Smart Panels
Digitized switchboards
Blokset design and assembly guide
Dear customer,

Here is the new edition of Smart Panels switchboard assembly and installation guide. In addition to the guide showing how to assemble Smart Panels using Prisma, this one explains and demonstrate how to make high power Smart Panels using Blokset.

Smart Panels make live in the same switchboard components of power and communication with their own circuits.

It is essential to comply with installation and implementation best practices, to avoid any risk of shut-down or malfunction due to insufficient distances between devices, temperature rise or electromagnetic compatibility, for example.

It is intended for use by panelbuilders in the factory and on-site and also by design engineers to integrate design rules, in compliance with IEC standards 61439-1&2. These rules are essential because the digital architecture must be defined very early in the design phase.

After a short review of basic rules, the guide develops more particularly the “Auxiliary and low-power circuits” chapter.

Structured according to the logical procedure for switchboard building up to the test conducted before shipping, it includes Quality control check list at the end of each chapter, as well as a model form “Routine verification – testing report”.
Introduction

Grouping most of the electrical protection, command and metering components, the switchboards are now significant sources of data locally displayed and sent via digital networks.

Smart Panels use reliable, simple to install and use displays, and Ethernet and Modbus interfaces on the Enerlin’X communication system.

Information is safely transmitted through the most efficient networks, to monitoring and control systems or on-line energy management services.

Structured into successive stages based on the chronological order of switchboard assembly, this guide presents more precisely all the best practices to apply when installing Enerlin’X, communication system for Smart Panels (see Enerlin’X catalogue: LVCATENLX_EN). It illustrates them through examples of configurations made in Blokset Smart Panels.

Before starting the mounting phases, ensure that the communication architecture constraints have been integrated in the design of the switchboard.

Mounting and connecting Enerlin’X switchgears are given with a lot of details and advice.

For this, the guide gives the key points, that affect the fundamental phases of implementation: assembling and covering enclosures, main busbars, installing the devices, power connection, auxiliary and low-power circuits connection.

As for all switchboards, IEC 61439-1&2 standard applies to Smart Panels and particularly dielectric tests.

At the end of each chapter, a quality control check list allows to check, step by step, the quality level.
**Smart Panels switchboards with Blokset**

**IFE Ethernet interface**
The IFE Ethernet interface for LV circuit breaker enables an intelligent modular unit (IMU), for example a Masterpact NT/NW or Compact NSX circuit breaker to be connected to an Ethernet network.

**Com’X 200 energy data logger**
Com’X 200 energy data logger is a compact, plug-and-play data logger that merges seamlessly with the Smart Panels energy management solution. It consolidates inputs from analog environmental sensors (e.g. temperature), digital readers (e.g. pulsed signals from smart energy or water meters, load running hours), and energy management equipment running over the Modbus protocol. Designed for ease of implementation, data can be transmitted securely via Ethernet, Wi-Fi, or GPRS to any energy management platforms. The Com’X 200 energy server is scalable and can be easily adaptable to accommodate future upgrades. Com’X 200 is a perfect fit with our energy management services, enabling visualization, tracking, and analysis of energy data to support optimization of energy performance and cost management.

**FDM128 switchboard display**
See Enerlin’X catalogue.
The FDM128 is a large display, but requires very little depth. The anti-glare graphic screen is backlit for very easy reading even under poor ambient lighting and at sharp angles.
IFM Modbus interface
This module required for connection to the network, contains the Modbus address (1 to 99) declared by the user via the two dials in front. It automatically adapts (baud rate, parity) to the Modbus network in which it is installed.
It is equipped with a lock-out switch to enable or disable operations involving writing to Micrologic, i.e. reset, counter reset, setting modifications, device opening and closing commands, etc.
There is a built-in test function to check the connections of the Modbus interface module with the Micrologic and FDM121 display unit.

I/O application module
The I/O (Input/Output) application module for LV breaker is part of an ULP system with built-in functionalities and applications to enhance the application needs.
The ULP system architecture can be built without any restrictions using the wide range of circuit breakers.
The I/O application module is compliant with the ULP system specifications.
Two I/O application modules can be connected in the same ULP network.
The ranges of LV circuit breakers enhanced by the I/O application module are:
- Masterpact NW/Easypact MVS
- Masterpact NT
- Compact NS 1600b-3200 and NS630b-1600
- Compact NSX100-630/ Easypact CVS100-630.

24 V DC power supply
An external 24 V DC power supply is required for installations with communication, whatever the type of trip unit.
A single external 24 V DC supply may be used for the entire switchboard.
The required characteristics are:
- output voltage: 24 V DC ±5 %
- ripple: ±1 %.
- overvoltage category: OVC IV - as per IEC 60947-1.

Ethernet switch
Ethernet switch, 5 copper ports
Communication port protocol: Ethernet TCP/IP
Ethernet port: 10BASE-T/100BASE-TX - 5 ports copper cables
Max number of cascading switches: unlimited.
Contents

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How to use the guide
**How to assemble a digitized switchboard**

**How to use the guide**

- **This guide is structured into 8 successive stages based on the chronological order of assembly of digitized switchboard.**

  Each of the workshop assembly phases up to transportation to the site and installation is described according to a 3-column page layout principle:

  1- the left column states the standard concerned,
  2- the middle column states trade practices on theoretical or practical aspects,
  3- the right column illustrates these rules with examples from the Schneider Electric Blokset Smart Panels switchboards.

- **Symbols used in the guide**

  **Navigation pictograms**

  To help you to use the guide

  1 - Assembling and covering enclosures
  2 - Main busbars and forms
  3 - Installing the devices
  4 - Power connectors
  5 - Auxiliary and low-power circuits
  6 - Digital system test
  7 - Factory quality inspection
  8 - Appendices

  **Information pictograms**

  To emphasise important information

  - **Tip**
    - Handy hints
  - Compliant
  - Non-compliant

  **Example**

  Follow the assembly order defined in the assembly guide.

  Mount all the devices, including those of Enerlin’X range, in accordance with the instructions given in the manufacturer’s technical manuals.
Assembly of enclosures
Assembly of enclosures

Enclosure structure

1. All switchboards must be mounted according to the manufacturer's instructions using approved equipment, regardless of their type (pre-assembled or dedicated to large industrial sites).

Example
The assembly of enclosures delivered is reliable and particularly fast. It may be done in the factory or on site. It simplifies storage and transportation.

IEC 62208 (Empty enclosure standard)

2. Components of the enclosure structure, components contributing to the distribution of energy, as well as switchgear and controlgear must be provided and tested to withstand stresses due to:
- the weight of the switchgear and controlgear,
- electromechanical stress arising from a short-circuit,
- transport,
- vibrations,
- the switchboard environment (ambient temperature, humidity),
- seismic risk,
- electrical risk (internal arc).

These structural details also concern the various systems used to ensure the closing of doors, etc.

It must also ensure the protection of:
- the operator,
- the switchgear and controlgear against external influences.
Assembly of enclosures

Earthing continuity

Theory

Standards

1. The standard requires effective continuity of the exposed conductive parts of the switchboard:
   - between each other,
   - between them and the main protective conductor PE (equipotential bonding).

All exposed conductive parts of the switchboard must be connected to the earthing circuit, except for those that do not present a potential hazard for users (small fasteners such as screws or rivets).

You must measure the earthing continuity electrically in case of doubt.

Example

Enclosure combination batches are available.

They are used to mechanically connect enclosures to each other. In most cases, earthing continuity is obtained by the screws, nuts and bolts or by the assembly design.

To do this, you must:
- use only components, screws, nuts and bolts and accessories recommended by the manufacturer,
- comply with the assembly instructions given in the technical manuals,
- tighten the screws to the recommended torque.

Electrical continuity for fixed parts

Standards

1. If there is no specific system used, paint or any other insulating coating such as varnish will affect the electrical continuity between two assembled parts.

You must use screws fitted with washers (picot contact washers). This system will scratch the paint up to the metal and thus ensure excellent electrical continuity.

Example

Picot contact washers

2. There are other systems for ensuring earthing continuity without using specific washers or adding earth braids:
   - 1/4 turn screws,
   - clips,
   - picot washers and serrated nuts.

Example

Picot washers and serrated nuts
**Assembly of enclosures**

### Earthing continuity

#### Electrical continuity of moving parts

**Standards**

ICE 60364
ICE 61439

**Good practice**

1. An earthing conductor must be fitted on all metal moving parts (door, panels, hinged front plates) that support electrical components with operating voltages of over 50 V.

   Standard IEC 60364-5-54 defines the minimum cross-section of the connection based on the live conductors of the switchgear and controlgear installed on the moving part.

   - **Tip**
     - Never earth a class 2 device.

2. The earth conductor may be either an earthing wire or earthing braid:
   - the switchboard does not have "sensitive" equipment in terms of electromagnetic compatibility: use a simple earthing wire,
   - the switchboard has "sensitive" equipment in terms of electromagnetic compatibility: use an earthing braid that provides higher EMC protection and equipotential protection.

3. There are three techniques for fastening an earthing wire or braid on a painted part:
   - screw + contact washer,
   - insert,
   - welded stud.

   Always place a contact washer between the earthing wire lug and the painted part.

4. Special case: wire connection or earthing braid on a welded stud

   Protect the stud with a sleeve during the painting operation.

**Example**

An earthing wire is supplied as a standard feature for doors accommodating HSI (Human Switchboard Interface) electrical components.

![Earthing wire](image)

![Earthing braid](image)
Assembly of enclosures

Quality control check list

Note: the list of control points presented is not exhaustive. It lists the minimum checks required and may be completed depending on the organisation in the workshop and/or recurrences of defects encountered.

