noise emission: ☹️☹️☹️

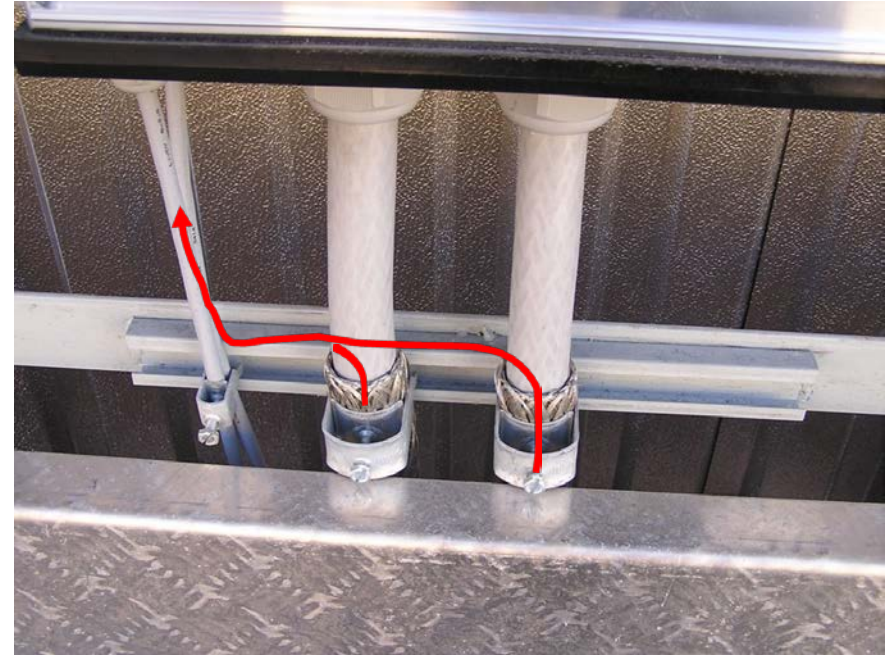
Shielded motor cable + high performance RFI mains filter: 😊, but €€

Some customers choose to save money and use an unshielded cable. They might face EMC issues

Some customers spent money on shielded cables, a high performance RFI filter and don't connect cable shields. They might face EMC issues.



Cable shields not connected.



Bus communication interrupted due to noise coupling to communication cables

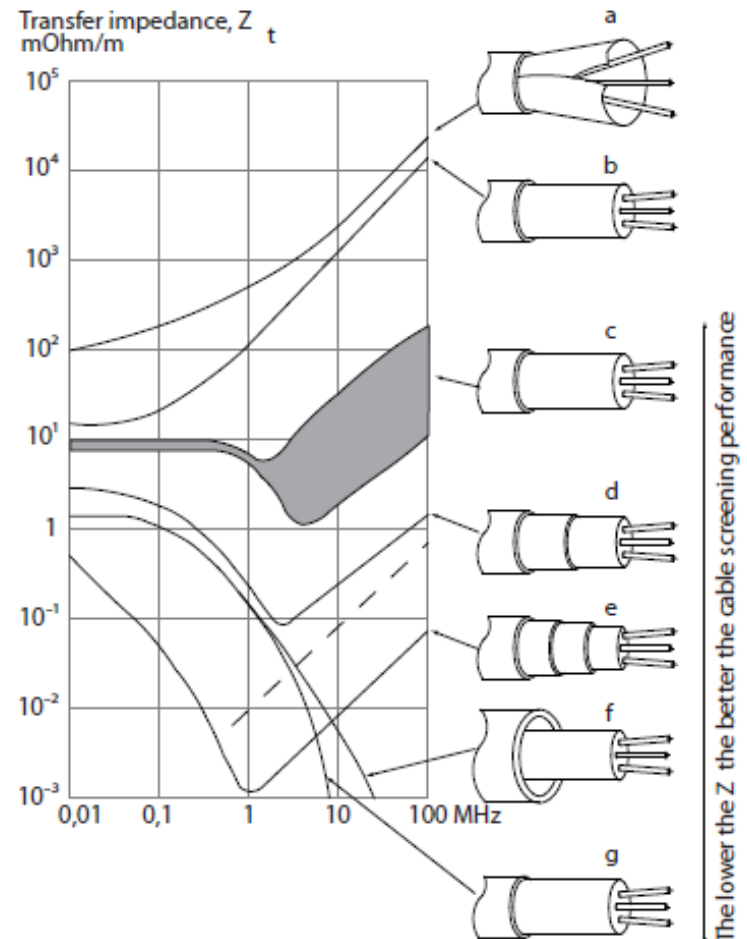
How good is a shield?

