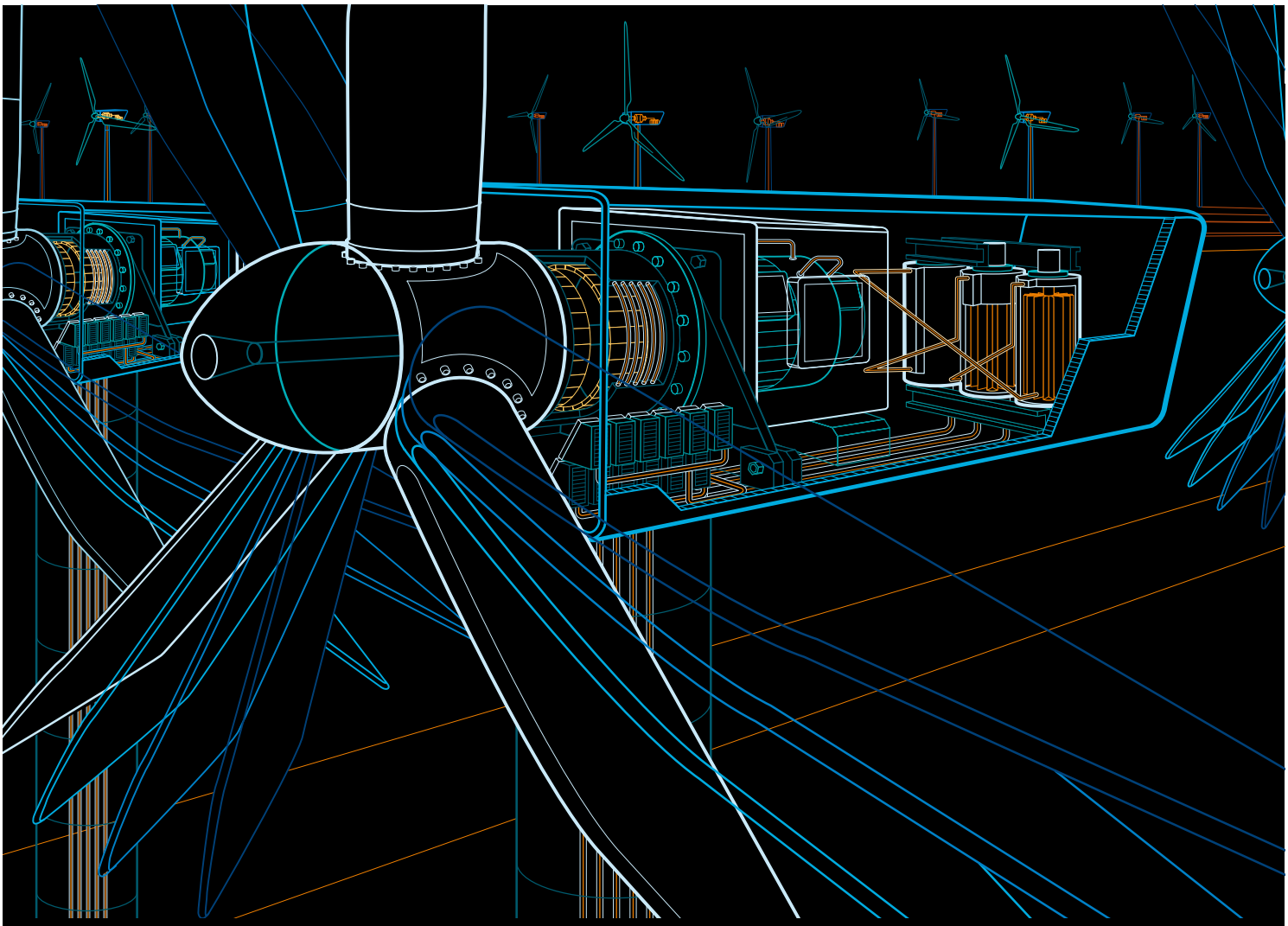
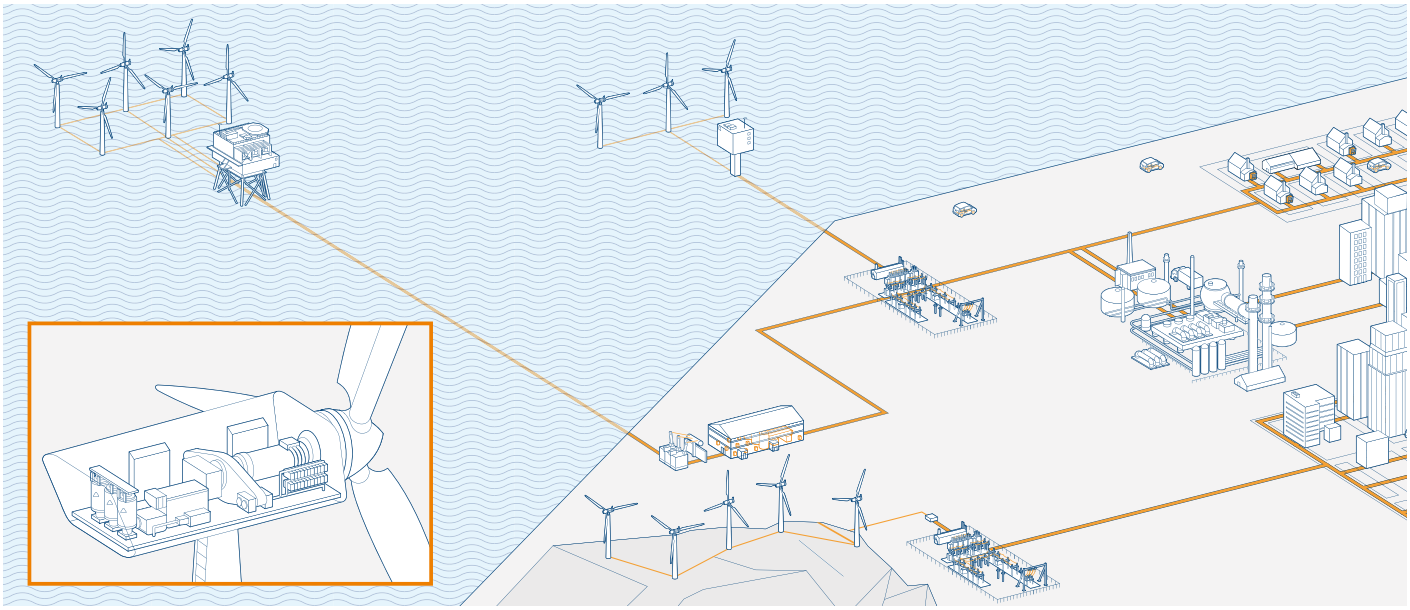


