MiCOM Px3x Series

EMC-Compliant Wiring

Application Guide

Index: h
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Schneider Electric

Content

1 Introduction

Protection devices are exposed to a multitude of electro-magnetic interference effects in substations. For example, as a result of short-circuits or of primary or secondary side switching operations these interference effects are induced in measuring, control and signal cables. This is taken into account in the design of protection devices, according to the current state of the art in technology and in compliance with the internationally harmonized requirements as summarized today in the IEC 60255 standard.

The resulting interference resistance (as well as the required reduction in emitted interference) can only be effective if basic guidelines are observed during installation. The aim of this Application Guide is to provide more detail to supplement the general installation instructions in the manuals of the devices and to provide specific examples.

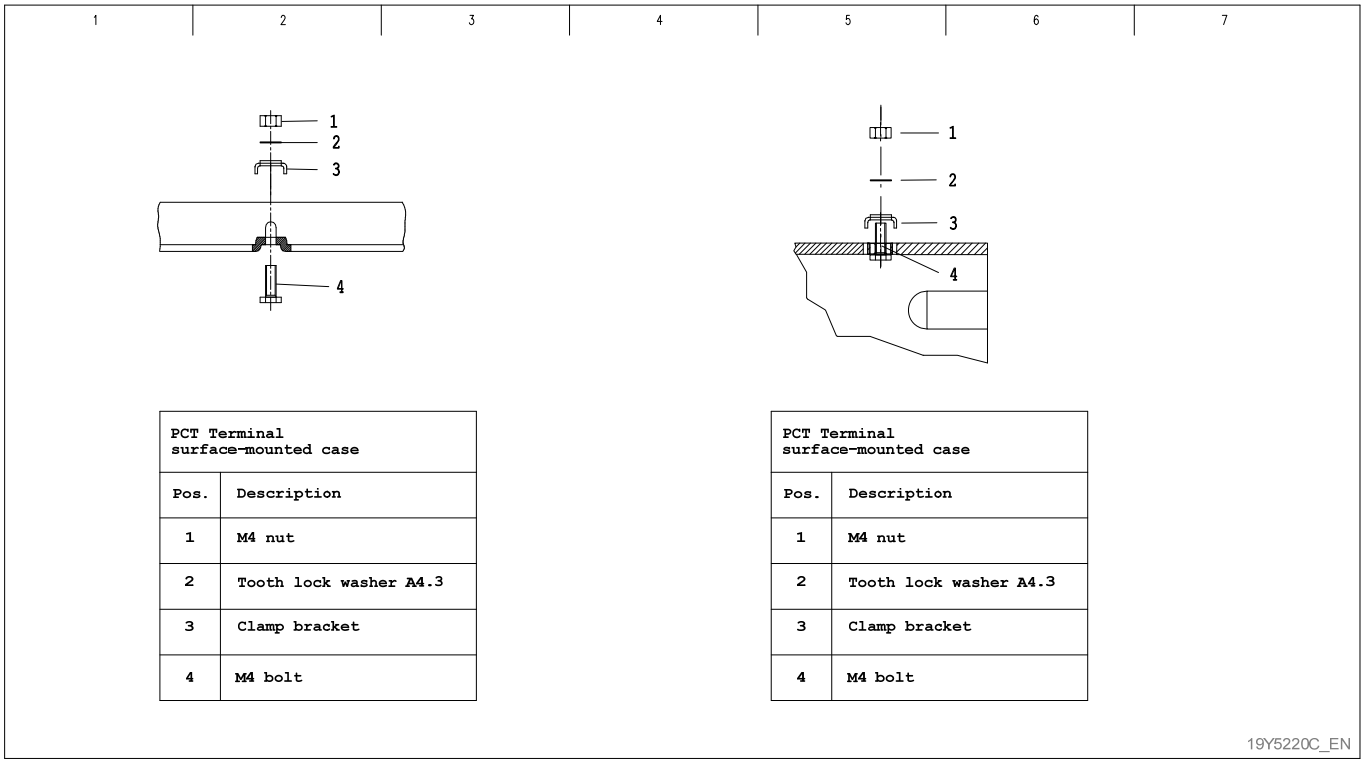
However, in any case measures on the power system side are necessary to reduce interference effects at source or to limit the spread of unavoidable interference. Despite the high degree of interference resistance of the devices, no guarantee against (excessive) interference can be given even in conjunction with optimum grounding and connection wiring. Should interference effects still persist in a particular case once all these measures had been taken in keeping with the generally recognized state of the art, then the identification of the cause (e.g. by measurement) and the remedial action must be undertaken in the affected facility.

