

## RECTIFIER FUNCTIONAL UNIT

MONT-ELE Power Conversion Division can design, assemble, test and supply rectifier functional units for traction systems implementing a wide array of solutions and in full compliance with EN50327/EN50328 and with EN50329.

- **Main output DC voltage values: 600 Vdc, 750 Vdc, 1500 Vdc, 3000 Vdc.** Other values are available on demand.
- **Main output power values: 600 kW, 700 kW, 1MW, 2MW, 4MW, 6MW, 10MW.** Other values are available on demand.
- **Main reaction types: 6 pulses, 12 pulses, 24 pulses.**
- **Main cooling types: Natural air, forced air, water.** Other cooling types available on demand.
- **Possible configurations: fixed rectifier, withdrawable rectifier, bolted withdrawable rectifier.**

All rectifiers can be non-controlled or totally controlled as needed.

### Non-controlled rectifier - Controlled rectifier comparison table

|  | Non-controlled rectifier | Controlled rectifier      |
|--|--------------------------|---------------------------|
| Semiconductor device   | Diode                    | SCR – Thyristor           |
| Direct voltage regulation Vdc  | No                       | Yes                       |
| Short-circuit current limitation   | No                       | Yes                       |
| Dimensions (for 3000 kW unit)  | 2800 x 1200 x 2300 mm    | 3400 x 1200 x 2300 mm     |
| Purchasing cost  | k                        | Approximately 1.5 – 1.9 k |
| Total cost including technical-economic advantages in the service period | k                        | Approximately 0.5 k       |

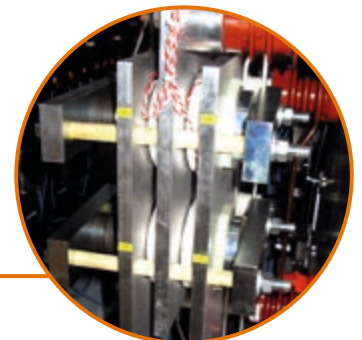
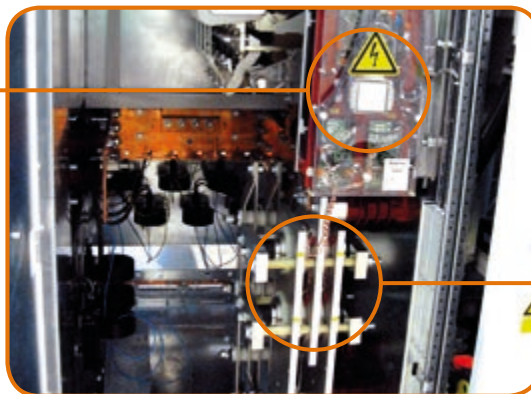
### Main advantages of controlled rectifiers with voltage regulation compared to traditional diode rectifiers

- To limit voltage drops caused by load variations.
- To increase the power that can be delivered by the conversion substations.
- To compensate the DC line voltage variations caused by voltage variations on the medium voltage power network.
- To keep voltage constant even in case of load variations.
- To control the fault current on faults far from the electrical substation and consequently to increase line protection settings.
- To limit short-circuit current on faults near the electric substation to reduce stress on extra-rapid switches and decrease respective maintenance.
- To improve the load distribution among all electrical substations of the traction line.
- To improve energy management flexibility to the power network.

## VOLTAGE LIMITING DEVICE FUNCTIONAL UNIT (VLD)



VLD CONTROL



STATIC SWITCH

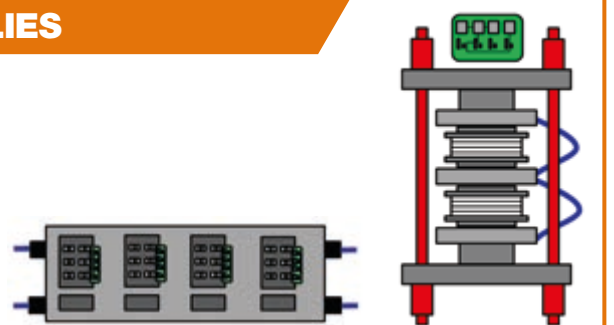
### MAIN FEATURES

|                           |                                  |
|---------------------------|----------------------------------|
| Rated voltage             | 1500 V<br>(from 600 V to 3000 V) |
| Making capacity           | 50 kA (200 ms)<br>(Up to 100 kA) |
| Breaking capacity         | 600 A                            |
| Trigger threshold voltage | Adjustable<br>starting from 50 V |
| Frequency                 | 50 / 60 Hz                       |