# Earthing, lightning and overvoltage protection
# Wind turbines

Power and productivity
for a better world™

# ABB a global leader in earthing, lightning and overvoltage protection

Based on the experience we have gained over the last decades, ABB provides state-of-the-art low-voltage surge protection devices (SPDs), medium and high-voltage surge arresters (SAs) and earthing and lightning protection (ELP) materials to protect against the impact of direct lightning and transient overvoltages caused by the secondary effects of lightning. Thanks to this wide product-range, ABB offers complete solutions for protection of wind-power installations.



### Earthing, lightning and overvoltage protection

With its wide product range, ABB can offer:

- Surge arresters for medium voltage (MV) networks such as the POLIM family and the MWK / MWD range
- Surge protection devices (SPDs) for low voltage (LV) systems with the OVR modular range, the Lovos-W and POLIM-R surge arresters
- Earthing components, designed to withstand mechanical damage and the thermal electromechanical stresses from the earth fault and leakage currents expected within an installation.

### Wind power

Wind turbines provide electrical power from a renewable energy source to the public power networks. Because of their height (over 100 meters) and exposed location wind turbines are prone to direct lightning flashes entering through the blades, the nacelle or the lines.

Transient overvoltages due to the lightning current can cause severe damage to the wind turbine installation and to the equipment. They can also create expensive downtime that can be avoided by installing a complete lightning protection system (LPS).