Shields are not ideal even if correctly mounted:

Transfer impedance (Z_T) can be assessed on the basis of the following factors:

- The conductivity of the screen material.
- The contact resistance between the individual screen conductors.
- The screen coverage, i.e. the physical area of the cable covered by the screen - often stated as a percentage value.
- Screen type, i.e. braided or twisted pattern.

- Aluminium-clad with copper wire.
- Twisted copper wire or armoured steel wire cable.
- Single-layer braided copper wire with varying percentage screen coverage. This is the typical Danfoss reference cable.
- Double-layer braided copper wire.
- Twin layer of braided copper wire with a magnetic, screened/armoured intermediate layer.
- Cable that runs in copper tube or steel tube.
- Lead cable with 1.1mm wall thickness.

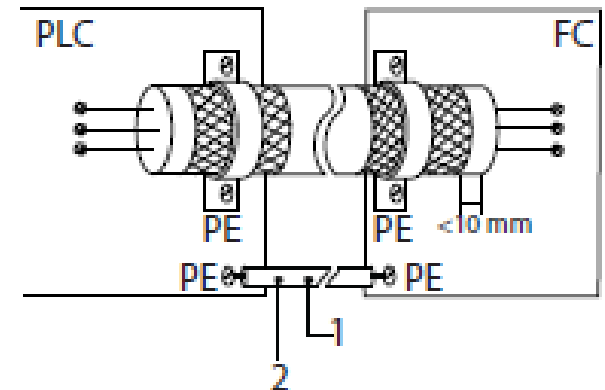


Installation recommendations.

EMC INTERFERENCE

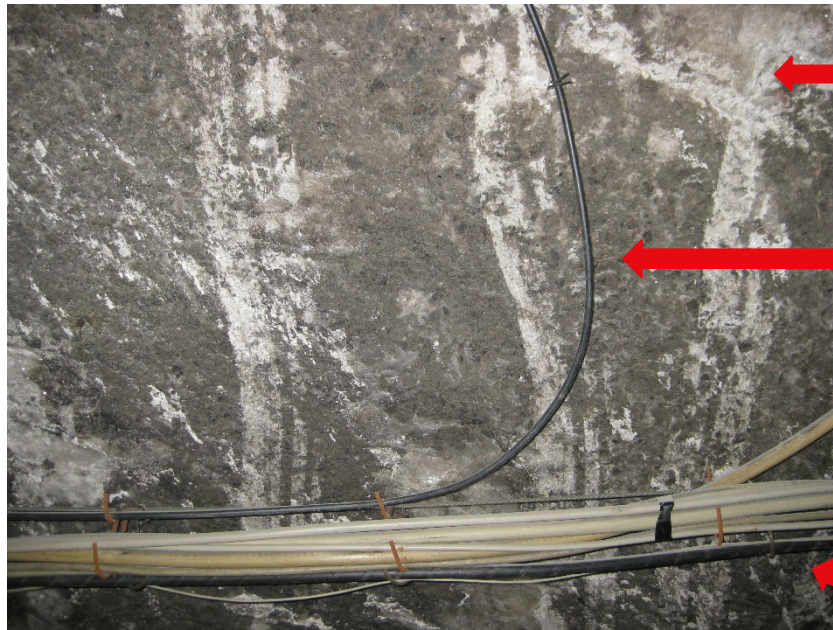
Use screened cables for motor and control wiring, and separate cables for input power, motor wiring and control wiring. Failure to isolate power, motor and control cables can result in unintended behaviour or reduced performance. Minimum 200 mm (7.9 in) clearance between power, motor and control cables is required.

If the ground potential between the frequency converter and the PLC is different, electric noise may occur that disturbs the entire system. Solve this problem by fitting an equalizing cable next to the control cable. Minimum cable cross-section: 16 mm² (6 AWG).



