The dimensioning of the protective conductor

1 Applicable Standard

DIN EN 61800-5-1 Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy (IEC 61800-5-1:2007); German version EN 61800-5-1:2007

2 Definition of terms

The design of the protective conductor applies for the following drive modules:

BDM (Basic Drive Module)	Drive module which consists of a power converter module and a control and regulating device for speed, torque, current or voltage.
CDM (Complete Drive Module)	Drive system without the motor and without the measuring sensors which are mechanically connected to the motor shaft, which consists of, but is not restricted to the BDM and extensions such as the feed module and auxiliary equipment.
PDS (Power Drive System)	Speed control system for an electric motor, including the CDM and motor, but without the equipment which it powers.

3 Requirements and operating conditions

3.1 Operating conditions

A protective conductor (PE) **must** be connected as soon as the PDS/CDM/BDM is supplied with power. (Exception: the PDS/CDM/BDM fulfils the requirements of Protection Class II –DIN EN 61800-5-1 Section 4.3.5.6)

In addition to the connected power, the strength of the leakage current (earth current) is the definitive criterion for the dimensioning of the protective conductor.

The limiting values for the leakage current are **AC 3.5 mA** or **DC 10 mA**

It must be assumed that in normal operation of the frequency inverter (CDM) leakage currents of **≥ AC 3.5 mA** will occur. Therefore the protective conductor must be installed so that the following requirements for systems with high leakage currents are fulfilled.

Information	Identification
 Warning symbol ISO 7000-04034 (2004-01)	The fact that the touch current in the protective conductor exceeds the limiting value of **AC 3.5 mA** or **DC 10 mA** must also be stated in the installation and operating manuals. In addition, the warning symbol SO 7000-04034 (2004-01) must be affixed to the product and the installation manual must contain an instruction for the user that the minimum cross-section of the protective conductor must comply with the local safety regulations for protective conductors for equipment with high leakage currents.

3.2 Requirements for equipment with high leakage currents

3.2.1 Connection via plug connector and socket

1. If the protective conductor is connected so that it can be disconnected via a plug connector, the power supply to the component which is to be protected must be interrupted simultaneously.
2. The minimum cross-section of the protective conductor is 2.5 mm².
3. The protective conductor must form part of a multi-conductor power supply cable.
4. Appropriate strain relief must be provided.
5. The protective conductor must be connected so that in case of failure of the strain relief device, the earth lead is the last conductor which is interrupted. This is normally ensured by installing the protective conductor in the plug so that it is longer than the other conductors.
6. Plugs for industrial applications in accordance with IEC 60309 are used:

CEE AC plug connector
16 A, 230 V, L+N+PE, 6h, IP44

CEE three-phase plug connector
16 A, 400 V, 3L+PE, 6h, IP44

7. If a plug connector for industrial applications in accordance with IEC 60309 is not used in the case of a single-phase connection, e.g. a so-called earthed plug, the touch current (measured according to DIN EN 61800-5-1 Section 4.3.5.6) must not exceed a value of AC 3.5 mA or DC 10 mA.

   In association with the operation of frequency inverters, it should be noted that without additional special measures, these values are normally exceeded in normal operation.

8. Adapter leads from an earthed plug connector to an AC CEE blue L+N+PE coupling do not comply with the standard.

3.2.2 Permanent connection

1. Use of a protective earthing conductor of at least 10 mm² Cu or 16 mm² Al or
2. Automatic mains switch-off if the protective earthing conductor is interrupted or
3. Connect a second protective earthing conductor with the same cross-section as the original protective earthing conductor." or
4. The minimum cross-section of the protective conductor is 2.5 mm². The protective conductor must form part of a multi-conductor power supply cable. Appropriate strain relief must be implemented. The protective conductor must be connected so that in case of failure of the strain relief device, the earth lead is the last conductor which is interrupted.

3.2.3 General requirements

All of the cross-sections stated above are minimum requirements. In the case of larger connected powers, the cross-section of the earth lead is oriented to the cross-section of the external cable of the PDS/CDM/BDM. Unless otherwise stated in the local wiring regulations, the cross-section of the earth lead must be determined according to the following table or by calculation according to IEC 60364-5-54, 543.1.