This LPS should include both external and internal lightning and overvoltage protection and should be designed, installed in compliance with IEC 62305, protection against lightning and with the IEC 61400-24 for wind turbines.

The risks associated with lightning can be assessed in a global risk analysis, according to IEC 62305-2 and IEC 61400-24. The risk analysis will define a lightning protection level (LPL), and will propose the right protection measures to be applied.

# Earthing, lightning and overvoltage protection
# Wind turbines

## Products for MV (medium voltage) and LV (low voltage) applications

### MWK / MWD and POLIM-C
MV surge arresters with a particular high mechanical and electrical strength. Suitable for protecting medium voltage AC networks against both, lightning and switching overvoltages, as well as Very Fast Transients (VFT). Designed for the protection of transformers, cables, wind generators. For indoor and outdoor application.

### POLIM-R
LV surge arresters with very high electrical energy handling capability. Suitable for application in AC and DC systems against both, lightning and switching overvoltages as well as Very Fast Transients (VFT). Designed for the protection of converters. For indoor installation only.

### Lovos-W
A new generation of LV surge arresters developed in cooperation with customers world wide. They ensure the surge protection of wind turbines from the direct effect of lightning and transient overvoltages. The Lovos-W is having a dry contact designed for wind turbines. This remote indication is to identify the status of the surge arrester and its location in the installation.

### OVR WT SPDs
A dedicated surge protection device is needed to protect wind turbines generators and converters.
The OVR WT SPDs can withstand the high pulse with modulation (PWM) peak transient overvoltages generated by the converters for a long and safe surge protection (Urp characteristics).

### OVR Type 1 SPDs
Wind turbines exposed to lightning surges shall be protected with Type 1 and Type 1+2 surge protection devices (SPDs). With a high impulse current discharge capacity (Iimp), they are located at the service entrance of the LV side of the wind installation to avoid the destruction of the equipment.

### OVR Type 2 SPDs
Most of the equipment sustain repetitive transient surges. Generated by indirect lightning strikes or by industrial environment, these transient overvoltages deteriorate and drastically reduce the lifespan of sensitive and costly equipment used in the turbines electrical network.

### OVR Plus autoprotected
All surge protection devices shall be installed with a dedicated backup disconnector in case of end of life of the device. The OVR Plus Type 2 range with its integrated MCB disconnector increase safety to the equipment of the LV side of the turbines.

### OVR TC dataline protection
To prevent data losses and to bring a complete surge protection of data, signals and telecom lines, dataline surge protection devices should be installed. The OVR TC brings an easyway to protect those lines with RJ11 and RJ45 base elements.

### Furse Earthing
A lightning protection system (LPS) forms part of a wind turbine installation. The earthing and the good interconnection of the LPS to the earthing system is a must to safely dissipate the lightning current.

# Earthing, lightning and overvoltage protection
# Wind turbines

## Dedicated surge and lightning protection devices for a specific application

### Different types of drive train

In wind turbines configuration, two main types of drive train are usually used: variable speed Doubly-fed or full converter version.

### Doubly-fed drive train

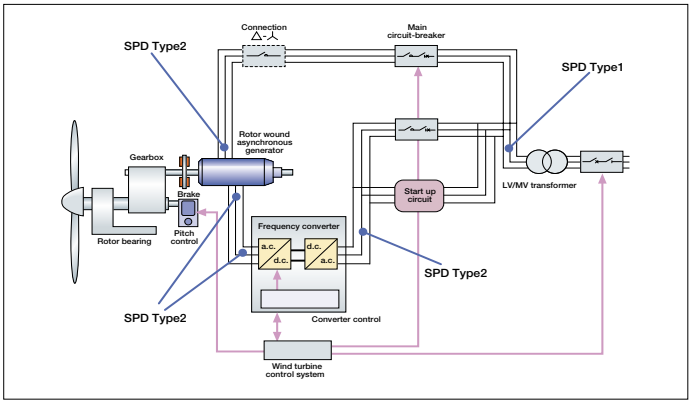



**Figure 1**

In a variable speed doubly-fed configuration, according to the diagram of Figure 1, it is advisable to place an SPD Type I into the main switchboard at the entrance of the turbine for the protection against transient overvoltages of atmospheric origin and against the surge current from the grid. If the SPD Type I does not have an effective protection level (Up) lower than the maximum withstand voltage (Uw) of the equipment to be protected or the distance from the equipment to be protected is longer than 10 m, it is recommended to install an SPD Type II near the generator for the additional protection of the stator windings and another one near the converter on the grid side for a better protection.
It is also recommended to install, between the converter and the rotor windings, SPDs Type II suitable for protection in the presence of transient overvoltages superimposed on the PWM (pulse with modulation) control voltage (Figure 3).