2 "Protective and Operational Grounding" - description from the manual

The device must be reliably grounded to meet protective equipment grounding requirements. The surface-mounted case is grounded using the bolt and nut provided for this purpose. The flush-mounted case must be grounded in the area of the rear side plates at the location provided. The cross section of the ground conductor must conform to applicable national standards. A minimum cross section of 2.5 mm^2 is required.

In addition, a protective ground connection at the terminal contact on the power supply module (identified by the letters "PE" on the terminal connection diagram) is also required for proper operation of the device. The cross section of this ground conductor must also conform to applicable national standards. A minimum cross section of 1.5 mm^2 is required.

The grounding connection at both locations must be low-inductance, i.e. it must be kept as short as possible.



PCT Terminal surface-mounted case	
Pos.	Description
1	M4 nut
2	Tooth lock washer A4.3
3	Clamp bracket
4	M4 bolt

PCT Terminal surface-mounted case	
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5-8 installing the protective grounding conductor terminal.

The bracket is marked with the protective ground symbol: ⏚

3 Grounding specifications

3.1 General

The **protective grounding** of the protection and control devices has two functions:

- Shielding the device from (high-frequency) electromagnetic fields that are coupled into the device itself or into its supply lines and that affect its functions.
- The reduction of disturbance emitted by the device so that it does not interfere with other (adjacent) devices.

To minimize such disturbances, specifications for the protective grounding as well as the wiring and shielding must be met. As a precondition for effective grounding, there must be continuous grounding from the protection device to the substation (system) grounding.

The following **universal rules** have to be observed:

- The cross section of the grounding connections must increase from the protection device towards the system grounding.
- Grounding connections from the device to the system grounding are always star-shaped; loops have to be avoided.
- Existing conductive system parts (mounting plates, cabinet parts, low-voltage switching devices, etc.) are integrated in the grounding.
- In order to eliminate high-frequency disturbances, copper braids are preferable due to their lower RF resistance compared to simple copper wires of the same cross section.

Regarding the choice between wires or copper braids, the location of the device within the substation and the resulting electromagnetic environment need to be taken into account. For example, for installation in MV compact cubicles within the secondary side compartment higher interference levels are generally expected than in a panel located in a separate building away from the primary side. Accordingly, copper braids should preferably be used in the first case, while in the second case simple copper wires may suffice.

The **functional or operational grounding** is required for proper operation since it ensures a defined reference potential for the internal electronics. For the EMC protection of the device, a low-inductance design is also important for the functional grounding so as to avoid the coupling of interference signals into the protection device.

3.2 Installing the protection and control devices

In accordance with the requirements of the substation, the protection and control devices are installed

- either in protection and control cabinets,
- or in panels or on walls; either in the same room as the (MV) switchgear or in separate rooms of the substation,
- or, for modern compact MV substations, directly in the low-voltage compartment of the bay.

Continuous grounding is built up starting from the protection device to the cabinet or mounting rack. The cross section rises from the protection device to the mounting rack.

- **Mounting in swing or fixed frame cabinets**

  Each MiCOM relay, mounted in the frame must be grounded with a protective grounding connection on the frame, with at least 2.5 mm² cross section as well as the operational grounding, with at least 1.5 mm² cross section, using the shortest path.

  For swing frame mounting, the protective grounding terminal on the side of the swing frame pivot point should be used (shortest distance to the swing frame grounding). The swing frame must be grounded with copper braid 1.5 x 20 x 360 mm at the top and bottom of the rack.