### POWER ASSEMBLIES

Design and supply of Power Assemblies including:

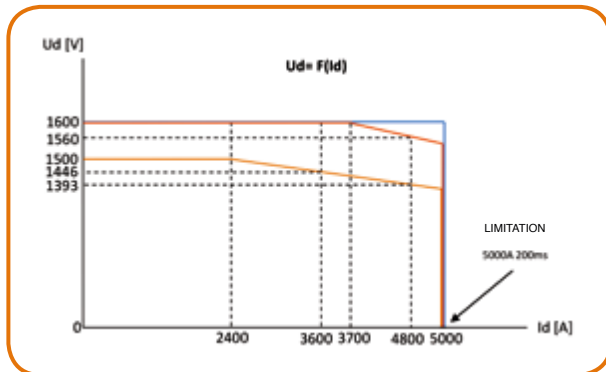
- Semiconductors
- Heat sinks
- Clamps
- Gate drive board



# RECTIFIER FUNCTIONAL UNIT

## RECTIFIER FUNCTIONAL UNIT - ATM METRO MILANO

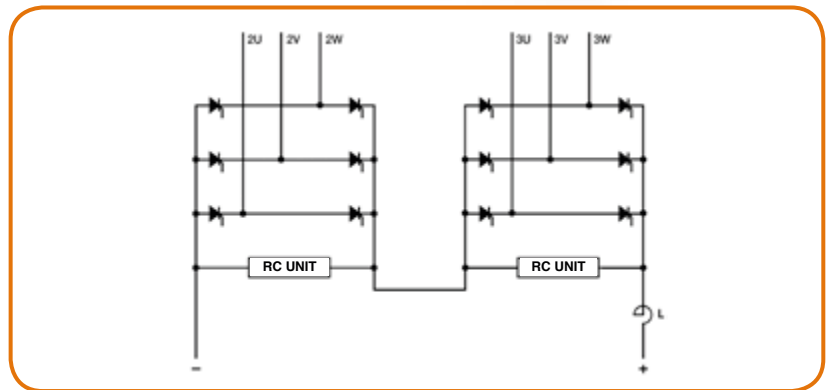
The MONT-ELE thyristor full controlled rectifier functional unit, developed for ATM METRO MILANO, has been designed, manufactured and tested to operate in railway traction systems having nominal voltage of 1600 Vdc. The rectifier allows the output voltage regulation to a value that can be set in the range from 1400 to 1700 Vdc. The maximum permitted medium voltage network variation is  $\pm 10\%$  and the rectifier itself guarantees the characteristic output voltage  $U_d$  versus load current  $I_d$  as shown in the below figure.



Regulation characteristics, rated network voltage 660Vac (red) - 660Vac +10% (blue) - 660Vac - 10% (orange)

Furthermore, the rectifier control system is able to limit the traction current in anomalous working conditions (e.g. short-circuit) to a value of 5000 A for 200 ms. This function allows:

- To offer a back up protection to the high speed circuit breaker in case they fail to open (HSCB);
- To limit the short circuit current and consequently increasing the HSCB contact life and decreasing maintenance costs.



