



DYNAMIC VOLTAGE RESTORER (DVR) FOR VOLTAGE DIPS AND MICRO-INTERRUPTIONS



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DYNAMIC VOLTAGE RESTORER (DVR) FOR VOLTAGE DIPS AND MICRO-INTERRUPTIONS

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1 INTRODUCTION

Brief power interruptions are the most frequent power supply problems with wide-ranging consequences for industry. In 2012, 72 percent of power supply disruptions were attributed to voltage dips and micro-interruptions, of less than one second, according to grid monitoring by the German Industrial Energy and Power Industry Association, VIK. A 2017 study from the Association of German Chambers of Industry and Commerce, conducted in Bavaria, Germany, confirmed these findings. The causes of these interruptions included short-circuits in the distribution grid, lightning strikes, the connection, and disconnection of power plants and volatile energy producers such as wind and solar. The typical duration of such interruptions was between 300 and 500 milliseconds. According to the standards IEC 61000-4-30 and IEEE 519, which define the energy supply quality in public power grids, a voltage dip is defined when the nominal voltage falls to less than 90 percent of the contractually agreed upon supply voltage for at least 10 milliseconds.

Since technologies and production processes are becoming increasingly complex, the electronic components and control units of the production systems respond sensitively to such voltage dips and micro-interruptions. The consequences range from faults to complete system failures. It can take minutes, hours, or days to restore the normal operational conditions, if it is necessary to repair or replace defective components. In addition, there is often damage to materials and products, which must be reworked or remade. This translates to massive economic harm for the impacted companies.

2 UNINTERRUPTIBLE POWER SUPPLIER (UPS) SYSTEMS FOR SMOOTH OPERATIONS

UPS are technical systems that protect companies from such disruptions. Typical solutions make use of batteries, rotating flywheels, or ultracapacitors for temporary storage of energy. The technologies can differ greatly in terms of the areas of application as well as the procurement and operational costs. Battery-based UPS systems are often used in a distributed fashion for the protection of individual production components. They are inexpensive and store the energy by means of chemical reactions. However, they are subject to aging which results in decreased reliability. For this reason, the batteries must be replaced after just a few years.

Flywheel-based UPS systems offer larger power capacities and long lifespans, making them suitable as central protection for entire systems. The investment costs are very high, however. Additional costs arise from the required annual maintenance as well as the regular replacement of wearing parts.

The UPS system based on ultracapacitors – “Ultracapacitor Uninterruptible Power Supply” (U-UPS) – is specially designed for bridging short voltage dips up to 10 seconds in low-voltage and medium-voltage networks and represents an especially economical and efficient solution for such applications. Compared with the other UPS solutions, the procurement, energy, and operational costs are significantly lower while offering high efficiency and low losses.

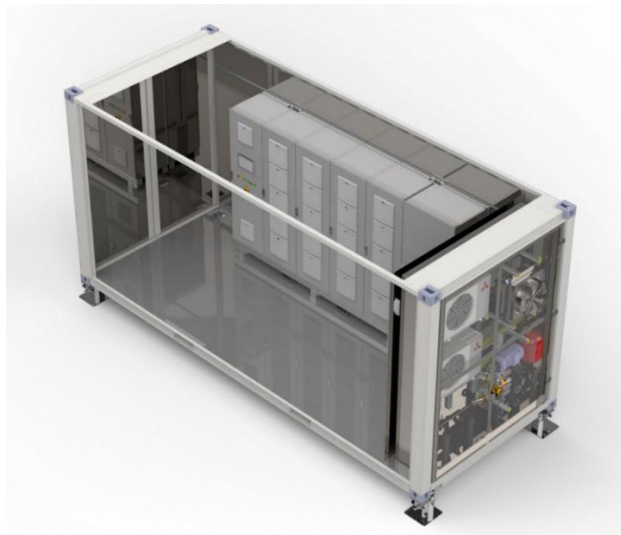


Fig. 1: View into the container – complete system with MSC-converter, ultracapacitor storage system and cooling system