  Examples:

Correct (short wire 2.5 mm²)

Wrong (unnecessary loops)

*Equipment **protective grounding** connection on the swing frame or cabinet door*

Correct (short connection with 1.5 mm² to the common grounding point of the cabinet
(Not illustrated: Incorrectly mounted with long lead in the cable harness together with conductors from the transformers etc.)

***Operational grounding** connection*

Correct

Incorrect

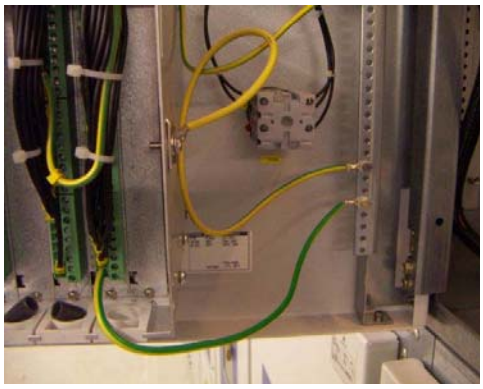
Connection of the swing frame to the rack
(Do not forget the additional connection at the upper end!)

- **Installation in the door of the low-voltage compartment**

  The MiCOM device must be grounded with a protective grounding connection at the door on the shortest path with at least 2.5 mm² cross section, with the protective grounding connection on the side of the door pivot point (shortest distance to the swing frame grounding).

  The door must be grounded on this grounding point with at least 4 mm² cross section wire to the mounting rack on the shortest way.

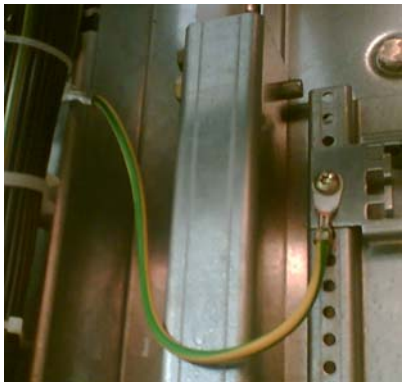
  Examples:



Correct (short wire 2.5 mm²)

Wrong

Equipment protective grounding and operational grounding *connection to the low-voltage compartment door*



Correct (short wire 4 mm²)

Connecting the door to the cubicle

- **Flush mounting**

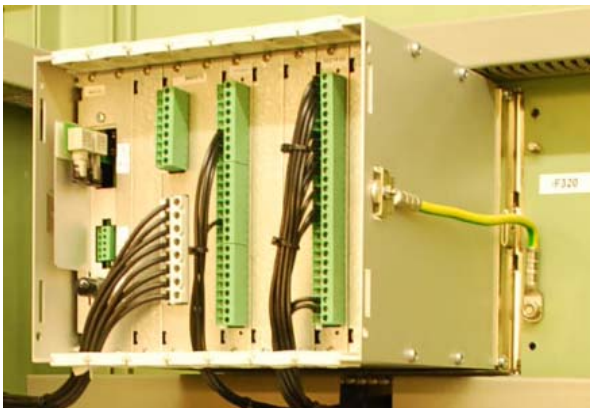
  For each device fitted on the mounting plate, both the protective grounding connection (with at least 2.5 mm²) and the functional (operational) grounding (with at least 1.5 mm²) must be implemented, either directly (tapping screw) or using a suitable terminal (e.g. USLKGx) via the top-hat rail to the mounting plate.

  As a mounting plate, galvanized sheet metal must be used. For painted plates, the insulating paint layer must be properly removed at the connection point and the bare surface has to be protected from oxidation.

  The mounting plate must be connected on the cable feed side (usually above or below) with at least 6 mm² wire on two sides of the rack, which must in turn have a low-impedance connection to the system grounding.

  Example:

Correct: Wire or copper braid



Good connection if paint has been removed properly! However, functional grounding is missing!