## MAIN FEATURES

|   |   |
|---|---|
| Number of input phases                    | 6   |
| Input rated voltage (UNV)                 | 2 x 660 V ~   |
| Input rated frequency (fN)                | 50 Hz   |
| Number of output phases                   | DC  |
| Structure                                 | 2 (6 x 1 x 3)   |
| Rated voltage (UNd)                       | 1600 Vdc  |
| Voltage regulation range                  | from 1400 to 1700 Vdc   |
| Basic DC current (Ibd)                    | 2400 A  |
| Rated power (P)                           | 3840 kW (2 x 1920 kW)   |
| Load cycle                                | a) 1.0 x Ibd continuous<br>b) 1.5 x Ibd 2 hours - after a)<br>c) 2.0 x Ibd 1 min - after b) |
| Short-circuit withstand capability (INSS) | 18 kA   |
| Short-circuit current limitation function | 2000 ÷ 8000 A   |
| Industrial frequency test voltage         | 8,3 kV x 1 min  |
| Cooling type                              | AN / AF   |
| Type of connection                        | N. 12 (Table 4 - EN50328 standard)  |
| Degree of protection                      | IP31  |
| Reference standard                        | IEC 60146-1 / EN 50328  |

## REGULATION AND CONTROL BOARD



## CONTROL PANEL



## CONTROL BOARD



## VOLTAGE LIMITING DEVICE FUNCTIONAL UNIT (VLD)

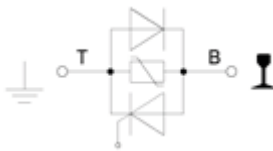
### VOLTAGE LIMITING DEVICE FUNCTIONAL UNIT – ITALIAN RAILWAY NETWORK

STATIC VOLTAGE LIMITING DEVICE FOR GROUND SYSTEMS AND RETURN CIRCUIT ON THE 3kVdc TRACTION SYSTEM

Compliant to RFI DPRIM STF IFS TE 111 Sper - Code 779/0070 technical specification. The voltage limiting device MEUVL3015ANF001 controls the track voltage (negative polarity) in DC traction systems according to the EN 50122-1 standard.

#### ELECTRICAL SPECIFICATIONS

|   |              |
|---|--------------|
| Rated voltage                             | 3600 Vdc     |
| Maximum voltage                           | 3900 Vdc     |
| Nominal current (diode/thyristor)         | 600 / 300 A  |
| Making capacity (10 s - diode/thyristor)  | 4 / 2.5 kA   |
| Making capacity (10 ms - diode/thyristor) | 35 / 24.5 kA |



It consists of four main devices:

- Power diode (Press-Pack technology)
- Power thyristor (SCR) (Press-Pack technology)
- Varistor (MOV technology) in Type 1 (Class 1), compliant with EN 61643-11
- Self-powered thyristor control board (GDB)

#### ASSEMBLY SPECIFICATIONS

|                               |  |
|-------------------------------|--|
| Construction type             | In stainless steel box                           |
| Accessibility                 | Through front door                               |
| Negative connection           | By cables from the bottom                        |
| Earth connection              | By cables from the bottom                        |
| Internal electric connections | Aluminium bar treated on surface with Surtec 650 |
| Insulation to earth           | -  |
| Length                        | 300 mm   |
| Depth                         | 249 mm   |
| Height                        | 438.5 mm   |
| Weight                        | 26 Kg  |

#### THERMAL AND MECHANICAL SPECIFICATIONS

|                                   |                                   |
|-----------------------------------|-----------------------------------|
| Installation type                 | External                          |
| Cooling type                      | Natural air (aluminium heat sink) |
| Maximum environmental temperature | +55°C                             |
| Minimum environmental temperature | -25 °C                            |
| IP degree of protection           | IP 32                             |

## FREQUENCY CONVERTER FUNCTIONAL UNIT

### FREQUENCY CONVERTER FUNCTIONAL UNIT - ATAC METRO ROMA

REDUNDANT 50/75 Hz 6kVA CONVERTER TO SUPPLY THE TRACK CIRCUITS ON THE ROME METRO LINES MA MB-B1

The converter provides frequency conversion from 50 Hz to 75 Hz, with a nominal power of 6 kVA. The input voltage is 400 Vac three-phase and the output is single-phase and adjustable in the 140-160 Vac range in 5 V steps. It is selectable by means of a selector. The converter consists of two inverters with complete redundancy and of an automatic and manual priority management switching circuit.

Breakers are inserted on the input and output of each inverter so that a branch can be replaced even with the converter running. Digital instruments are provided on the front panel to measure voltage, current and frequency. An analogue instrument is provided to measure the output line insulation to earth. The panel also fits a voltage selector and an inverter priority selector in addition to warning and alarm indications for the user.