Fig. 2: Space-saving setup of the U-UPS system Cabinet setup from left to right:

Cabinet 1: Control systems

Cabinet 2: Powerstacks / IGBTs

Cabinet 3: Choke coils

Cabinet 4: DC switch, AC filter, circuit breaker

Cabinet 5: EMC filter

Cabinet 6: Ultracapacitors

3 FUNCTIONING PRINCIPLE OF U-UPS

The U-UPS solution responds to voltage dips or micro-interruptions and automatically takes over the load in less than 10 milliseconds (steady state). The integrated Fast Disconnecter (FFD) disconnects the power supply from the public grid and creates its own isolated network with the energy stored in the ultracapacitors. This island grid operates with the same nominal voltage, phase angle and frequency as the public grid. When the distribution grid returns to the required voltage, the system automatically synchronizes with the public grid within a few milliseconds and re-establishes the connection. In normal operation, the ultracapacitors of the U-UPS solution are only charged by the public grid. This functioning principle applies to applications in the low-to medium-voltage range.

The load disconnection, and creation of an island grid in the event of a disruption by means of the FFD, puts the U-UPS system into a state of “offline” connection to the grid. In other words, the consumer

load flows only through this system when the Fast Disconnecter is active. As a result, the power loss compared with typical “online” UPS systems is reduced by more than 90 percent.

If the voltage dip lasts longer and the energy stored in the ultracapacitors is no longer sufficient to supply the load of the production system, the U-UPS automatically connects to the public power grid without synchronization. The system to be protected is therefore supplied with the best available power quality – either via the U-UPS or the main supply.

4 SPECIAL SOLUTION FOR MEDIUM-VOLTAGE NETWORKS

For applications in the medium-voltage range (MV), PROVENTUS offers a powerful back-to-back U-UPS solution. Two AC/DC converters are connected to the energy storage system via a shared DC/DC converter. In the event of voltage dips and micro-interruptions, this is the ideal solution for safeguarding the MV load and network either simultaneously or separately from each other, depending on the situation and requirements, and for bidirectional charging of the energy storage systems. If necessary, the U-UPS solution can simultaneously supply power and reactive power to support both the load and the network.

5 MANY APPLICATIONS AND ADVANTAGES

The U-UPS is particularly suited for industrial applications, which are especially sensitive to disruptions due to time-critical workflows and networked production systems. This includes, for example, systems in the automotive industry, data centers, semiconductor manufacturing, high-speed packaging lines or in food, chemical and pharmaceutical production. The U-UPS system is designed for 20+ years of sustained operation in such industrial environments with minimal maintenance requirements. Thanks to the powerful and robust multi-source converter technology (MSC), line disturbances can be smoothly bridged for durations from seconds to several minutes. Additional battery storage systems or generators can be integrated to compensate for disruptions lasting multiple hours. It is also possible to flexibly integrate other power grid services such as primary balancing power, additional DC or AC sources (such as photovoltaic systems or wind turbines) and to create a microgrid, for example.

The ultracapacitors are primarily made of carbon and aluminum. Rare metals such as cobalt or alkali metals like lithium are not used. Due to their electrochemical structure, the ultracapacitors offer fast charging and discharging times as well as a long lifespan of up to 1 million cycles.

The power capacities of the U-UPS system range from 170 kilowatts to 5 megawatts per unit, are modular and can be scaled up to tens of MWs depending on the specific project. The systems can be designed for indoor installation and as a turnkey, transportable container solution. STATCOM functionality for reactive power compensation is also available as an option.

6 U-UPS IN AUTOMOTIVE PRODUCTION: FAST AMORTIZATION OF THE COSTS

As a result of up to 50 voltage interruptions of less than 1 second per year, the production plants of a large European automotive manufacturer experienced regular shutdowns of the fully automated car body painting line. The robots switched off at interruptions as short as 0.2 seconds, bringing the painting work to an abrupt halt. The financial damages from the production downtime of up to 6 hours, for restoring the functionality of the robots and reworking the damaged vehicle parts, were considerable. Roughly 900 car bodies per year were subjected to faulty paintwork due to the power disruptions.