Equipment protective grounding on the mounting plate

- **Special considerations for surface-mounting**

  The terminals for surface-mounting are located between the case and the hinged front panel. To avoid bay interferences, loops are not permitted in this connection area (excess cable length should generally be avoided, a few centimetres extra length can be accommodated loop-free in the cable channel).

Example of bad cable connection with unnecessary loops
(and on top of that there is no functional grounding)

The ribbon-cable connection of the front panel should not be placed on the conductors from the transformers, but should be carefully folded into the area between the housing side plate and the shielding of the communication module.

The two front panel bolts securing the protective grounding must be firmly secured.

3.3 Further grounding connections

- Cabinet Grounding

  All metal parts of the cabinet as well as the grounding bar in the cabinet must be connected by suitable electrical connections to the rack as the most stable part with the largest cross section of the entire structure. The grounding bar of the cabinet should be connected to the system ground via copper braid.

- Similar considerations apply to grounding in the low-voltage compartment.
- The same applies also to grounding the mounting plate for flush mounting.

3.4 Reliable grounding connections

The following are deemed reliable grounding connections:

- Welds
- Bare metal, surface-protected parts, securely bolted, riveted or pressed on top of each other
- Self-tapping screws or coated screws in cut threads towards the thread hole
- On paint, screws with cutting rings regardless of head shape
- Tooth lock washers or crown washers on paint
- Terminal connections, copper braids with suitable ferrule-equipped crimped joints

Tooth lock washers, crown washers or cutting rings on screw heads are designed for the destruction of non-conductive surfaces. On conductive coated surfaces they must not be used since they would scratch the surface and render it susceptible to corrosion. Moreover, the contact area would be reduced. To secure the screws, only spring washers should be used in conjunction with standard washers.

4 Cable shields

4.1 Measurement and control cables

The cable screens should be connected at both ends to the ground system in a suitable manner using the shortest path. However, shields with good current carrying capacity and parallel grounding cables with good current carrying capacity are required.

In the cabinet or bay, the cable shields must be guided on the shortest path (max. 10 cm) immediately after the cable support rail to the potential equalization rail.

The shield must be protected with a clamp for strain relief and at the same time making the ground connection. Alternatively, the individual stranded conductors are slightly twisted (no braids) and pressed with a ferrule (only one shield per ferrule).

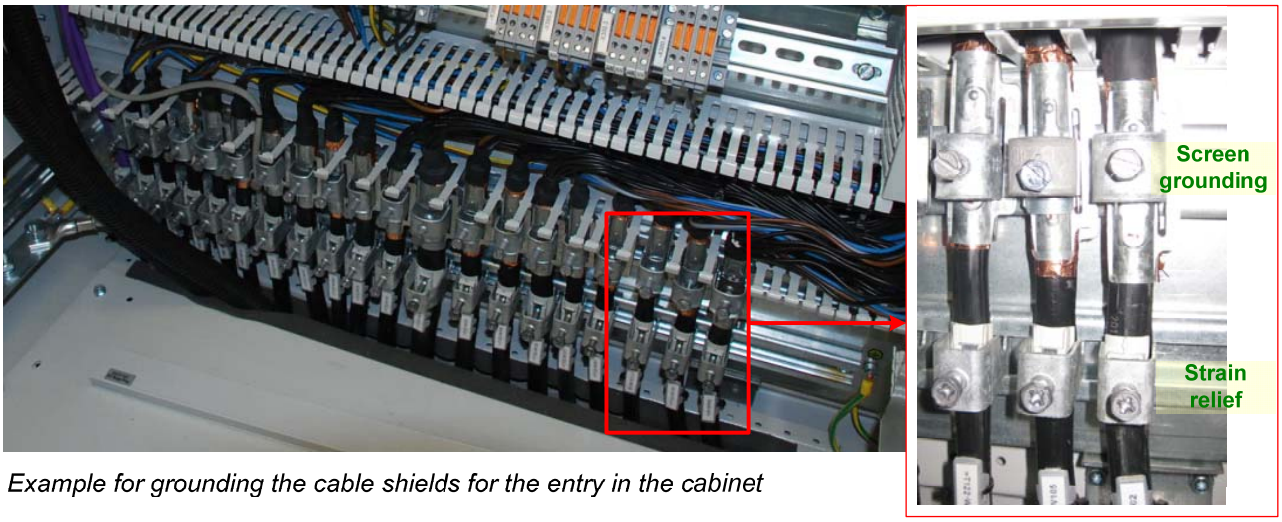
The potential equalization rail should consist of bare copper with a minimum cross section of 5 x 30 mm². This section must not be weakened by further drilling.