The two converter branches are configured in hot redundancy mode and the following controls are implemented on each branch:

- Input voltage out of limit
- Output overvoltage
- Output overload
- Output short-circuit
- Excessive temperature
- IGBT control

#### INPUT ELECTRIC SPECIFICATIONS

|  |                |
|--|----------------|
| Rated input voltage                            | 400Vac         |
| Input voltage variation range                  | ±15%           |
| Input frequency                                | 50Hz           |
| Input frequency variation range                | ±6%            |
| Dielectric strength                            | 2000V 50Hz 60s |
| Insulation                                     | 1GΩ @1000Vdc   |
| Operation with no input voltage at rated power | 22ms           |

#### POWER AND OVERLOADS

|                       |       |
|-----------------------|-------|
| Rated power           | 6kVA  |
| Short time over loads |       |
| 10 minutes            | 7kVA  |
| 60s                   | 8kVA  |
| 100ms                 | 10kVA |

#### OUTPUT ELECTRIC SPECIFICATIONS

|   |                            |
|---|----------------------------|
| Rated output voltage                              | 150Vac                     |
| Selectable output voltages                        | 140, 145, 150, 155, 160Vac |
| Output voltage tolerance                          | 2.5%                       |
| Output frequency                                  | 75Hz                       |
| Output frequency variation tolerance              | ±0.01%                     |
| Dielectric strength                               | 2000V 50Hz 60s             |
| Insulation  | 1GΩ @1000Vdc               |
| Harmonic distortion                               | < 1%                       |
| Maximum fluctuation for resistive load variations |                            |
| from 10% to 90%                                   | ±10%                       |
| from 90% to 10%                                   | ±10%                       |

#### GENERAL SPECIFICATIONS

|                       |                     |
|-----------------------|---------------------|
| Operating temperature | 0° ÷ 45°C           |
| Dimensions            | 750 x 600 x 1750 mm |
| Weight                | 325kg               |
| Acoustic noise at 1m  | < 60dBA             |
| Efficiency            | 85%                 |

Converters with output frequency of 83.3 Hz may be provided in addition to converters with output frequency of 75 Hz. Other output frequencies are available on demand.

## ENERGY RECOVERY FUNCTIONAL UNIT

### BRAKING ENERGY RECOVERY INVERTER

The braking recovery system developed by the Power Conversion Division is used for the following traction line power voltage values:

**600 Vdc**

**750 Vdc**

**1500 Vdc**

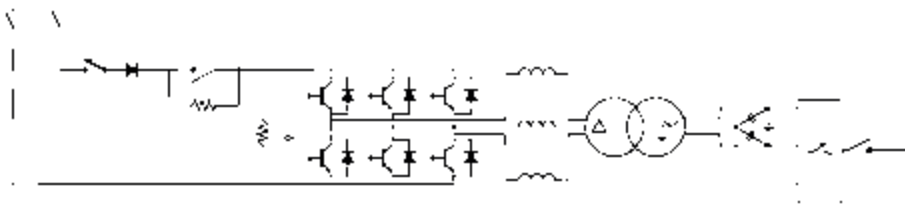
**3000 Vdc**

According to needs available powers are in the range from 500 kW to 2 MW peak.

#### ADVANTAGES

- The system is added to the existing structure. It is installed in parallel to the traction line power substation.
- The low number of conversion steps makes energy recovery very efficient.
- The reliability of the existing traction line power system is not influenced in any way.
- The system is designed to minimise maintenance operations.
- The system can also work as active harmonic filter or it can compensate the reactive power making the substation more efficient.
- A very rapid-acting current limitation system avoids supplementary short-circuit current on the catenary.
- The system can also power the catenary and it can be used as back-up during rush hours or in case of fault of the main traction power supply system.