Cross-section of the external conductor of the PDS/CDM/BDM "S" [mm²]	Minimum cross-section of the corresponding protective earthing conductor "S_p" [mm²]
S ≤ 16	S
16 < S ≤ 35	16
35 < S	S/2

Information **Materials for the protective earthing conductor**

The values in the table only apply if the protective earthing conductor is made from the same material as the external conductor. If this is not the case, the cross-section of the protective earthing conductor must be determined so that a conductivity results, which is equivalent to the results for the application in the table.

The cross-section of each protective earthing conductor which is not a part of the power supply cable must not be less than

- 2.5 mm², if mechanical protection is provided,
  or
- 4 mm², if no mechanical protection is provided.

4 PE cable connection

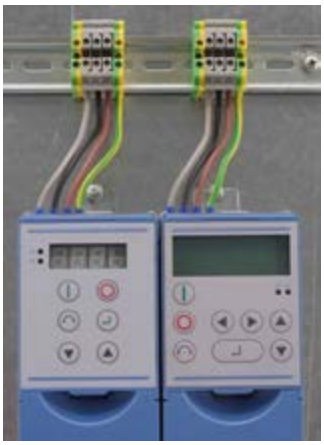
4.1 SK 500E series – PE cable connection

The following fundamental conditions are relevant for the connection of the PE cable:

1. SK 500E series inverters are equipped with two PE connection terminals. Both terminals are connected to the central PE connection in the control cabinet in order to meet the requirement for a redundant earth connection (second earth connection). The possible alternative connection of a PE cable with a cross section ≥ 10 mm^2 is not practical for low power inverters.
2. A minimum cross-section of 2.5 mm^2 is specified for wiring with individual conductors in the control cabinet if mechanical protection is provided.
3. Only **one** conductor may be connected to a PE connection terminal.

4.1.1 Connection examples

4.1.1.1 PE connection on the mains side



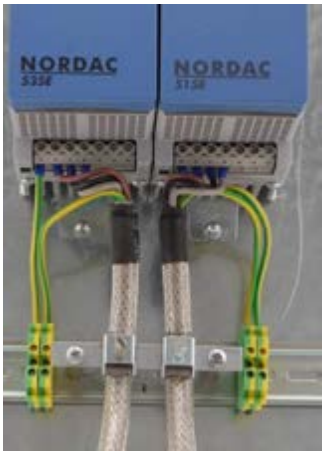
- Each PE connection terminal on the mains side must be earthed to the PE connection terminal on the snap-on rail with a single conductor.
- "Through connection" with a single PE conductor from inverter to inverter is not permissible.
- Due to the construction, the PE- terminals on the snap-on rail are electrically connected to it. The snap-on rails form a part of the central earthing system of the control cabinet.

4.1.1.2 PE connection on the motor side

Version 1

- Each PE connection terminal on the motor side must be earthed to the PE connection terminal on the snap-on rail with a single conductor.
- The motor cable is connected to the connection terminals on the snap-on rail. Adequate strain relief must be provided for the motor cable.
- Due to the construction, the PE- terminals on the snap-on rail are electrically connected to it. The snap-on rails form a part of the central earthing system of the control cabinet.

Version 2



- If the motor cable is connected directly to the motor terminal of the inverter without intermediate terminals, the PE conductor of the motor cable must be connected to the snap-on rail via the PE connection terminals.
- A large area of the motor cable shield is connected to the shield rail; the motor cable has strain relief. Adequate strain relief must be provided when an unshielded motor cable is used.
- Due to the construction, the PE- terminals on the snap-on rail are electrically connected to it. The snap-on rails form a part of the central earthing system of the control cabinet.

Version 3

- On the motor side, the PE conductor can be guided with the aid of the optionally available shield bracket.
- A large area of the motor cable shield is connected to the shield bracket; the motor cable has strain relief. Adequate strain relief must be provided when an unshielded motor cable is used.
- Due to the construction, the PE- terminals on the snap-on rail are electrically connected to it. The snap-on rails form a part of the central earthing system of the control cabinet.