<table>
<thead>
<tr>
<th>Control points</th>
<th>Control resources</th>
<th>Self-control</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; Identification of the project</td>
<td>&gt; Assembly drawings</td>
<td></td>
</tr>
<tr>
<td>&gt; Identification of columns and quantity</td>
<td>&gt; Assembly drawings</td>
<td></td>
</tr>
<tr>
<td>&gt; Conformity with front panel drawings</td>
<td>&gt; Assembly drawings</td>
<td></td>
</tr>
<tr>
<td>&gt; Dimensions</td>
<td>&gt; Assembly drawings</td>
<td></td>
</tr>
<tr>
<td>&gt; Quality of paints*</td>
<td>&gt; Visual inspection</td>
<td></td>
</tr>
<tr>
<td>&gt; Protection degree**</td>
<td>&gt; Visual inspection and technical documentation</td>
<td></td>
</tr>
<tr>
<td>&gt; Bonding continuity***</td>
<td>&gt; Visual inspection and installation guide</td>
<td></td>
</tr>
</tbody>
</table>

(*) homogeneity, no scratches, deformations, etc.
(**) quality of washers
(***) screws, contact washers, etc.

Objectives

- View ongoing projects
- Save time (avoid having to redo anything, do not forget anything from the beginning of the process, etc.)
- Check conformity with civil engineering drawings
- Check conformity with assembly standards
Power busbar
Power busbar

Foreword

IIEC 61439-1

The following must be taken into account when choosing a power busbar:
- environmental characteristics of the switchboard (ambient temperature, IP degree of protection, pollution),
- type of switchboard installed regarding to validation test,
- characteristics of the client's power supply: on the top, middle or bottom,
- the rated current of the short-circuit: Icw.

The installation of a power busbar consists in the following steps:
- select the busbar material,
- size it (busbar section, number of busbars per phase) and define its position in the switchboard based on the client's incoming devices,
- install it in compliance with the creepage and clearance distances of the standard,
- fasten it according to good practice.

The installation must ensure the protection of persons:
- against direct contact by installing the appropriate internal partitions (forms) or by installing live parts out of reach.
- against indirect contact by creating an equipotential bonding inside the switchboard (PE/PEN protective conductor and earthing of the grounding electrode conductors).

The current of a power busbar is measured using a current transformer (CT) such as a busbar passing current transformer. The main role of the current transformer is to lower the value of the current to be measured to a value that is acceptable for metering devices (usually 1 to 5 A).
**Definition of a power busbar**

## Choice of material

### Standards

- EN 13599 Cu-ETP R240
- ISO 1634 Cu-ETP HB

### Good practice

1. The material used is copper because it offers the following characteristics:
   - excellent electrical conductivity,
   - excellent heat dissipation,
   - good corrosion resistance,
   - ease of installation.

2. **Choice of copper bars**

   Use Cu-ETP copper only, that complies with the following specifications:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>General description of material</td>
<td>EN 13599 Cu-ETP R240</td>
</tr>
<tr>
<td>Standard international equivalent</td>
<td>ISO 1634 Cu-ETP HB</td>
</tr>
</tbody>
</table>

   The bars must be:
   - rectilinear,
   - free of scratches, traces of impact, marks or rust,
   - qualified and with a compliance certificate.

### Example

Schneider Electric copper bars are of Cu-ETP type (H12) and are qualified and compliant with the standard.
Power busbars must be sized to withstand heat and dynamic stresses resulting from short-circuit currents that do not exceed the value of the rated short-circuit current. Electrodynamic stress withstand depends mainly on the following:
- the intensity of the default current,
- the shape and cross-section of the bars,
- their location in the switchboard,
- their fastening method.

**Example**
Schneider Electric is proposing a new innovative range of busbars. They present the following advantages:
- greater performance (a single busbar can withstand ratings of up to 1250 A),
- 50% lighter than copper bars that achieve similar sections,
- robust and flexible—higher resistance to short-circuit currents (50 kA/1s),
- cheaper to mount and assemble,
- vertical or horizontal installation,
- a wide range of available profiles.

Busbar manufacturers usually provide the information required for sizing power busbars. These figures must be used in calculating the cross-section of the busbar. The busbar cross-section depends on:
- the rated current \(I_n\) to be conveyed in the busbar,
- the rated current of the short-circuit (permissible short-time withstand current): \(I_{cw}\),
- the ambient temperature around the switchboard,
- the IP protection index of the enclosure,
- the rated diversity factor (RDF),
- the space reserved for future enhancements,
- the constraint defined by the trigger time of the protective device.

> **Caution:** never under-size a busbar (risk of overheating).

### Busbar sizing

**Standards**

IEC 61439-1

§ 8.6.1

**Tip**
The various ratings and their names to be taken into account are defined in
IEC 60947-2 and IEC 61439-1

IEC 61439-1

§ 3.8.10

§ 5.3.3

Appendix E

IEC 61439-2

§ 5.3.3

### General considerations

<table>
<thead>
<tr>
<th>Number of devices</th>
<th>Diversity factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 and 3</td>
<td>0.9</td>
</tr>
<tr>
<td>4 and 5</td>
<td>0.8</td>
</tr>
<tr>
<td>6 to 9</td>
<td>0.7</td>
</tr>
<tr>
<td>10 +</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Generally, not all the devices connected to a busbar are used at full load or at the same time. It is therefore not necessary to size the busbar to transport the sum of rated currents of all the devices continuously.

The rated current \(I_n\) in the busbar must be calculated:
- by adding up the rated currents of all the connected devices,
- by multiplying the result by the diversity factor (RDF) defined by IEC 61439-1.

The value of the diversity factor depends on the number of devices connected to the busbar:
Quality control check list

Note: the list of control points presented is not exhaustive. It lists the minimum checks required and may be completed depending on the organisation in the workshop and/or recurrences of defects encountered.

<table>
<thead>
<tr>
<th>Control points</th>
<th>Control resources</th>
<th>Self-control</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; Busbar cross-section and number Note: to be done preferably when the busbars are installed</td>
<td>&gt; Manufacturing file</td>
<td>☐</td>
</tr>
<tr>
<td>&gt; Manufacturing quality* Note: to be done preferably after the bars are manufactured</td>
<td>&gt; Installation guide</td>
<td>☐</td>
</tr>
<tr>
<td>&gt; Order and identification of phases</td>
<td>&gt; Technical documentation</td>
<td>☐</td>
</tr>
<tr>
<td>&gt; Creepage distance</td>
<td>&gt; Visual inspection and installation guide</td>
<td>☐</td>
</tr>
<tr>
<td>&gt; Clearances</td>
<td>&gt; Visual inspection and installation guide</td>
<td>☐</td>
</tr>
<tr>
<td>&gt; Fastening of busbars**</td>
<td>&gt; Technical documentation</td>
<td>☐</td>
</tr>
<tr>
<td>&gt; Protection circuit***</td>
<td>&gt; Manufacturing file, visual inspection, installation guide</td>
<td>☐</td>
</tr>
<tr>
<td>&gt; Conformity of partitioning forms</td>
<td>&gt; Technical documentation, manufacturing file</td>
<td>☐</td>
</tr>
<tr>
<td>&gt; Conformity and installation (current transformer)</td>
<td>&gt; Manufacturing file, installation guide</td>
<td>☐</td>
</tr>
</tbody>
</table>

Note: the list of control points presented is not exhaustive. It lists the minimum checks required and may be completed depending on the organisation in the workshop and/or recurrences of defects encountered.

(+) forming of bars (drilling, folding, cutting, etc.)
(**) number of supports, centre distance, etc.
(***) cross-section, identification, bonding continuity, etc.

Objectives

- Avoid risks of temperature rises
- Avoid electrical risks
- Avoid risks caused by electrodynamic stress
- Ensure the protection of persons
- Avoid the deterioration/destruction of equipment
Installing the devices
The layout of devices must be designed taking into account:
- the entry/exit direction (from the top or from the bottom) of the customer’s wires,
- the space available in the switchboard,
- heat constraints inside the switchboard.

See the "Device layout" section in this chapter.

The devices in the switchboard must be mounted, scrupulously following the instructions given in the switchgear manufacturers' guides.

Special precautions must be taken when mounting door-mounted devices.

Operations in switchboards must be carried out by qualified persons who comply with all required safety measures.

It is imperative to ensure the protection of operators against accidental direct contacts.
Installing the devices

Device layout

Positioning rules

**Standards**

**Good practice**

1. **IEC 61439-1**
   **Table 6**
   Define the layout of devices in the column based on constraints related to:
   - the entry and exit points of the customer's wires (from the top, the bottom of the column or other specific configuration) and the position of the main busbars in order to have the shortest possible connections,
   - the routing of prefabricated wires or connections at the input and output of the switchboard,
   - the space required for the device to work correctly (volume of device, safety perimeter, connection pads, radius of curvature of wires, control units, etc.),
   - the accessibility of the various control units and connection zones (side, rear, etc.) of devices,
   - heat dissipation of devices that contributes to increasing the internal temperature of the column,
   - the mutual thermal and electromagnetic influence between the main busbars and the devices,
   - the maintenance or upgrade of the system (for example, enable the opening of the motorised control of a circuit breaker).
   
   The resulting layout of the switchgear should also be studied to optimise connection zones, busbars, enclosure sizes, etc.

2. **IEC 60480**
   
   Place devices with a high heat dissipation in the upper part of the switchboard to:
   - avoid heating the entire switchgear installed in the column,
   - maintain the performance of devices of lower power placed at the bottom to keep derating to a minimum,
   - enable greater legibility of the electric layout.

3. **Tip**
   
   To maintain the internal temperature of the switchboard within the operating limits of most devices (< 70 °C), a forced ventilation of cubicles may be necessary, to replace derating, in order to optimise the volume of copper and reduce the cost.

   Several devices with a high heat dissipation may be installed in the same column if:
   - the maximum internal temperature is observed (below the manufacturer’s recommendations),
   - the capacity of the busbars to convey the rated current is observed (see derating tables),
   - the expected performance of each device is reached (see derating tables).

4. **IEC 61439-1**
   **Table 6**
   Comply with the temperature rise limits recommended by standard IEC 61439-1.
Installing the devices

Device layout

Positioning rules

Standards

IEC 61439-1
Table 6

Tip
For the electromagnetic compatibility of the switchboard, the use of separator sheets for all communicating devices is recommended.

Tip
Use separate routings for power cables and communication cables is recommended.

5 Good practice

To avoid serious malfunctions, do not install devices that are sensitive to temperature rises (e.g., control/command devices) near devices with high heat dissipation.