### Full converter drive train

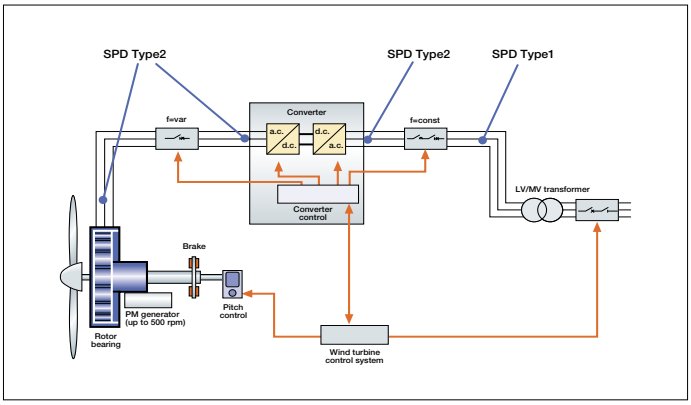



**Figure 2**

In this configuration, according to the diagram Figure 2, it is recommended to place an SPD Type I into the main switchboard at the entrance of the turbine for the protection against transient overvoltages of atmospheric origin and against the surge current from the network. If the SPD Type I does not have an effective protection level (Up) lower than the maximum withstand voltage of the devices to be protected (Uw) or the distance from the devices to be protected is longer than 10m, it is recommended to install an SPD Type II near the converter on the grid side for a better protection.
It is also recommended to install between the converter and the synchronous generator, SPDs Type II suitable for protection in the presence of transient overvoltages superimposed on the PWM (pulse with modulation) control voltage (Figure 3).

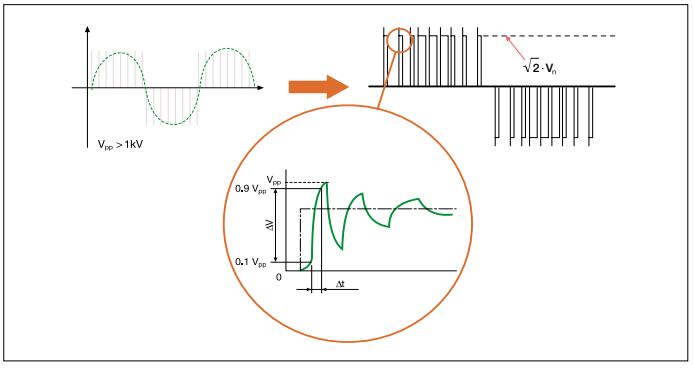



**Figure 3**

### Pulse with modulation (PWM)

Actual variable-speed wind turbines are equipped with PWM (Pulse With Modulation) controlled inverters using IGBT or IGCT in order to regulate their output voltage and frequency. These technologies, if not filtered properly, generate peak transient overvoltages surperimposed on the PWM control voltage. These peaks, of several kV, will be seen by a standard SPDs as transient overvoltages due to lightning, creating unwanted triggering of the surge arresters with a high frequency and therefore reducing considerably their life time. That's why it is necessary to use SPDs with a specific withstand to these PWM, the peak repetitive voltage withstand characteristics (Urp).