The potential equalization rail must be initially insulated and then directly connected to the main grounding bar at one point with copper braid 1.5 x 20 x 150 mm. Generally, the connection to the system grounding must be via short paths, with very low impedance and with low inductance.

If a second potential equalization rail is required because cables enter elsewhere in the cabinet (e.g. double cabinet), then the two rails must be connected with copper braid. It should be noted that only a single connection to the main grounding bus is permitted in order to avoid loops!

Reasons for this recommended relatively high effort:

- The potential equalization rail serves the purpose of low-impedance forcing of a uniform potential on the cable shields so that they will not entrain potentials from various distant parts of the substation.
- All cable shields should be removable together for troubleshooting.
- Each individual cable screen should be removable separately for selective troubleshooting.



Example for grounding the cable shields for the entry in the cabinet

4.2 Communication links

Also, for communication links, the cable shield is connected at both ends where possible.

As a condition for the two-sided grounding of the cable shield, a parallel grounding connection directly to the cable and with good current carrying capacity is required (meshed network, compensating cable, etc.). This condition is always met within cabinets and low-voltage compartments with correct and complete implementation of the grounding connections. For panel mounting, compensating cables run in parallel may be necessary in addition.

This rule does not hold for connections between different substation buildings if it is not possible to ensure a potential-equalizing low-impedance grounding connection. In such cases, the shield grounding is performed on one side only.

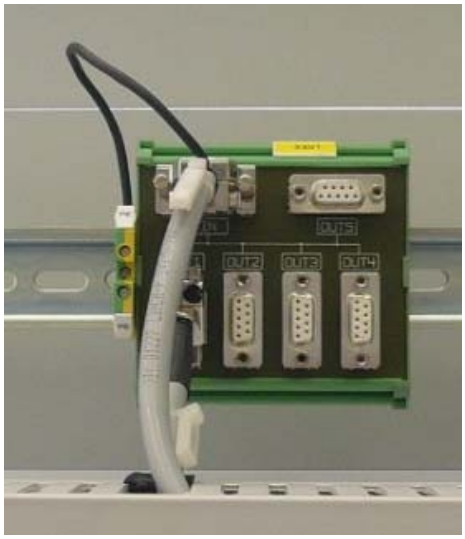
For the bay units, the screens should be connected directly to the case grounding terminals or to the corresponding cable clamps.

Generally, cable shield connections to the grounding system must be as short as possible. The lengths of the stripped cable shield and the signal wires must not exceed 10 cm.

We recommend modules PSM or PSM-PTK PTK4 for the RS-485 data link on transfer into the cabinet to ensure complete shielding. The cable shields must be connected to the connector housing.