It is recommended to separate the switchboard into two zones (high-power devices and low-power devices) to improve the efficiency of the installation.

Installing the communicating devices at the bottom of the switchboard is recommended (see example given below).

Example

Smart panel modules to be isolated from heat sources.

IEC 61439-1
IEC 60947-x

Tip
For tables with a high operating voltage of 690 V, you may have to install additional barriers to reduce the risk of sparking in case of a short-circuit.

6 Keep within the safety perimeter defined by the manufacturer for each device and make sure they are working properly:
- minimum distance between two devices,
- minimum distance of the device from surrounding components (frame, plate, etc.),
- minimum distance from powered live bars.
Positioning rules

Standards

Good practice

7 The safety perimeter is usually stated by the manufacturer in the device technical manual or the catalogues.

8 The safety perimeter is a zone where it is forbidden to:
   - route wires other than those intended for the connection of the device itself,
   - install other devices.

9 Connect the devices with care. In particular:
   - do not strip insulated flexible bars and connection wires too much, to avoid all risk of sparking between phases in the event of a short-circuit,
   - position the lugs correctly on the connection pads,
   - if necessary, install barriers, terminal covers or insulating sleeves between each phase.

Sleeves used for marking wires do not act as insulators.

10 Position measurement devices requiring a visual inspection at a height comprised between 0.2 m and 2.2 m from the ground. Their exact position must be determined in consultation with the switchboard user.

Tip
The safety perimeter may be reduced by adding a cover, terminal cover, barrier, etc.

IEC 61439-1 § 8.5.5

Example
Installing the devices

Quality control check list

Note: the list of control points presented is not exhaustive.
It lists the minimum checks required and may be completed depending on the organisation in the workshop and/or recurrences of defects encountered.

<table>
<thead>
<tr>
<th>Minimum checks required</th>
<th>Control points</th>
<th>Control resources</th>
<th>Self-control</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔</td>
<td>&gt; Conformity of the switchgear and controlgear (placing of equipment and conformity of front panel)</td>
<td>&gt; Manufacturing file</td>
<td></td>
</tr>
<tr>
<td>✔</td>
<td>&gt; Mechanical operation</td>
<td>&gt; Switchgear and controlgear guide</td>
<td></td>
</tr>
<tr>
<td>✔</td>
<td>&gt; Accessibility of switchgear and controlgear (maintenance and operation)</td>
<td>&gt; Switchgear and controlgear guide</td>
<td></td>
</tr>
<tr>
<td>✔</td>
<td>&gt; Fixing of switchgear and controlgear</td>
<td>&gt; Switchgear &amp; controlgear and system guide</td>
<td></td>
</tr>
<tr>
<td>✔</td>
<td>&gt; Customer connection</td>
<td>&gt; Manufacturing file</td>
<td></td>
</tr>
<tr>
<td>✔</td>
<td>&gt; Compliance with safety perimeters</td>
<td>&gt; Switchgear and controlgear guide</td>
<td></td>
</tr>
<tr>
<td>✔</td>
<td>&gt; IP degree of protection</td>
<td>&gt; Manufacturing file (IP conformity), installation guide</td>
<td></td>
</tr>
</tbody>
</table>

(*) type, calibre, number of poles, accessories, etc.

Objectives

- Guarantee that the installation complies with project specifications
- Check that the equipment is working properly
- Ensure the maintainability of the installation
- Avoid risks of mechanical deterioration
- Facilitate customer connections on site
- Ensure the protection of persons and property
Power connections
Power connections can be obtained through:
- rigid bars (horizontal and vertical main busbars, transfer bars),
- cables.

By convention, power circuits are circuits connected to conductors with a cross-section of over 6 mm².

The means of connection is chosen based on the switchgear electrical characteristics: (electrical power) and available space in the column.

See the technical guides or manufacturer’s data sheets to install the appropriate conductors.

All connections must be sufficiently sized to withstand electrical and thermal stresses. Do not forget to take into account:
- the installation environment (pollution, ambient temperature, etc.),
- IP degree of protection of switchboard.

The conductor cross-section and the type of connection must be determined based on:
- the characteristics of the switchgear/ controlgear to be connected,
- the length of the connection,
- the thermal environment of the connection.

See:
- the technical guides or manufacturer’s data sheets to size the conductors.
- the chapter 1 “Assembly of enclosures”.
The creation of rigid busbars requires (cutting, punching, drilling, and folding) that requires a real expertise in order not to weaken or damage the intrinsic characteristics of the bars.

Rigid busbars must be assembled according to specific rules to ensure the quality of electrical contacts. The quality of an electrical contact depends on:
- the condition and size of the contact surfaces,
- the contact pressure.

Insulated flexible bars are primarily used for direct connections between transfer busbars and the switchgear/controlgear. Defining and installing them requires the same cares as for rigid busbars (≤ 630 A).
An incorrect choice and/or installation may:
- lead to a temperature rise,
- and disrupt or even damage connected or surrounding devices.

Cables may be used for all power connections. Nevertheless, connection becomes more difficult after a given power owing to:
- the limited space inside the switchboard,
- the large cable cross-section,
- the minimum radius of curvature to be complied with,
- the number of cables to install,
- the space needed for lugs.
Power connections

Connecting with cables

General routing rules

<table>
<thead>
<tr>
<th>Standards</th>
<th>Good practice</th>
</tr>
</thead>
</table>

1. Power cables can be routed inside the switchboard:
   - using cable strands,
   - by individual installation.
   Do not place power cables in ducts or straps.

2. Do not route cables between or too close to power busbars to avoid a temperature rise and deterioration of the insulator.

3. Avoid all risks of damage or cutting of the insulating sleeve:
   - do not route cables on parts with sharp edges.
   - cables that are routed through a hole in a sheet must be protected with grommets, cable glands, gaskets, plastic rings, etc.

   **Example**
   Cable glands are used to protect cables from the hole in the sheet.

4. Comply with the general wiring rules described in the chapter.

   **Tip**
   A damaged insulating sheath increases the risk of sparking and therefore of a short-circuit.

   **Tip**
   It is essential to comply with the permissible radius of curvature for each type of cable.
Power connections

Quality control check list

Note: the list of control points presented is not exhaustive. It lists the minimum checks required and may be completed depending on the organisation in the workshop and/or recurrences of defects encountered.

<table>
<thead>
<tr>
<th>Minimum checks required</th>
<th>Control points</th>
<th>Control resources</th>
<th>Self-control</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>&gt; Observance of conductor cross-sections</td>
<td>&gt; Technical documentation</td>
<td></td>
</tr>
<tr>
<td>✓</td>
<td>&gt; Method of installing and fastening conductors</td>
<td>&gt; Installation guide</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; Cable characteristics (e.g. 1000 V, 105 °C)</td>
<td>&gt; Customer requirements (specifications)</td>
<td></td>
</tr>
<tr>
<td>✓</td>
<td>&gt; Quality of power connections*</td>
<td>&gt; Installation guide</td>
<td></td>
</tr>
<tr>
<td>✓</td>
<td>&gt; Tightening to torque</td>
<td>&gt; Torque wrench, switchgear and controlgear guide, installation guide</td>
<td></td>
</tr>
</tbody>
</table>

(*) Surface state, drilling, conformity of fasteners, varnish, etc.

Objectives

- Avoid risks of temperature rises
- Avoid electrodynamic stresses
- Check the conformity of conductors:
  - with customer specifications (colours, type of core, minimum cross-section)
  - to switchgear and controlgear characteristics (cross-section, etc.)
- Avoid electrical risks
Auxiliary and low-power circuits
Auxiliary and low-power circuits

Auxiliary and low-power circuits are:
- control and monitoring circuits: auxiliary power supplies, relays, contactor coils, circuit breaker remote controls, PLC inputs/outputs,
- digital circuits: Ethernet network, Modbus and ULP.

By convention, auxiliary and low-power circuits use cables with cross-sections of under 6 mm².
The conductor cross-section and the type of connection must be determined based on:
- the characteristics of the switchgear to be connected,
- the length of the connection,
- the thermal environment of the conductors,
- nominal range of upstream protective device.

Cables inside the switchboard can be routed using:
- ducts,
- straps,
- cable strands,
- by individual installation.
Ducts and straps must be preferred when there are a large number of auxiliary circuits. This choice provides the following advantages:
- improved efficiency in terms of heat exchanges,
- improved mechanical protection of cables,
- greater ease of installation,
- faster wiring,
- excellent scalability (easy to change and maintain).
Conversely, when there are few cables to connect, it may be more economically advisable to make strands.

Tip
The use of steel or aluminum duct reinforces the immunity installation with respect to electromagnetic compatibility.

Foreword
Cables must be prepared using tools or machines in good working condition that are correctly calibrated. They must be connected according to trade practice to avoid all risks of temperature rise that may cause serious damage.

See the “Connections” section in this chapter.

Given their sensitivity to electromagnetic disturbance, the communication switchgear installed must meet the requirements of the relevant immunity and emission standards.

See the “Digital circuits” section in this chapter.

Toroids are mounted on cables to detect leakage currents. They transmit a signal that is proportional to the current measured to the related receiver.

Toroids are fragile components. They must be installed in the switchboard according to professional good practice.

The circuit of the current measuring devices are generally realized with a wiring section ≥ 2.5 mm². To improve the safety of circuits, cables reinforced insulation are used to reduce the risk of mechanical damage.
**General circulation rules**

**Good practice**

1. Use separate routings for auxiliary circuit and low power cables (cross-section ≤ 6 mm²) and power cables (cross-section < 6 mm²). Moreover, given their sensitivity to electromagnetic disturbance, it is preferable to separate control/monitoring cables from communication cables.

![Diagram of cable routing](image)

2. Do not route cables between or too close to power bars to avoid all risks:
   - of a temperature rise in the cable,
   - damage to the insulator,
   - electromagnetic disturbance.

![Example of cable routing](image)

3. Avoid all risks of damage or cutting of the insulating sleeve:
   - do not route cables on parts with sharp edges.
   - protect cables that are routed through a hole in a sheet with grommets.

![Tip on cable protection](image)

**Example**

Grommets are used to protect cables from the hole in the sheet.