## Lightning protection zones concept (LPZs)

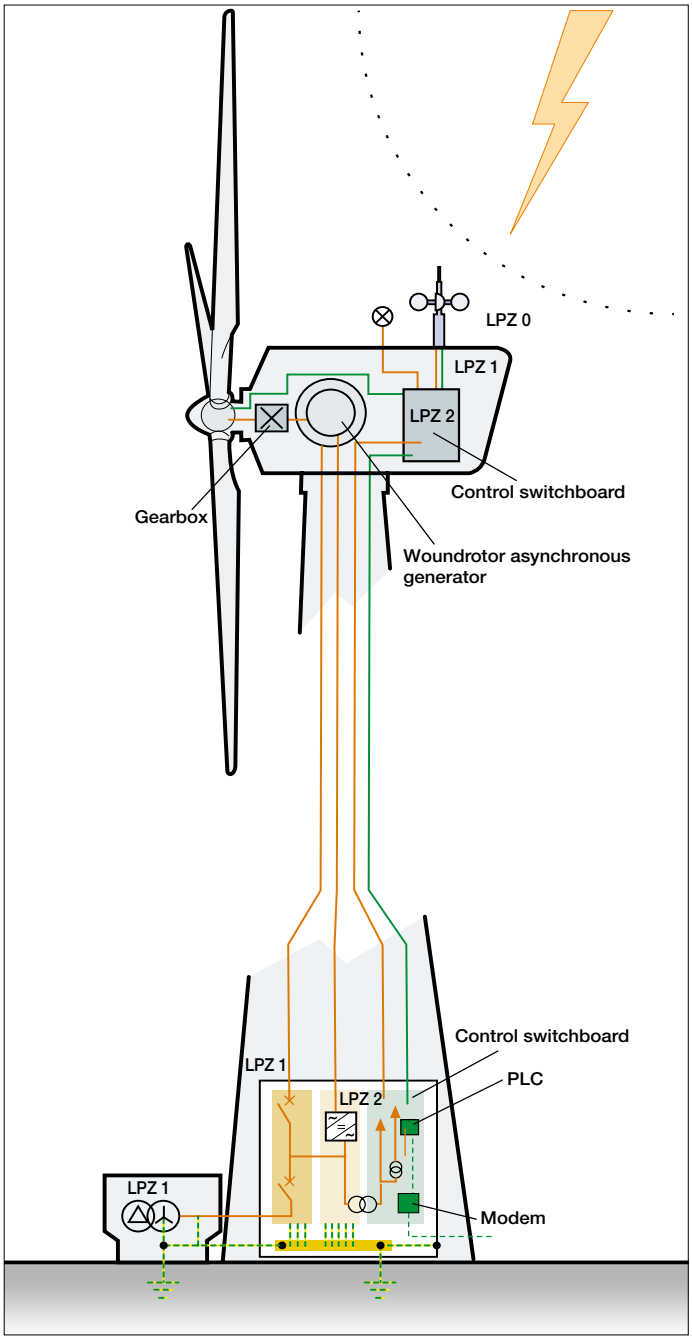
The IEC standard introduced the concept of lightning protection zones (LPZs) to help in selecting the correct surge protection to the right location (IEC 62305-4). This concept ensure the gradual reduction by stages of the energies and surge current caused by direct lightning or transient overvoltages caused by lightning. This logic of coordination in the protection is what we call the “stepping protection”.
It consists in dividing a structure in several volumes: the protection zones. The objective is to ensure that the LPZ gives enough protection to the equipment inside a define zone, which means that the protection level (Up) of the installed SPD is in relation with the maximum voltage withstand (Uw) of the equipment. To do so, SPDs are installed at the protection zone boundaries. Each time an SPD is installed, a new protection zone is created.

## Furse earthing

An effective earthing system is a fundamental requirement of any structure or system for operational and/or safety reasons. Without such a system, the safety of a structure and the equipment contained within it are compromised.

## Earth Termination

The earth termination network connects the LPS down conductor network to the base of the structure and provides the means through which lightning current is dissipated to the general mass of earth.
Earthing components must have both a low resistance to earth and have excellent corrosion resistance, as they will be buried in the ground for many years.
The range of Furse earthing products including earth rods, conductors, clamps and inspection pits, are all designed and manufactured in line with the IEC and BS EN standards, to ensure they meet the demands of earth termination systems. Additionally many earthing system conductors and steel rebar are connected by the use of exothermic welded joints creating a connection of virtually pure copper, with a greater cross sectional area of the conductors being welded and therefore high quality, corrosive resistant joints.