### BRAKING ENERGY RECOVERY INVERTER CHARACTERISTICS FOR METRO APPLICATIONS

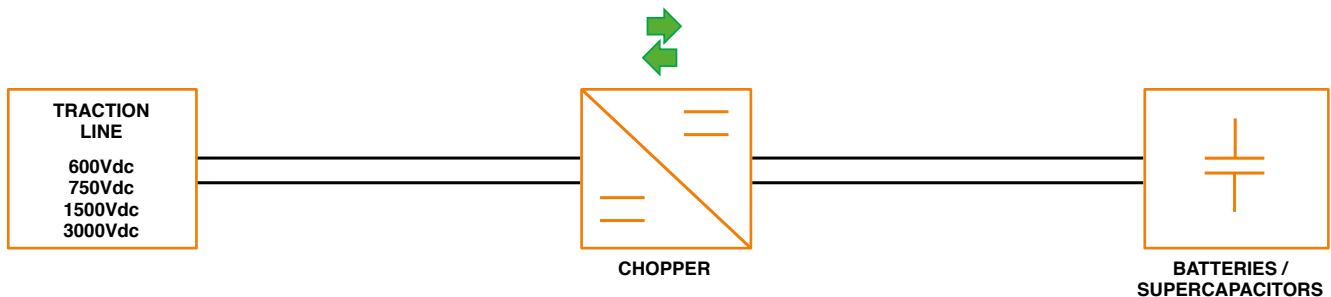


|   |                                  |
|---|----------------------------------|
| Metro network rated voltage                       | 750 Vdc                          |
| Inverter start-up voltage                         | 850 Vdc                          |
| Inverter output voltage upstream of transformer   | 595 Vac                          |
| Inverter output voltage downstream of transformer | 400 Vac                          |
| Rated output frequency                            | 50 Hz                            |
| Rated power                                       | 500 kVA<br>(overload at 700 kVA) |

## ENERGY STORAGE FUNCTIONAL UNIT

### CHOPPER FOR STORING RECOVERED ENERGY IN SUPERCAPACITORS OR BATTERIES BANK

The two-way chopper developed by Power Conversion Division allows the storage of the recovered braking energy from railway and metro trains through a DC/DC conversion in batteries or supercapacitor banks and the supply of this energy back to the traction line when required. The energy storage system is provided with a bidirectional chopper which regulates the voltage and the recharging current flow of the batteries and of the supercapacitor banks.