**Tip**

The routing of cables inside the enclosure may be organised as follows, “Cable ladder” wire running:

- Power
- Control
- Communication

**IEC 61439-1/2**

- The deterioration of the insulating sleeve of a conductor will result in the deterioration of its dielectric characteristics and increases the risk of sparking and therefore of a short-circuit.
Auxiliary and low-power circuits

Routing cables

General circulation rules

Standards

Good practice

4. Do not route the cables:
- in the device safety perimeter, e.g., installation of ducts above the circuit breaker gas evacuation areas,
- close to moving parts (handle, reset button, mechanical interlocking, rotary handle, etc.) where there is a risk of blocking the cable.

Example

The cables are routed too close to the rotary handle.

Tip

The safety perimeter of a device is defined in chapter 3 - Installing the devices.

5. Comply with the permissible radius of curvature for each type of cable.
Notably:
- provide for sufficient space for connecting the cables, with a minimum radius of curvature (6 to 8 times the external diameter of the cables),

- no use of tools to bend the cable.
Failure to observe this recommendation may result in an abnormal temperature rise in the conductors.

Tip

The values of the permissible curvature radii are given by the cable suppliers. They depend on the type:
- of core (copper or aluminium),
- of insulator.
Routing cables

Cable routing in ducts

**Standards**

**Good practice**

1. Choose trunkings adapted to the cross-section and the number of cables that they are to hold. Provide for a reserve for future extensions. The final fill rate must not exceed 70%.

   ![Example](image1)

2. Never install a trunking in contact with or between power busbar conductors.

   ![Example](image2)

3. Define the number of fastening points of a trunking based on its mechanical characteristics and the fill rate. The trunking must be straight after fastening. At any event, the centre distance between fastening points must not be more than 600 mm.

   ![Example](image3)

4. Fasten the trunking using rivets or plastic screws to reduce the risk of damaging the cables.

   ![Example](image4)

5. Do not tie cables inside the trunkings to facilitate heat dissipation. Never stretch a wiring cable to avoid all risks of disconnecting the cable. As a rule, there must always be some slack between the duct outlet and the connection point.

   ![Example](image5)
Cable routing in straps

1. Cable straps are used to ensure faster installation, and facilitate the modification of operations and maintenance. Choose the size of the straps based on the number of cables that they are to hold. The final fill rate must not exceed 70%.

2. Lock the straps on a modular rail or vertical mounting plate. Fit a sufficiently large number of straps to ensure that cables are properly held in place: 1 strap approximately every 8 cm.

3. Do not tie cables running inside the straps to facilitate heat dissipation.
Routing cables

Cable stranding

**Standards**

1. Choose ties that are adapted to the strand to be made. They must:
   - be mechanically resistant enough to keep the cables fastened in case of a short-circuit,
   - be of a length that is adapted to the strand circumference,
   - be wide enough not to damage the cable insulating sleeve.

2. Fit a sufficiently large number of ties to ensure that cables are properly held in place.
   Centre distance recommended according to strand diameter:

<table>
<thead>
<tr>
<th>Diameter D of strand (in mm)</th>
<th>Distance L between ties Mini (in mm)</th>
<th>Maxi (in mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20</td>
<td>60</td>
<td>120</td>
</tr>
<tr>
<td>Between 20 and 30</td>
<td>70</td>
<td>140</td>
</tr>
<tr>
<td>Between 31 and 45</td>
<td>90</td>
<td>180</td>
</tr>
<tr>
<td>Between 46 and 75</td>
<td>125</td>
<td>200</td>
</tr>
</tbody>
</table>
Strand fastening

1. Never run a strand in contact with or between power busbar conductors to avoid temperature rise and damage to insulators.

2. If the cables of the strand do not meet the class 2 requirements, fasten the strand on insulation supports. If they are metal supports, insert an insulating wedge between the strand and each metal support. If cables meet the class 2 requirements you may fasten them directly on metal supports.

3. Strands must be run flush with doors, panels, swivelling front panels or panels that hold the switchgear in such a way as to reduce the risks of damaging or pinching the cables to a minimum.

   The strand is protected mechanically by:
   - a tubular plastic sleeve,
   - a braided polyester sleeve,
   - a spiral bearing.

   Follow the recommendations below to mount the strand:
   - make sure that the strand allows the movement of the moving part without any risk of damage to the cables.
   - make sure that the cables are not subject to twisting or pulling. If necessary divide the strand to limit mechanical stresses.
   - comply with the permissible radius of curvature.
   - fasten the strand firmly on the fixed part (framework) as well as on the moving part (door, faceplate, panel, etc.).
Routing between columns

**Standards**

**Good practice**

1. There are two possible scenarios depending on the switchboard configuration:
   - **limited number of columns and cables to connect**: it is preferable to connect the cables directly to the switchgear concerned. In this case, you have to protect conductors against risks of deterioration (strand protected by a polyester sleeve, cable tray or trunking),
   - **large number of columns and cables to connect**: use terminal blocks to facilitate the installation and connection on site (faster and more reliable laying) and any maintenance operations.

   In both cases:
   - identify the cables with marks that are consistent with those of the switchboard to facilitate subsequent operations.

**Example**

Schneider Electric provides terminal blocks to be mounted on modular rails. They make it possible to connect cables of auxiliary circuits between two columns.

This type of terminal block can be disconnected. It enables fast connection and disconnection during maintenance.

2. For voltage collector power supply, choose an appropriate cable cross-section that will limit voltage drops (usually 6 mm²).

**Tip**

You can interrupt a form to lay a trunking on condition that it is not possible to touch a live part with your hand or a tool.
Electrical connections must have absolute reliability to ensure that the switchboard is working properly.

A good quality connection means:
- a connection that is adapted to the cross-section of the conductor to connect,
- a conductor that has been stripped correctly,
- a crimping tool or machine that is in good condition and regularly calibrated,
- an operator qualified and trained for this operation,
- effective tightening.

Cables must be formed (stripped, crimped) according to professional good practice, using appropriate equipment in good working condition that is correctly calibrated.

You may use different types of crimping connections:
- pre-insulated lugs,
- pre-insulated cable terminals,
- female clips,
- spade lugs.

Prefer the use of integrated connection accessories.

The stacker is used to connect the IFM without extra cable.
Connecting current transformers

**Standards**

**Good practice**

1. The secondary circuit of a current transformer must never be open when the primary is energized. High voltages may appear on the secondary circuit terminals. They present a hazard to persons and result in the deterioration of the transformer.

   Observe the following recommendations to limit the risks of interrupting the transformer’s secondary circuit:
   - always connect the secondary circuit using round lugs,
   - never use the terminal block to connect the secondary circuit.

2. Place the current transformer as close as possible to the measuring device to avoid having cables that are too long.
The electromagnetic compatibility (EMC) of a switchboard is its ability to function in a disturbed environment while limiting its own disruptive emissions.

Electromagnetic disturbances are potential sources of malfunctioning for all electronic materials:
- regulators and measuring devices that deal with analogue signals,
- PLCs and communication interfaces that deal with digital signals.

Overall performance is obtained by:
- reducing disturbances at the source, which can also be from outside the switchboard,
- protecting information exchanged with the process throughout their routing in the switchboard,
- preserving the entry into the switchboard of radiated and conducted disturbances.
The earthing mesh inside a switchboard is an essential parameter. All metal structures will be interconnected with an electric contact. Be careful of the various protective coatings, which are generally insulating.

The digital equipment must meet the requirements of the relevant immunity and emission standards. The wiring rules that follow are general ones. They do not replace the wiring guidelines given by the switchgear and controlgear manufacturer.

Example: Sensitivity of the various cable families

<table>
<thead>
<tr>
<th>Family</th>
<th>Cables</th>
<th>Type of signal</th>
<th>EMC behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Analogue</td>
<td>Power supply and measurement circuits of analogue sensors</td>
<td>Sensitive signals</td>
</tr>
<tr>
<td>2</td>
<td>Digital and Telecom</td>
<td>Digital circuits and data bus</td>
<td>These signals are sensitive. They are also disruptive for family 1</td>
</tr>
<tr>
<td>3</td>
<td>Relay</td>
<td>Dry-contact circuits with risks of re-priming</td>
<td>These signals are disruptive for families 1 and 2</td>
</tr>
<tr>
<td>4</td>
<td>Power supply</td>
<td>Power supply and power circuits</td>
<td>These signals are disruptive</td>
</tr>
</tbody>
</table>

Remark: A shielded cable is neither disruptive nor sensitive.

Use shielded cables or double shielded strands to protect circuits against radiated parasites. The metal armour must be earthed correctly. All free conductors in a cable (except for the analogue cable) must be systematically earthed at both ends.

Example: Earthing terminals with metal fastening system with modular rail.
General wiring recommendations
- Do not bend or damage the cables.
- Minimum bending radius: 10 x cable diameter.
- Avoid sharp angles of paths or passages of the cable.
- The connection of the shield of the cable must be as short as possible.
- Several shields can be connected together.
- Make a physical mark at the end of each cable.
- Identify the logical name and the address of each device.

Wiring must be in accordance with the following colours:

<table>
<thead>
<tr>
<th>Wire type</th>
<th>Wire colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Power</td>
<td>Black</td>
</tr>
<tr>
<td>Neutral</td>
<td>Light blue (RAL 5024)</td>
</tr>
<tr>
<td>Control wire 24 V DC</td>
<td>Dark blue (RAL 5013)</td>
</tr>
<tr>
<td>0 V DC</td>
<td>Gray (RAL 7001)</td>
</tr>
<tr>
<td>24 V AC</td>
<td>Red</td>
</tr>
<tr>
<td>0 V AC</td>
<td>Ivory (RAL 1015)</td>
</tr>
<tr>
<td>Earth</td>
<td>Green/Yellow</td>
</tr>
</tbody>
</table>

Adjust the cable length to actual requirements. Cables must be as short as possible by avoiding the creation of loops that generate parasites currents resulting from magnetic fields.
Cables must be stripped as close as possible to the connection point.

Avoid all earth loops: they are very sensitive to power magnetic fields.
### Auxiliary and low-power circuits

#### Digital circuits

#### Wiring rules

**Standards**

**Good practice**

1. Metallic tubing
   - Secure the communication cable inside the metallic profile when possible, or stick it on metallic parts.