On the device's protective grounding connection

To the cover fastening screw



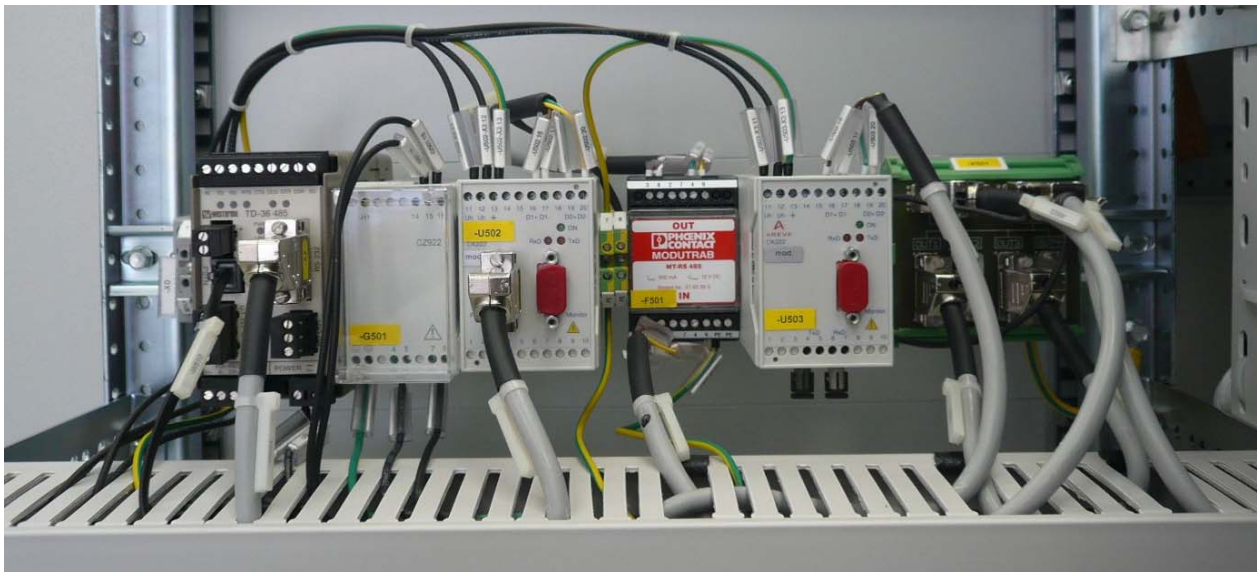
To the star connector ground terminal

Shield grounding for electrical communication lines

Overvoltage protection of communication links

To limit overvoltage on the electrical data links between remote devices, overvoltage protection with coarse and fine protection elements must be used, the recommended one being surge protection MT-RS485 by PHOENIX CONTACT. Installation is generally on the bus master side for all RS-422 or RS-485 interfaces when the data link emerges from the cabinet in which the bus master is housed.

In the immediate vicinity of the surge protector there must be a low-impedance grounded terminal. This is used to ground both the cable shields of the data links and also the surge protection using a cross section of 2.5 mm².



Electrical communication link consisting of a modem, star couplers and surge protection

Of course the same requirements with respect to device grounding as for protection devices are also valid for communication devices in Ethernet networks (i.e. Switches).

5 Cable routing

Basically, separate routing is required for cables/links in the cabinets/bays, to minimize the coupling between these electric circuits.

The three main categories are cables/links

- for measurement (conductors from the transformers)
- for control (binary input/output, DC supply)
- for communication

Even partial solutions are advantageous and should be implemented if possible, such as routing in separate cable harnesses or tubing between the cable ducts on the cabinet rear wall and the swing frame. Experience has shown that even a few centimetres distance between the separate cable bundles can drastically reduce electrical coupling.

Illustrations to follow in the next edition of this document.

6 Literature

VDEW Ringbuch „Schutztechnik“, Register 8 „Empfehlungen für Maßnahmen zur Herabsetzung von Transienten Überspannungen in Sekundärleitungen (TÜ) innerhalb von Hochspannungsschaltanlagen“, 2. Ausg. 06.1992

IEC 61000-5-2 Electromagnetic compatibility (EMC) –
Part 5: Installation and mitigation guidelines – Section 2: Earthing and cabling, ed. 11.1997

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insbes. Teil DIN EN 60255-26 - Anforderungen an die elektromagnetische Verträglichkeit

GUIDE ON EMC IN POWER PLANTS AND SUBSTATIONS
CIGRE Working Group 36.04, December 1997

Sepam Digital Protection Relays Installation Assistance Guide
Schneider Electric, 06/2010

7 Contacts

As a user or substation builder, your first contact for questions or contributions to this document will be your local Schneider Electric representative.

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8 Notes

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