**Doubly-fed drive train turbine example**

| External zones | |
|---|---|
| **LPZ 0** | Exposed area to lightning flash and which can be subjected to full or partial lightning current. This zone is divided in two: LPZ0A and LPZ0B |
| **LPZ $0_A$** | Unprotected zone outside the building where items are subjected to direct lightning flash and therefore may have to handle to the full lightning current and lightning electromagnetic field. |
| **LPZ $0_B$** | Zone protected against direct lightning flash by external air terminal and where the threat is the full lightning electromagnetic field. |

| Internal zones (zones inside the building which are protected against direct lightning flashes) | |
|---|---|
| **LPZ 1** | Zone subject to partial lightning or surge currents. Type I SPDs shall be installed at the boundary between LPZ OA and LPZ 1 to block the entrance of lightning currents through power lines (i.e. main distribution board of an installation). |
| **LPZ 2...n** | Zone where the surge current is limited by current sharing and where the surge energy is reduced by additional surge protection like SPDs. Type 2 SPDs are installed at the boundaries of each zone, i.e. LPZ 1 and LPZ 2, LPZ 2 and LPZ 3, etc..., to divert the remaining surge currents and limit overvoltage (i.e. sub-distribution boards of an installation). |

# Earthing, lightning and overvoltage protection
# Wind turbines: example of protection

## Lightning and overvoltage protection of full converter drive train turbine


Example on a full converter drive train turbine with power converter installed at the tower base and the LV/MV transformer outside the turbine

1 2 SPD OVR WT for generator protection in nacelle and converter on the generator side in the tower base

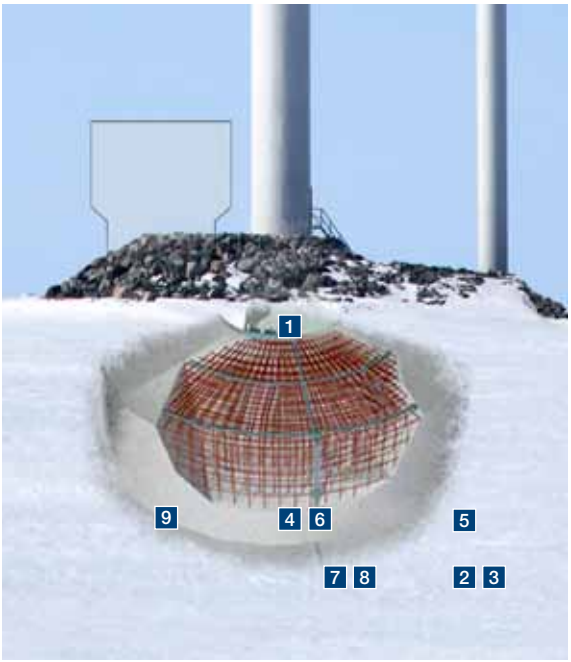
2 Polim-R surge arresters for converter protection on the grid side in the tower base