2. Never position communication cables close to busbars or power cables.
   - Use a flexible metal tubing.

3. **Example**
   - Metallic tubing
   - Secure the communication cable inside the metallic profile when possible, or stick it on metallic parts.

4. Never position communication cables close to busbars or power cables.
   - Use a flexible metal tubing.

5. The presence of many earth structures in switchboards provides optimum protection.
   - When routing to moving parts (doors, front plate), route the communication cable close to a hinge or earthing wire.

6. **Example**
   - Protective effect inside a switchboard:
     - all the cables must be flattened against earthing structures,
     - plastic cabling ducts can be used because they are installed on DIN rails connected to the switchboard earth.
   - Cables must be routed close to assembly points (hinges) or be doubled by an earthing wire.
**Wiring rules**

- **Standards**
- **Good practice**

**6.** Divide the cables into three separate groups (power, command and communication) to let them be routed in separate paths. The routing of wires of groups 2 and 3 is tolerated in the same ducts. However, they should not be mixed in the same sheath or tightened into a single strand.

**Example**

To maintain the protective effect, we advise that you observe a ratio of the distance \(d\) between cables to the radius \(R\) of the largest cable of over 5.

![Diagram showing the ratio of distance to radius for protective effect.]

**7.** When communication cables have to cross over power cables (e.g. when drawer space is small), the angle between the two types of cables should be as close as possible to 90°.

![Diagram showing correct and incorrect cable routing.]

1. Power cable
2. Communication cable
3. Right angle
4. Parallel cable routing (NOK)

**8.** The best possible path for a communication cable is as close as possible to an earthed plane, i.e. on the steel plates of cubicles.

![Diagram showing correct and incorrect cable routing on earthed plane.]

1. Earthed metal plane
2. Communication cable laid on the metal parts
3. Communication cable far from the metal parts (NOK)
Screen continuity

**Standards**  **Good practice**

1. **Do not use the connector pins to ensure screen continuity.**
   "Pig tails" are forbidden (very poor efficiency at high frequency).
   Connect the cable screens directly on the metal plate:
   - to reduce the common impedance,
   - to divert disturbances directly to earth (outside the products).

**Example**

2. **Earthing clip DIN rail mounted.**
**Screen continuity**

1. **360° steel earthing clamp (do not use aluminium clamps).**
   - Clamp diameter shall be adapted to the cable screen diameter.

   ![Image of clamp适应](image)

   - Clamp adapted to screen diameter
   - Clamp too large
   - Clamp too small

2. **Device with an open style connector**
   - Add a heat shrink tubing at the screen cable end (to contain braid metallic particles).

3. **Modbus tap earthing and bonding**
   - Never let the tap isolated. Use an universal DIN rail fixing system.
**Earthing and bonding**

### Standards

**Good practice**

1. **Electrical continuity**
   The electrical continuity between the drawer frame and the cubicle structure shall be obtained using the connector pins. The connection length should be as short as possible.

   - Internal FU connector
   - Connector earthing
   - Earthing connection too long
   - External FU connector
   - Earthing by a earth terminal DIN rail mounted.

2. **Electromagnetic barrier**
   Connect together all the "earthing" contacts of the removable connector (= electromagnetic barrier) to the drawer earth.
Auxiliary and low-power circuits

Digital circuits

Relays and contactor coils disturbances

AC and mostly DC coils relay, contactor, actuator could be very disturbing sources if no overvoltage protection is fitted in parallel with the coil.

For DC and AC applications, the relay/contactor coils have to be protected to avoid significant disturbances. In this case, the energy stored inside the coil will be dissipated in the Transient Voltage Suppressor, as shown in the picture above on the right side.

Different types of Transient Voltage Suppressor (TVS) components could be used. The following table provides information.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>R-C network</th>
<th>For AC</th>
<th>For DC</th>
<th>Overvoltage limitation</th>
<th>Contact fall time</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="R-C Network" /></td>
<td>R-C network</td>
<td>O</td>
<td>O</td>
<td>2 to 3 Un</td>
<td>1 to 2 times the standard time</td>
</tr>
<tr>
<td><img src="image" alt="Metal Oxide Varistor" /></td>
<td>Metal Oxide Varistor</td>
<td>O</td>
<td>O</td>
<td>&lt; 3 Un</td>
<td>1.1 to 1.5 times the standard time</td>
</tr>
<tr>
<td><img src="image" alt="Transient Voltage Suppression Diode Bi directional" /></td>
<td>Transient Voltage Suppression Diode Bi directional</td>
<td>O</td>
<td>O</td>
<td>&lt; 2 Un</td>
<td>1.1 to 1.5 times the standard time</td>
</tr>
</tbody>
</table>

To be efficient, the TVS shall be installed closely to the coil.
Wiring of Ethernet network

1. Although there are 4 twisted pairs of wires, 10 Base-T / 100 Base-T Ethernet uses only 2 pairs: White/Orange (pins 1 & 2) and White/Green (pins 3 & 6).

As a minimum, an Ethernet line cable must be screened (overall braided screen) and screened also by a foil (SF/UTP).

There are different Ethernet topologies, they can be used separately or mixed.

<table>
<thead>
<tr>
<th>Rules</th>
<th>Standard Ethernet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum number of</td>
<td>No limits</td>
</tr>
<tr>
<td>devices per network</td>
<td></td>
</tr>
<tr>
<td>Transmission rate</td>
<td>10/100 Mbit/s and 1 Gbit/s</td>
</tr>
<tr>
<td>Maximum length</td>
<td>Twisted pair 100 m - Multi-mode</td>
</tr>
<tr>
<td></td>
<td>Fibre optic: 2 km - Mono-mode</td>
</tr>
<tr>
<td></td>
<td>Fibre optic &gt; 2 km</td>
</tr>
<tr>
<td>Cable type</td>
<td>Depends on the transmission rate</td>
</tr>
</tbody>
</table>

2. It is highly recommended to attach a communications wiring diagram in addition to the electrical wiring diagram.

**Data to show in this diagram:**
- network name and number of each link,
- name, address and location of the equipment,
- identify used ports for each switch,
- all the elements of the architecture (routers, switches, by-pass switch, etc.),
- cable length.

3. **Detailed view of a good wiring**

Use straight cable through connection in accordance with TIA/EIA-568-B (T568B) for the number of pins, number of pairs and color coding.

<table>
<thead>
<tr>
<th>Pin position</th>
<th>Pin N°</th>
<th>Pair N°</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>White/Orange</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1</td>
<td>Orange</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2</td>
<td>White/Green</td>
</tr>
<tr>
<td></td>
<td>4 &amp; 5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>2</td>
<td>Green</td>
</tr>
<tr>
<td></td>
<td>7 &amp; 8</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>
This chapter is dedicated to general rules on cable lengths, shielding, path and preparation to comply with EMC and communication specifications.

The Modbus RTU protocol (a.k.a. Modbus SL) is based on a Master-Slave concept.

In the standard Modbus system, all the devices are connected to a main 3 wires cable. Two wires form a balanced twisted pair, on which bi-directional data are transmitted.

The Modbus topology is a main cable with devices connected directly (daisy chaining) or by short derivation cables.

The main cable, a.k.a. "Bus", must be connected at its two extremities with Line Terminations. Generally speaking, the sum of all the derivation lengths must be lower than the length of the bus.

The "Common" circuit must be connected directly to protective ground, preferably at one point only for the entire bus. In general, this point is chosen either on the master device or on the polarization device.

A Modbus Serial Cable must be shielded. The shield must be connected to protective ground at both ends.

### Rules

<table>
<thead>
<tr>
<th>Rules</th>
<th>Standard Modbus RTU</th>
<th>Smart Panels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum number of devices per bus</td>
<td>32 (without repeater)</td>
<td>8</td>
</tr>
<tr>
<td>Bus Speed</td>
<td>1200 bps to 115.2 Kbps</td>
<td>19.2 Kbps</td>
</tr>
<tr>
<td>Maximum bus length</td>
<td>1300 m (without repeaters) and depending on the transmission rate</td>
<td>1000 m</td>
</tr>
<tr>
<td>Maximum length of the sum of the derivations</td>
<td>Depends on the transmission rate</td>
<td>40 m</td>
</tr>
<tr>
<td>Cable type</td>
<td>TIA / EIA - 485 Standard</td>
<td>Ditto standard</td>
</tr>
<tr>
<td>Location of the terminations</td>
<td>Line termination at the 2 extremities of the bus (R or RC)</td>
<td>Line termination at the 2 extremities of the bus (Only R = 120 Ω)</td>
</tr>
<tr>
<td>Location of the polarization</td>
<td>The polarization is given by only one equipment at the beginning of the bus (in general: the master)</td>
<td>Ditto standard</td>
</tr>
</tbody>
</table>

**Example**

1. Name of the master
2. Names of the slaves
3. Line Termination
4. Name of the bus, number and location

**Data to show in this diagram:**
- name, address and location of the equipment
- all the elements of the architecture (copper and fibre optic repeaters, coupling, bridges)
- Line Termination (LT)
- cable length.
Particular rules for Modbus RTU

1. Master
2. Slave 1
3. Slave n
4. Balanced twisted pair
5. Line termination at the 2 extremities of the bus
6. Length of the main line > sum of slaves derivation lines
7. Ground signal to reference all the devices
8. Polarity resistor (generally integrated in the master)

Detailed view of a good wiring

General wiring recommendations
- Do not bend or damage the cables
- Minimum bending radius: 10 x cable diameter (about 75 mm in diameter)
- Avoid sharp angles of paths or passages of the cable
- The connection of the shield of the cable must be as short as possible
- Several shields can be connected together
- Make a physical mark at the end of each cable
- Identify the logical name and the logical address of each device
- Wiring must be in accordance with the following colours:

<table>
<thead>
<tr>
<th>Wire type</th>
<th>Wire colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC POWER</td>
<td>BLACK</td>
</tr>
<tr>
<td>NEUTRAL</td>
<td>LIGHT BLUE (RAL 5024)</td>
</tr>
<tr>
<td>24 V DC control wire</td>
<td>DARK BLUE (RAL 5013)</td>
</tr>
<tr>
<td>0 V DC control wire</td>
<td>GRAY (RAL 7001)</td>
</tr>
<tr>
<td>24 V AC control wire</td>
<td>RED</td>
</tr>
<tr>
<td>0 V AC control wire</td>
<td>IVORY (RAL 1015)</td>
</tr>
<tr>
<td>Ground</td>
<td>GREEN / YELLOW</td>
</tr>
</tbody>
</table>
Auxiliary and low-power circuits

Smart Panels connection in Blokset switchboards

Architecture example
Communication Cubicle example
Smart Panels architectures in Blokset switchboards

Communication Architecture example

- **Modbus**
- **ULP**
- **Ethernet**

LV Switchboard - Blokset

FD Panel – Blokset
Auxiliary and low-power circuits

Smart Panels architectures in Blokset switchboards

Architecture example
Smart Panels architectures in Blokset switchboards

Architecture example
Auxiliary and low-power circuits

Notes

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Quality control check list

**Objectives**

- Avoid communication "bugs"
- Avoid risks of temperature rises
- Guarantee correct electrical functioning
- Avoid electrical risks
- Guarantee compliance with customer specifications

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**Minimum checks required**

<table>
<thead>
<tr>
<th>Control points</th>
<th>Control resources</th>
<th>Self-control</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; Compliance of wiring installation</td>
<td>&gt; Installation guide</td>
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<td>[ ]</td>
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<tr>
<td>&gt; Crimping quality</td>
<td>&gt; Installation guide</td>
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</tr>
<tr>
<td>&gt; Compliance of communication cable installation</td>
<td>&gt; Installation guide</td>
<td></td>
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<tr>
<td>[ ]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; Wiring cross-section and characteristics</td>
<td>&gt; Customer requirements, installation guide</td>
<td></td>
</tr>
<tr>
<td>[ ]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; Modbus addressing</td>
<td>&gt; Installation guide</td>
<td></td>
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<tr>
<td>[ ]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; Device connection</td>
<td>&gt; Test button on ULP</td>
<td></td>
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<tr>
<td>[ ]</td>
<td></td>
<td></td>
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<tr>
<td>&gt; Earthing continuity</td>
<td>&gt; Installation guide</td>
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<td>[ ]</td>
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<td></td>
</tr>
<tr>
<td>&gt; Communication of devices</td>
<td>&gt; Internet browser</td>
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<td>[ ]</td>
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</tbody>
</table>
Digital system test
The configuration and the check are carried out with configuration software tools or through devices’ web pages based on the Blokset Smart Panels switchboard configuration.

To go further on commissioning recommendation a specific guide is available: “TVDA - How can I configure a Smart Panels”, see reference document list.

Smart Panels system can be configured by the device web pages.

Enerlin’X devices have web pages that allow an easy configuration of the system. However configuration tool may be useful for some advanced setting (protection setting, automatic check report...)

**Ethernet discovery**

Enerlin’X devices provide an automatic discovery and identification over Ethernet network. This feature is called device profile for web services (DPWS) and is available by Windows 7.

Connect your computer to your Smart Panels Ethernet network or individually to each device. Open the windows explorer:

By clicking on network, connected devices appear automatically:

Then click on each devices to access it own web pages.

**Note:** connection via routers is forbidden for DPWS feature.
Modbus addressing
Modbus addressing must be set with the two rotary switches symbolized with X1 and X10. The symbol X10 corresponds to the tens, and the symbol X1 to the ones.

Example
To set the Modbus address to 4, proceed as follows:
- IFM rotary switch:
  - set the X10 switch to 0,
  - set the X1 switch to 4,
  - turn the padlock switch to the unlocked position.

ULP connection
The aim is to check the ULP system connection between IFM and circuit breaker, thanks to “ULP test button”. Press the test button on IFM and check that IFM and associated Micrologic trip unit flash simultaneously (ON: 1000 ms/OFF: 1000 ms).

Example
Hardware configuration - Configuration of Enerlin' X IFE

1. **ULP connection**
   - All connection configurations require the breaker ULP cord. The insulated NSX cord is mandatory for system voltages greater than 480 V~. When the second ULP RJ45 connector is not used, it must be closed with a ULP terminator.
   - The next step is to check the ULP system connection between IFE, I/O application module and circuit breaker, thanks to “ULP test button”. Press the test button on IFE and check that IFE, I/O application module and associated Micrologic trip unit flash simultaneously (ON: 1000 ms/OFF: 1000 ms).

2. **Ethernet connection**
   - IFE has two Ethernet ports E1 and E2.
   - Ethernet Cabling,
     - 100 base T – 2* RJ45 – E1 and E2
   - Ethernet 1 and Ethernet 2 ports act as a non manageable switch.
   - **Note**: IFE doesn’t support redundant Ethernet protocol (RSTP, MRP, Hyper Ring...).
   - IFE provides Ethernet daisy chain connection.
   - If daisy chain loop is requested an Ethernet loop manager must be used.

Be careful with ULP and Ethernet connection that use both RJ45 connector type. ULP system supply the 24 V DC to all connected devices so serious damage can occur in case of bad connection.
Software configuration - Configuration of Enerlin'X IFE

Good practice

This part details the IFE configuration and test that is carried out by web pages. IFE device must be connected correctly and all addressing are correct.

1. IFE Ethernet web pages access
   From Ethernet discovery feature (DPWS) open the IFE Ethernet web pages by clicking on IFE_XXYYZZ and enter login and password to access the web pages.

2. Ethernet network configuration
   Fill all general and communication parameters of Setup menu: Name, IP addressing, Label.
Software configuration - Configuration of Enerlin'X IFE

Modbus configuration
Then configure the Modbus slave devices: Name, Modbus addressing. The IFE provides an autodiscovery feature of connected Modbus serial slave devices.

Test report
Both communication and functional aspects (Open/Close status and Open/Close control) can be tested with the web pages. A print screen of the web page can be used to create a report:
I/O application module identification setting
Two I/O application modules can be used for the same breaker connected on the ULP system (I/O application module 1 or I/O application module 2).
When two I/O application modules are connected in the same ULP network, the two I/O application modules are differentiated by the position of the switch located on the bottom of the I/O application module.

Example
Dip switch on position 1 for I/O application module 1 (factory setting).
Dip switch on position 2 for I/O application module 2.

I/O application module predefined application
The application rotary switch enables the selection of a predefined application. It has 9 positions and each position is assigned to a predefined application.

<table>
<thead>
<tr>
<th>Application rotary switch position</th>
<th>Predefined application</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cradle management</td>
<td>Monitors the position of the circuit breaker in the cradle</td>
</tr>
<tr>
<td>2</td>
<td>Circuit breaker operation</td>
<td>Controls the opening and closing of the circuit breaker by using the control mode (local or remote) and the close inhibit order</td>
</tr>
<tr>
<td>3</td>
<td>Cradle management and Energy Reduction Maintenance Setting (ERMS)</td>
<td>Monitors the position of inputs and controls the ERMS mode of the circuit breaker</td>
</tr>
<tr>
<td>4</td>
<td>Light and load control</td>
<td>Controls the light and load application.</td>
</tr>
<tr>
<td>5-8</td>
<td>Spare</td>
<td>Future evolution</td>
</tr>
<tr>
<td>9</td>
<td>Custom</td>
<td>Performs the user-defined applications with the I/O application module</td>
</tr>
</tbody>
</table>

Example
The factory-set position of the switch is predefined as application 1.
Software configuration - Enerlin’X I/O

This part details the I/O application module check in the IFE web pages. IFE device and I/O application module must be connected correctly and all addressing are correct.

I/O application module test

Access to the monitoring web page of the IFE associated with the I/O application module:

A print screen of the web page can be used to create a report on the I/O application module correct installation.
Ecoreach is a software application that helps the user to manage a project as part of Designing, testing, site commissioning, and maintenance of the project life cycle. It enables the user to prepare the settings of the devices offline (without connecting to the device), save the project in cloud as reference and configure the devices when connected with the devices. Also it provides lot of other value added features for the user to manage the project such as organize devices in switchboard wise, manage a hierarchical structure of the installation, project sharing, communication test, comprehensive reports, etc.

### Value Proposition:
Panel Builders: Simple & Easy Software to setup and test a Panel board with Smart Devices.

### Key Functions:
- Device Discovery
- Project management
- Multiple Device configuration
- Communication Test and Reports
- Storage of settings and reports in cloud
- Project Sharing.

I want to test & deliver a “ready to commission” smartpanel easily.
Device Discovery

This part details the device discovery function of Ecoreach. When the user connects Ecoreach on a communication network, he can discover all devices which are known to Ecoreach and wired in the network. Once the devices are discovered, the user will be able to add the devices to the project.

1. From the main page, click Tools and then Device Discovery.

2. Click Import to do the device discovery.
Device Discovery

2. Enter the IP range for discovering devices. Click “Include deep Scanning for serial network” to discover serial devices behind the gateway.

Select the Modbus addresses and Click “Discover Devices”.

Enter the IP range for discovering devices.
Click “Include deep Scanning for serial network” to discover serial devices behind the gateway.
Click “Add” to add the devices to the project.

Additionally you can save the discovery results as a pdf report as well.
Once general and communication architecture is made, select the device and connect.

- Discovered Devices are added to the project.
- Project architecture can be made as per the SLD by drag and drop.

Communication architecture can be made as per the network topology.
Communication Test

When a user has installed communicating devices in a switchboard/panel board, Ecoreach offers the capability to test the communication network. Regardless of the communication network deployed inside a switchboard or a panel board, the communication test will cover the connection of devices to switchboard access point and provides a communication test report.

Communication Test & Settings Upload/Download - Multiple Devices

1. Switch to Table view for multi-devices actions.
   Select the desired devices in the table.

   ![Table view](DB418498.eps)

   - Upload settings from Devices to Project,
   or
   - Download settings from Project to Devices.

   Start Communication test and generate the report.
Communication Test - Result

Communication Test Results will be displayed and the report can be generated.
Quality control check list

**Note:** the list of control points presented is not exhaustive.
It lists the minimum checks required and may be completed depending on the organisation in the workshop and/or recurrences of defects encountered.