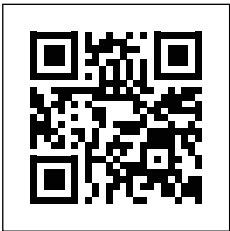


#### ADVANTAGES

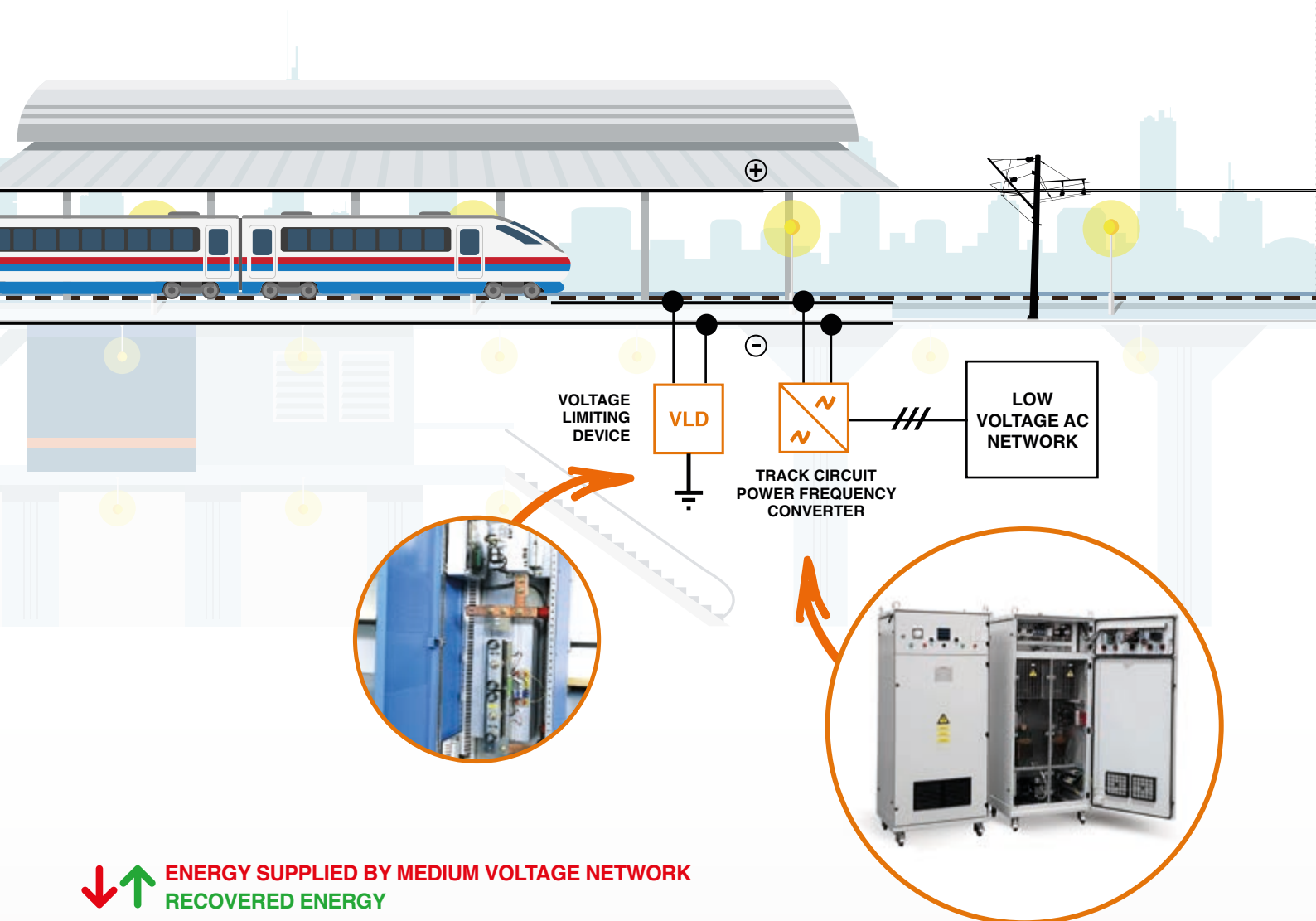
- The system is independent and can be positioned at any point of the line where energy recovery is optimal.
- The reliability of the existing traction line power system is not influenced in any way.
- The system is designed to minimise maintenance operations.
- The system can stabilise voltage in the critical points of the line to compensate voltage drops.
- The system is easy to implement. No special requirements or adjustments are needed because the system is not connected to the network.
- The system is cost saving making it possible to use a low peak power energy supply contract.

## Power Conversion Division Power Conversion Solutions

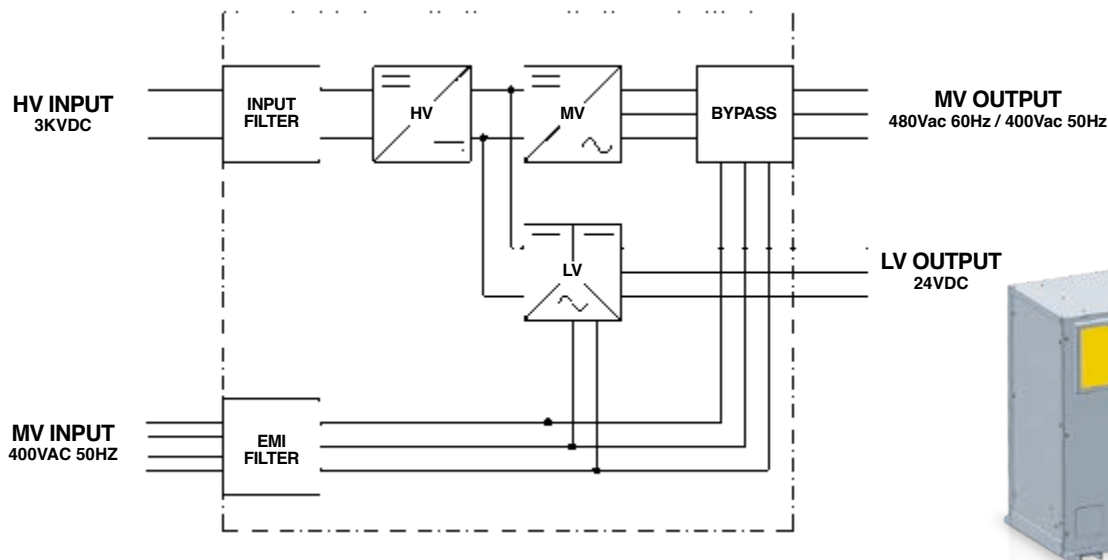
MONT-ELE Power Conversion Division can satisfy all transport, industry, energy and environment conversion needs meeting the most stringent quality, reliability and safety requirements in compliance with the international standards. Power Conversion Division is the new MONT-ELE branch specifically dedicated to providing comprehensive answers to customer needs in the field of power electronics. This new division, established in 2017, capitalises the consolidated experience of its power electronics and semiconductor engineers. State-of-the-art design and simulation software packages (CAD 3D, circuit simulators, calculation tools etc.) are used to provide the right solution for the customers in terms of quality and competitive pricing.