Radio communication interference

Drive disturbed emergency radio system in mine



← Mine gallery ceiling

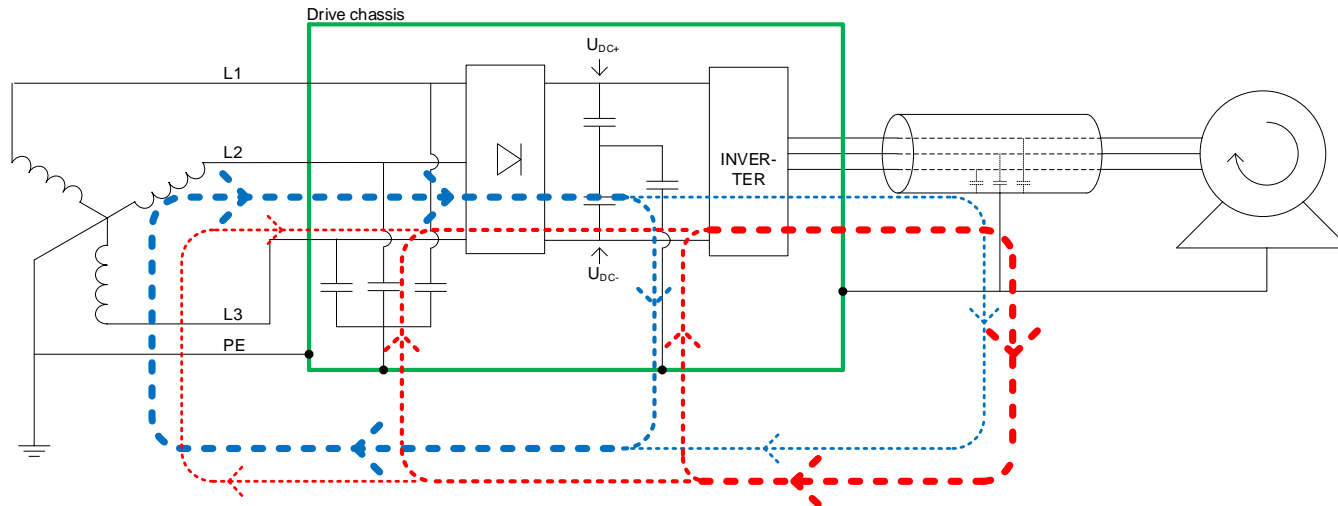
← Radiating coax cable antenna covering all galleries

← Mains cable supplying drive

Solution: separation of cables

Common mode noise (leakage) current paths.

A shielded motor cable will reduce noise emission directly from the cable, but increase residual current:



"Red" currents relate to inverter switch frequency and harmonics, $> 10\text{MHz}$

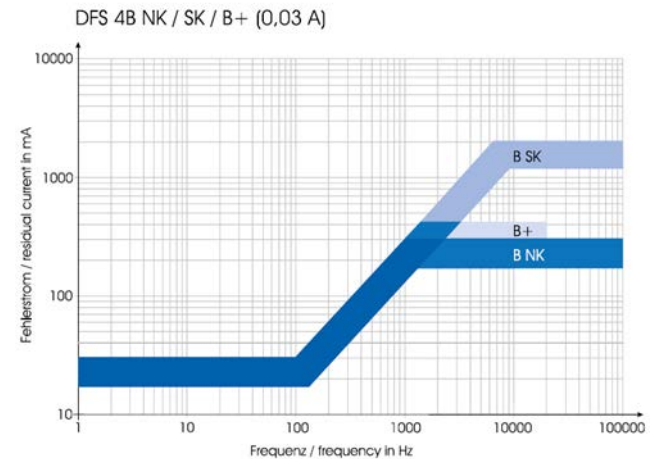
"Blue" currents relate to grid frequency: 50Hz and harmonics

RFI filter design is a compromise

RCD compatibility

Danish: HPFI relæ is one type of RCD

German: Fehlerstromschutzschalter



Frequenzgangkennlinie ($I_{\Delta n} = 30 \text{ mA}$)
für DFS 4 B NK / NK V / SK / SK FT / SK HZ /
SK HZ V / SK V / SK V T / B+

For electrical safety reasons a RCD is mandatory for some grid types and drive applications.

An improper drive / RCD combination can cause false RCD trips due to common mode currents.

New installations should use RCD's less sensitive to high frequencies.

Existing installations having RCD problems: Good question.