<table>
<thead>
<tr>
<th>Minimum checks required</th>
<th>Control points</th>
<th>Control resources</th>
<th>Self-control</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>&gt; Modbus addressing</td>
<td>&gt; Installation guide</td>
<td></td>
</tr>
<tr>
<td>✓</td>
<td>&gt; Device connection</td>
<td>&gt; Test button on ULP</td>
<td></td>
</tr>
<tr>
<td>✓</td>
<td>&gt; Earthing continuity</td>
<td>&gt; Installation guide</td>
<td></td>
</tr>
<tr>
<td>✓</td>
<td>&gt; Communication of devices</td>
<td>&gt; Internet browser</td>
<td></td>
</tr>
</tbody>
</table>

**Objectives**
- Verify access to each digital device
- Verify the global health of the system
- Provide a test report
Factory quality inspection
Factory quality inspection

What standard IEC 61439-1 says about quality inspections?

Routine verification
Routine verification is designed to detect materials and manufacturing defects and to ensure that the manufactured assembly is working properly. It is performed on each assembly. Panelbuilders must determine whether routine is carried out during and/or after manufacturing. If necessary, the routine verification must ensure that design verification is available.

Verification comprises two categories below:

1. **"Construction" verifications**
   (see sections 11.2 to 11.8 of the standard)
   1. Degree of protection of enclosures
   2. Clearances and creepage distances
   3. Protection against electric shock and integrity of protective circuits
   4. Incorporation of built-in components
   5. Internal electrical circuits and connections
   6. Terminals for external conductors
   7. Mechanical operation

2. **"Performance" verifications**
   (see sections 11.9 to 11.10 of the standard)
   1. Dielectric properties
   2. Wiring, operational performance and function

What is the risk if the quality inspection is not conducted (during and/or after manufacturing)?

- Quality organisation does not comply with standard
- Customer not satisfied
- Hazardous installation
- Negative impact on the image of the panelbuilder and manufacturer
- Higher costs of intervention
- Operating loss (break in service continuity)
- Financial loss
Organise quality checks
Organise quality checks (self-checks) throughout the switchboard assembly and installation process, from acceptance of components until the delivery of the switchboard (see quality control check list opposite).

Benefits
- Increased accountability of operators
- Improved traceability
- Optimisation of installation rules
  E.g., busbar tightening must be checked at the end of manufacturing (involves the dismounting of sheets, resulting in a significant loss of time).

Conduct a final quality inspection
In a secured area dedicated for this purpose (in particular during electrical checks).

Note: the final quality inspection must be performed by qualified and authorised personnel.

Documents required for the final inspection
- Check lists of quality checks (self-checks) conducted throughout the switchboard assembly and installation process
- Final inspection report
  (See example provided in the guide on page 85)
  Note: to be completed depending on the customer’s specifications and requirements.
- Other useful documents: notification of non-compliance, check list of missing components, quality measurements
- Manufacturing file
- Switchgear guide
- Technical documentation

To find out more about the final quality inspection, see the “Quality inspection guide” written by our experts.
Factory quality inspection

List of checks to be made during the final quality inspection

Make sure that self-checks have been performed throughout the assembly and installation process or validated (e.g. by the line controller).

<table>
<thead>
<tr>
<th>Control points</th>
<th>Control resources</th>
<th>Final control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Compliance checks</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; Identification &amp; column numbers</td>
<td>&gt; Assembly drawing file</td>
<td>✔</td>
</tr>
<tr>
<td>&gt; Type</td>
<td>&gt; Customer specifications</td>
<td></td>
</tr>
<tr>
<td>&gt; Dimensions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; Compliance of front panel, block diagram</td>
<td></td>
<td></td>
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<tr>
<td>&gt; Handling devices</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Visual checks</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; Paint (colour, homogeneity, finishing)</td>
<td>&gt; Visual inspection</td>
<td>✔</td>
</tr>
<tr>
<td>&gt; No scratches and deformations</td>
<td></td>
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<tr>
<td><strong>Frame, structure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; Functioning of doors, swivelling front panels</td>
<td>&gt; Operating test</td>
<td>✔</td>
</tr>
<tr>
<td>&gt; Locks (type, functioning)</td>
<td>&gt; Specifications, visual inspection</td>
<td></td>
</tr>
<tr>
<td>&gt; IP degree of protection</td>
<td>&gt; Visual Inspection, technical guide</td>
<td></td>
</tr>
<tr>
<td><strong>Switchgear</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; Position</td>
<td>&gt; Visual inspection</td>
<td>✔</td>
</tr>
<tr>
<td>&gt; Fastening</td>
<td>&gt; Visual inspection</td>
<td></td>
</tr>
<tr>
<td>&gt; Characteristics: nominal range, breaking capacity</td>
<td>&gt; Specifications, visual inspection</td>
<td></td>
</tr>
<tr>
<td>&gt; Identification and marking</td>
<td>&gt; Technical guide</td>
<td></td>
</tr>
<tr>
<td>&gt; Safety perimeter</td>
<td>&gt; Operating test</td>
<td></td>
</tr>
<tr>
<td>&gt; Mechanical operation</td>
<td>&gt; Operating test</td>
<td></td>
</tr>
<tr>
<td>&gt; Mechanical indication (test position, connected, etc.)</td>
<td>&gt; Operating test</td>
<td></td>
</tr>
<tr>
<td>&gt; Plugging-in and withdrawing procedure</td>
<td>&gt; Visual inspection</td>
<td></td>
</tr>
<tr>
<td>&gt; Striker pin</td>
<td>&gt; Visual inspection</td>
<td></td>
</tr>
<tr>
<td>&gt; Accessibility of switchgear</td>
<td>&gt; Visual inspection</td>
<td></td>
</tr>
<tr>
<td>&gt; Ability to connect on terminals or pads</td>
<td>&gt; Visual inspection</td>
<td></td>
</tr>
<tr>
<td>&gt; Accessibility for connection</td>
<td>&gt; Visual inspection</td>
<td></td>
</tr>
<tr>
<td>&gt; Locking, foolproofing</td>
<td>&gt; Visual inspection</td>
<td></td>
</tr>
<tr>
<td><strong>Busbars</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; Busbar cross-section</td>
<td>&gt; Technical guide</td>
<td>✔</td>
</tr>
<tr>
<td>&gt; Coating and internal arc device</td>
<td>&gt; Customer drawings and specifications file</td>
<td></td>
</tr>
<tr>
<td>&gt; Busbar support (fastening device and number)</td>
<td>&gt; Technical guide</td>
<td></td>
</tr>
<tr>
<td>&gt; Marking</td>
<td>&gt; Customer drawings and specifications file</td>
<td></td>
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<tr>
<td>&gt; Compliance of joint blocks</td>
<td>&gt; Technical guide</td>
<td></td>
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<tr>
<td><strong>Cables &amp; flexible bars</strong></td>
<td></td>
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<tr>
<td>&gt; Cross-section and characteristics of conductors</td>
<td>&gt; Technical guide</td>
<td>✔</td>
</tr>
<tr>
<td>&gt; Compliance of installation mode (fastening, sharp edges, etc.)</td>
<td>&gt; Technical guide</td>
<td></td>
</tr>
<tr>
<td>&gt; Auxiliary Power separation</td>
<td>&gt; Assembly and installation guide and communication guide</td>
<td></td>
</tr>
<tr>
<td>&gt; EMC protection</td>
<td>&gt; Assembly and installation guide and communication guide</td>
<td></td>
</tr>
<tr>
<td><strong>Connection</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; Compliance and quality of bolted connections (e.g. covering and fastener type)</td>
<td>&gt; Technical guide</td>
<td>✔</td>
</tr>
<tr>
<td>&gt; Torque and marking</td>
<td></td>
<td></td>
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<tr>
<td>&gt; Crimping quality</td>
<td></td>
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<tr>
<td><strong>Protection of persons</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; Earth bar (cross-section and fastening)</td>
<td>&gt; Technical guide and assembly technical guide</td>
<td>✔</td>
</tr>
<tr>
<td>&gt; Earthing braids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; Forms</td>
<td></td>
<td></td>
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<tr>
<td>&gt; Bonding continuity</td>
<td></td>
<td></td>
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<tr>
<td>&gt; IP of measuring devices (fastened on doors)</td>
<td></td>
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<tr>
<td>&gt; Blanking shutters</td>
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<tr>
<td>&gt; Terminal guards and covers</td>
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<tr>
<td>&gt; Fastening of protective barriers</td>
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<tr>
<td><strong>Safety distances</strong></td>
<td></td>
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</tr>
<tr>
<td>&gt; Clearance</td>
<td>&gt; Assembly and installation guide and visual inspection</td>
<td>✔</td>
</tr>
<tr>
<td>&gt; Creepage distances</td>
<td>&gt; Installation and assembly guide</td>
<td></td>
</tr>
<tr>
<td><strong>Dielectric check (power circuit)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; Insulation tester</td>
<td>✔</td>
</tr>
</tbody>
</table>
### Control points

<table>
<thead>
<tr>
<th>Control points</th>
<th>Control resources</th>
<th>Final control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insulation check (power circuit)</strong></td>
<td>&gt; Megohmmeter</td>
<td></td>
</tr>
<tr>
<td><strong>Electrical compliance</strong></td>
<td>&gt; Phasing test</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; Electric tests, voltmeter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; Electric tests, voltmeter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; Test consoles, injection test bench, etc.</td>
<td></td>
</tr>
</tbody>
</table>

### Functional tests:
- Operating sequence (controls and signalling)
- Checking of source transfer
- Electrical and mechanical inter-locking
- Checking of opening/closing orders of units
- Trip tests (defects)
- Information report (OF-SDE-SD)
- Signalling (indicator lights, etc.)
- Injection on protection and measurements (values, etc.)