3 Lovos-W for protection of the LV side of the transformer

3 MWD surge arresters for protection of the MV side of the transformer and grid lines

4 5 6 7 SPD Type 2 & dataline for protection of pitch, yaw and control systems

## Earthing of wind turbines




1 LK245-6

2 CB070

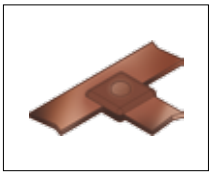
3 TC030/50

4 CR705

5 RB305 + CG370 + ST300

6 PC116

7 CC2-4-7070



8 BB14-4-253253

9 CM025

# Complete ABB offer for wind turbines

## Technical data

| | System voltage | Class of protection | Impulse current $I_{imp}$ 10/350 - kA | Max. discharge current $I_{max}$ 8/20 - kA | Nominal current $I_n$ - kA | Type |
|---|---|---|---|---|---|---|
| **Generator** | | | | | | |
| Full Converter, Stator | up to 1000 V | I+II | 2 | 40 | 20 | **OVR WT 3L 690 P TS** |
| Doubly Fed, Stator | 690 V | I+II | 5 | - | 20 | **POLIM-R...1** |
| | | I+II | 2.5 | 100 | 5 | **LOVOS-W 40** |
| | | II | - | 40 | 20 | **OVR T2 40 660 P TS U** |
| Doubly Fed, Rotor | 690 V | I+II | 2 | 40 | 20 | **OVR WT 3L 690 P TS** |
| **Converter** | | | | | | |
| Generator side | up to 1000 V | I+II | 2 | 40 | 20 | **OVR WT 3L 690 P TS** |
| Grid side | 690 V | I+II | 5 | - | 20 | **POLIM-R...1** |
| | | I+II | 2.5 | 100 | 5 | **LOVOS-W 40** |
| | | II | - | 40 | 20 | **OVR T2 40 660 P TS U** |
| **Main power panel** | | | | | | |
| LV Side | 690 V | I | 25 | - | 25 | **OVR T1 25 440-50** |
| | | I+II | 15 | - | 20 | **POLIM-R...2** |
| | | I+II | 5 | 140 | 5 | **LOVOS-W 60** |
| | | II | - | 40 | 20 | **OVR T2 40 660 P TS U** |
| **Transformer** | | | | | | |
| MV Side outdoor | up to 44 kV | LD2 | - | - | 10 | **MWK** |
| MV Side outdoor | up to 7.5 kV | LD2 | - | - | 10 | **POLIM-C N** |
| MV Side indoor | up to 44 kV | LD2 | - | - | 10 | **MWD** |
| LV Side indoor / outdoor | 690 V | I+II | 15 | - | 20 | **POLIM-R...2** |
| | | I+II | 5 | 140 | 5 | **LOVOS-W 60** |
| **Pitch, Yaw & other auxiliary systems** | | | | | | |
| Power circuit | 690 V | II | - | 40 | 20 | **OVR T2 40 660 P TS U** |
| | 400 V | II | - | 40 | 20 | **OVR T2 40 440 P TS U** |
| Command circuit | 230/400 V | II | - | 40 | 20 | **OVR T2 40 320 P TS U** |
| | 48 V | II | - | 40 | 20 | **OVR T2 40 75 P TS U** |
| Data Circuit | 12, 24 V, 48 V | C2 | - | 10 | | **OVR TC xx V P** |
| **Control System** | | | | | | |
| Command circuit | 230/400 V | II | - | 40 | 20 | **OVR T2 40 320 P TS U** |
| | 48 V | II | - | 40 | 20 | **OVR T2 40 75 P TS U** |
| Data Circuit | 12, 24 V, 48 V | C2 | - | 10 | 5 | **OVR TC xx V P** |
| Communication | | C2 | - | 10 | 5 | **OVR TC xx V P** |

## Technical data

| | Dimension | Weight (Kg) | Description | Type |
|---|---|---|---|---|
| Earth bar | 400 mm x 90 mm x 90 mm | 1.8 | 6 way earth bar mounted on base | **LK245-6** |
| Conductors | 70 mm² cross section | 0.62 per meter | 70 mm sq stranded bare copper cable | **CB070** |
| Conductors | 50 m | 0.67 per meter | 25 mm x 3 mm bare copper tape supplied in 50 mtr coils | **TC030/50** |
| Earth rods clamp | / | 0.39 | Rod to cable clamp 16-20 mm dia to 70 mm sq cable | **CR705** |
| Earth rods | 1200 mm length | 2.44 | 3/4" UNC x 1200 mm lg copperbond earth c/w coupling & driving stud | **RB305 + CG370 + ST300** |
| Earth points | 500 mm | 0.84 | Earth point with pre-welded tail for connection to steel rebar | **PC116** |
| Conductive agregate | / | 20 | FurseCEM conductive agregate | **CM025** |
| Cable to reinforcing bar | / | / | Furseweld exothermic to connect 70 mm sq cable to steel rebar | **CRE3-3-70** |
| Cable to cable | / | / | Furseweld exothermic to connect 70 mm sq cable to cable | **CC2-4-7070** |
| Tape to tape | / | / | Furseweld exothermic to connect 25 x 3 copper tape to copper tape | **BB14-4-253253** |

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www.abb.com/highvoltage

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