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# ROLLING STOCK AUXILIARY CONVERTER FUNCTIONAL UNIT



## ROLLING STOCK AUXILIARY CONVERTER (FOR LOW-FLOOR TRAIN CARRIAGES)

Power Conversion Division provide on-board train auxiliary converters which fully comply with the international standards having the following main features:

### DC high-voltage input stage

|   |   |
|---|---|
| Rated input voltage                                   | 3 kVdc                                    |
| Input voltage variation range                         | 2 kVdc - 4 kVdc                           |
| Inrush current limitation method                      | DC Link capacitor pre-charge input filter |
| Random start-up delay                                 | Random comprised between 0 and 10 s       |
| Start-up in case of low or no rolling stock batteries | With Auto Starter device                  |

### AC medium voltage input stage in place of the DC high voltage input

|                 |  |
|-----------------|--|
| Rated voltage   | 400 Vac  |
| Rated frequency | 50 Hz  |
| Operating mode  | The device guarantees the battery charging and the operation in case of no power from the DC high-voltage line directly connecting the AC low-voltage input (400 Vac/50 Hz) to the output. |

### DC/AC conversion stage

|                         |                                 |
|-------------------------|---------------------------------|
| Rated output voltage    | 480 Vac $\pm 5\%$               |
| Rated frequency         | 60 Hz $\pm 1\%$                 |
| Number of output phases | 3                               |
| Rated power             | 35 kW ( $\cos = \varphi 0.75$ ) |
| Overload for 60 s       | 50 kW ( $\cos = \varphi 0.75$ ) |
| Overload for 2 s        | 50 kW ( $\cos = \varphi 0.5$ )  |

### DC/DC conversion stage

|                            |                |
|----------------------------|----------------|
| Rated output voltage       | 24 Vdc         |
| Rated power                | 5.5 kW         |
| Battery charge current     | 30 A $\pm 5\%$ |
| Total output current range | 191 - 240 A    |

### General specifications

|                               |  |
|-------------------------------|--|
| Cooling                       | Forced air   |
| Diagnostics                   | Error code display and USB interface                 |
| Electromagnetic compatibility | CEI EN 50121-1 – CEI EN 50121-3-1 – CEI EN 50121-3-2 |

### Service conditions

|             |                |
|-------------|----------------|
| Temperature | -25°C – + 55°C |
|-------------|----------------|

This document contains general description of the technical options which may not be present in individual cases. Therefore, the required performance characteristics must be defined in individual cases during conclusion of the contract. In view of the constant evolution in standards and design, and due to continuous developments, the characteristics of the elements contained in this catalogue are subject to changes without prior notification. These characteristics, as well as the availability of components, are subject to confirmation by the MONT-ELE Technical Sales Department. No contractual value. All right reserved. No part of this publication may be reproduced without the permission of MONT-ELE S.r.l. MONT-ELE is a registered trademark. **Cod. PCD-R01**

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**Power Conversion Division - Railway**

# Comprehensive Power Conversion Solutions