### Measurement and protection:
- Protection tests (fault tripping, etc.)
- Injection on measuring devices (Pa, PWH, etc.)
- CT winding direction

### Automation and communication:
- Equipment addressing
- Network tests (read/write)
- Verification of PLC inputs/outputs
- Validation of the PLC (according to functional specifications)

### Cleaning and preparation of columns
- Functioning of doors, swivelling front panels
- Locks (type, functioning)
- IP degree of protection

### Documentation related to switchboard
- Switchboard building drawings
- Installation and maintenance documents
- Switchgear guides
- List of shortages

### Packaging
- Compliance of the package Packing list
- Compliance of packaging Packing list

### Objectives
- Avoid having to repeat the process from the beginning
- Meet the customer's specifications to the letter
- Provide a product of high quality, without defect, from the design phase to delivery
# Routine verification - Testing report

**Customer:**

**Project:**

**Switchboard identification:**

**Equipment:**

**Quantity:**

**Drawing No:**

## Checking program

Routine verification checks are carried out in compliance with the Std. IEC 61439-2

### 1. Construction

| a. degree of protection of enclosures | V |
| b. clearances and creepage distances | V |
| c. protection against electric shock and integrity of protective circuits | V & T |

If electrical control indicate meter reference Ohm Value

| d. incorporation of built-in components | V |
| e. internal electrical circuits and connections | V & T |
| f. terminals for external conductors | V |
| g. mechanical operation | T |

### 2. Performance

| a. dielectric properties | T |

---

**Circuits**

<table>
<thead>
<tr>
<th>Circuit</th>
<th>Main circuits</th>
<th>Auxiliaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated insulation voltage (U_i)</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Dielectric check voltage</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

Option: up to 250 A, dielectric check can be replaced by insulating checks under 500 V:

<table>
<thead>
<tr>
<th>Circuit</th>
<th>Main circuits</th>
<th>Auxiliaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation value</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| b. wiring, operational performance and function | T |

---

**Comments:**

Having passed the above checks, the LV switchgear assembly under consideration is in compliance with the Std. IEC 61439-2 (IEC/EN 61439-2).

---

**Customer representative**

**Quality inspector**

**Quality manager**

**Date**

**Visa**
Appendices

IP and IK degree of protection

Foreword

Standards

IEC 60529 and IEC 62262

1. Enclosures must protect equipment against environmental risks and persons against accidental contact with a powered equipment part.

2. The characteristics of the room in which the switchboard will be installed make it possible to:
   - define an IK degree of protection,
   - define an IP degree of protection,
   - choose an appropriate switchboard type (kit, switchboard for critical applications, universal enclosure, etc.).

Example

Refer to the technical data of each type of table.

IK degree of protection

Standards

IEC 62262

1. International standard IEC 62262 defines an IK protection code as the ability of enclosures to resist external mechanical impacts on their entire surface.
Appendices

IP and IK degree of protection

IP degree of protection

IEC 60529

The IP code is made up of two characteristic digits:
- the first digit characterizes the protection of persons and equipment against the ingress of foreign solid bodies,
- the second digit characterizes protection against the ingress of water with harmful effects.

To improve the effective protection of persons against access to hazardous parts, the IP code may be completed by an additional letter. This letter defines a higher protection than the one specified by the first digit of the IP code.

The IP code must always be read and understood digit by digit and not as a whole.

<table>
<thead>
<tr>
<th>1st digit</th>
<th>Protection of persons</th>
<th>Protection against the penetration of solid particles</th>
<th>2nd digit</th>
<th>Protection against liquid bodies</th>
<th>Additional letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No protection</td>
<td>No protection</td>
<td>0</td>
<td>No protection</td>
<td>A</td>
</tr>
<tr>
<td>1</td>
<td>≤50 mm</td>
<td>≤50 mm</td>
<td>1</td>
<td>Protected against solid bodies larger than 50 mm</td>
<td>B</td>
</tr>
<tr>
<td>2</td>
<td>≤12 mm</td>
<td>≤12.5 mm</td>
<td>2</td>
<td>Protected against solid bodies larger than 12.5 mm</td>
<td>C</td>
</tr>
<tr>
<td>3</td>
<td>≤2.5 mm</td>
<td>≤2.5 mm</td>
<td>3</td>
<td>Protected against rainwater falling at an angle up to 60° from the vertical position</td>
<td>D</td>
</tr>
<tr>
<td>4</td>
<td>≤1 mm</td>
<td>≤1 mm</td>
<td>4</td>
<td>Protected against water projections from all directions</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>≤1 mm</td>
<td>Protection against dust (no harmful deposit)</td>
<td>5</td>
<td>Protected against water projected from all directions by a nozzle</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>≤1 mm</td>
<td>Fully protected against dust</td>
<td>6</td>
<td>Protected against water projections comparable to heavy sea</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>7</td>
<td>Protected against the effects of temporary immersion</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>8</td>
<td>Protected against the effects of continuous immersion</td>
<td></td>
</tr>
</tbody>
</table>

When only personnel protection is worth mentioning, the two characteristic digits of the IP code are replaced by the letter X (example, IPXXB).

Over and above existing rules, standards and recommendations, Schneider Electric recommends the use of IP/IK switchboards based on the French guide UTE C15-103 depending on applications (see the product catalogue).
# Appendices

## Bill of material

<table>
<thead>
<tr>
<th>Description</th>
<th>Reference</th>
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</thead>
<tbody>
<tr>
<td>I/O application module</td>
<td>LV434063</td>
</tr>
<tr>
<td>IFE Ethernet interface for LV breaker</td>
<td>LV434010</td>
</tr>
<tr>
<td>24 Vdc Power supply Class B product</td>
<td>ABL7RM24025</td>
</tr>
<tr>
<td>Com’X 200: Energy server</td>
<td>EBX200</td>
</tr>
<tr>
<td>Switchboard front display module FDM128</td>
<td>LV434128</td>
</tr>
<tr>
<td>IFM Modbus-SL interface module Stacker</td>
<td>TRV00210, TRV00217</td>
</tr>
<tr>
<td>IEM3150</td>
<td>A9MEM3150</td>
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<table>
<thead>
<tr>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communicating device with BCM (Breaker Control Module)</td>
<td>LV434205</td>
</tr>
<tr>
<td>IPE Internal terminal block</td>
<td>33106</td>
</tr>
<tr>
<td>ULP cord, shielded cable L = 0.35 m</td>
<td>LV434195</td>
</tr>
<tr>
<td>L = 1.3 m</td>
<td>LV434196</td>
</tr>
<tr>
<td>L = 3 m</td>
<td>LV434197</td>
</tr>
<tr>
<td>Ethernet cable RJ45:</td>
<td>VDIP184546010</td>
</tr>
<tr>
<td>10-100 mb</td>
<td>VDIP184546005</td>
</tr>
<tr>
<td>Lenght 100 m max</td>
<td></td>
</tr>
<tr>
<td>Cable RJ45, Category 6 SFTP, recommended</td>
<td></td>
</tr>
<tr>
<td>Modbus cable:</td>
<td></td>
</tr>
<tr>
<td>shielded twisted pair</td>
<td></td>
</tr>
<tr>
<td>RS485 standard + Power Supply</td>
<td></td>
</tr>
<tr>
<td>a roll of cable RS485, 4 wires (2 x RS485 + 2 power supply) with a length of 60 m</td>
<td>50965</td>
</tr>
<tr>
<td>10 ULP line terminators</td>
<td>TRV00880</td>
</tr>
<tr>
<td>ULP cable, shielded cable L = 0.3 m</td>
<td>TRV00803</td>
</tr>
<tr>
<td>L = 0.6 m</td>
<td>TRV00806</td>
</tr>
<tr>
<td>L = 1 m</td>
<td>TRV00810</td>
</tr>
<tr>
<td>L = 2 m</td>
<td>TRV00820</td>
</tr>
<tr>
<td>L = 3 m</td>
<td>TRV00830</td>
</tr>
<tr>
<td>L = 5 m</td>
<td>TRV00850</td>
</tr>
<tr>
<td>5 RJ45 connectors female/female</td>
<td>TRV00870</td>
</tr>
<tr>
<td>Communicating device with BSCM (Breaker Status &amp; Control Module)</td>
<td>LV434205</td>
</tr>
<tr>
<td>NSX cord shielded cable L = 0.35 m</td>
<td>LV434200</td>
</tr>
<tr>
<td>L = 1.3 m</td>
<td>LV434201</td>
</tr>
<tr>
<td>L = 3 m</td>
<td>LV434202</td>
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</tbody>
</table>
## Reference Documents

The table below outlines referenced documents that can be used as a resource to gather more details when needed.

<table>
<thead>
<tr>
<th>Document title</th>
<th>Reference</th>
<th>Date</th>
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<tbody>
<tr>
<td>Enerlin’X catalogue</td>
<td>LVCATENLX_EN</td>
<td>04/2014</td>
</tr>
<tr>
<td>IFE - Instruction sheet</td>
<td>HRB49218-</td>
<td>01/2014</td>
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<tr>
<td>IO module - Instruction sheet</td>
<td>HRB49217-</td>
<td>00/2014</td>
</tr>
<tr>
<td>FDM128 - Instruction sheet</td>
<td>HRB45777-</td>
<td>00/2014</td>
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<tr>
<td>Com’X 200 - Instruction sheet</td>
<td>253537642</td>
<td>2014</td>
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<tr>
<td>BCM ULP - Instruction sheet</td>
<td>5100512864A (B)</td>
<td>2014</td>
</tr>
<tr>
<td>IFM - Instruction sheet</td>
<td>GHD1632301-</td>
<td>05/2014</td>
</tr>
<tr>
<td>IFE - User Guide</td>
<td>DOCA0084EN-00</td>
<td>04/2014</td>
</tr>
<tr>
<td>IO module - User Guide</td>
<td>DOCA0055EN-00</td>
<td>04/2014</td>
</tr>
<tr>
<td>Com’X 200 - User Guide</td>
<td>DOCA0036EN-01</td>
<td>03/2014</td>
</tr>
<tr>
<td>Com’X 200 - Data acquisition design guide</td>
<td>DOCA0035EN-01</td>
<td>02/2014</td>
</tr>
<tr>
<td>FDM128 - Display for 8 LV Devices - User Guide</td>
<td>DOCA0037EN-01</td>
<td>04/2014</td>
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