Since the use of the U-UPS solution, none of the short voltage dips in the distribution grid have led to any interruptions in the painting lines. During the entire bridging process, the system guarantees a consistent power quality, resulting in no error messages or downtime for the sensitive painting robots. In consideration of the previous downtime and repair costs, the investment in the U-UPS system paid for itself in just a few months. The operational costs are also very low.

7 PACKING MANUFACTURER AND ITS PRODUCTION

An Italian manufacturer of thin plastic packaging located in the vicinity of Naples also frequently experienced problems with short voltage dips in the distribution grid, which resulted in downtimes in the high-speed automation line. The plastic packaging materials are shaped into the finished product by the application of heat and passing through several rollers in an endless process. Brief power disruptions of less than 1 second resulted in production halts. The costs for cleaning and restarting the system were

very high. After examining the available solutions, the company decided to purchase the ultracapacitor UPS in 2020.

The solution included Low Voltage U-UPS system as a turnkey container solution consisting of an MSC and ultracapacitor storage system with a capacity of 1 megawatt for voltage dips of up to 1 second, including a transformer.

One special aspect of the project was that the customer requested that the Fast Disconnecter be installed externally and integrated directly into the existing supply network of the customer.

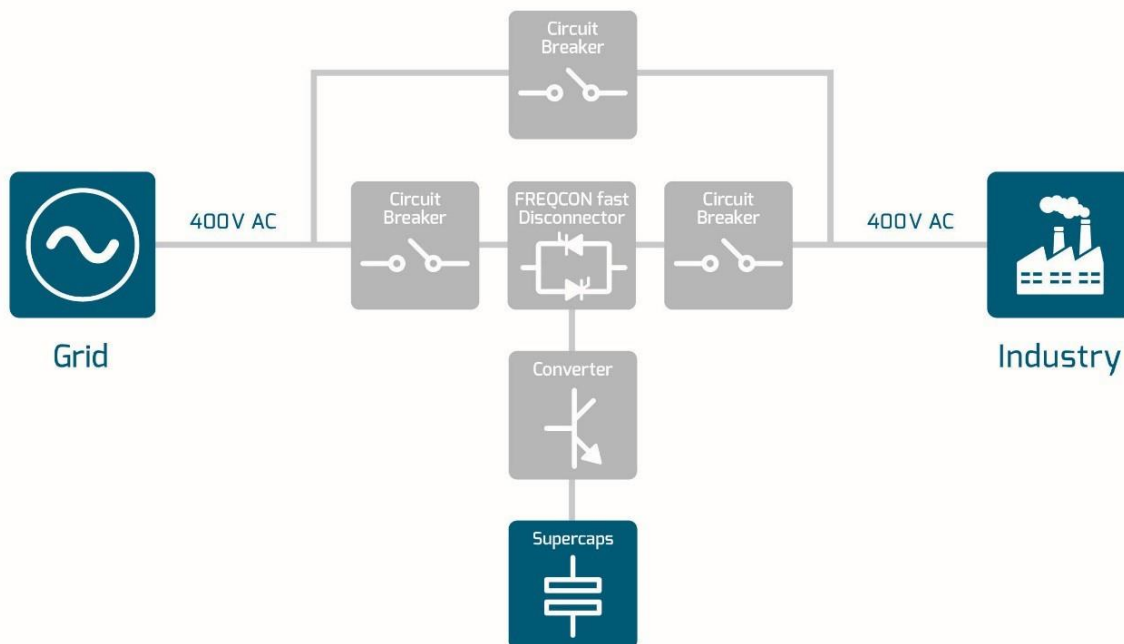


Fig. 3: System setup of U-UPS for low-voltage applications

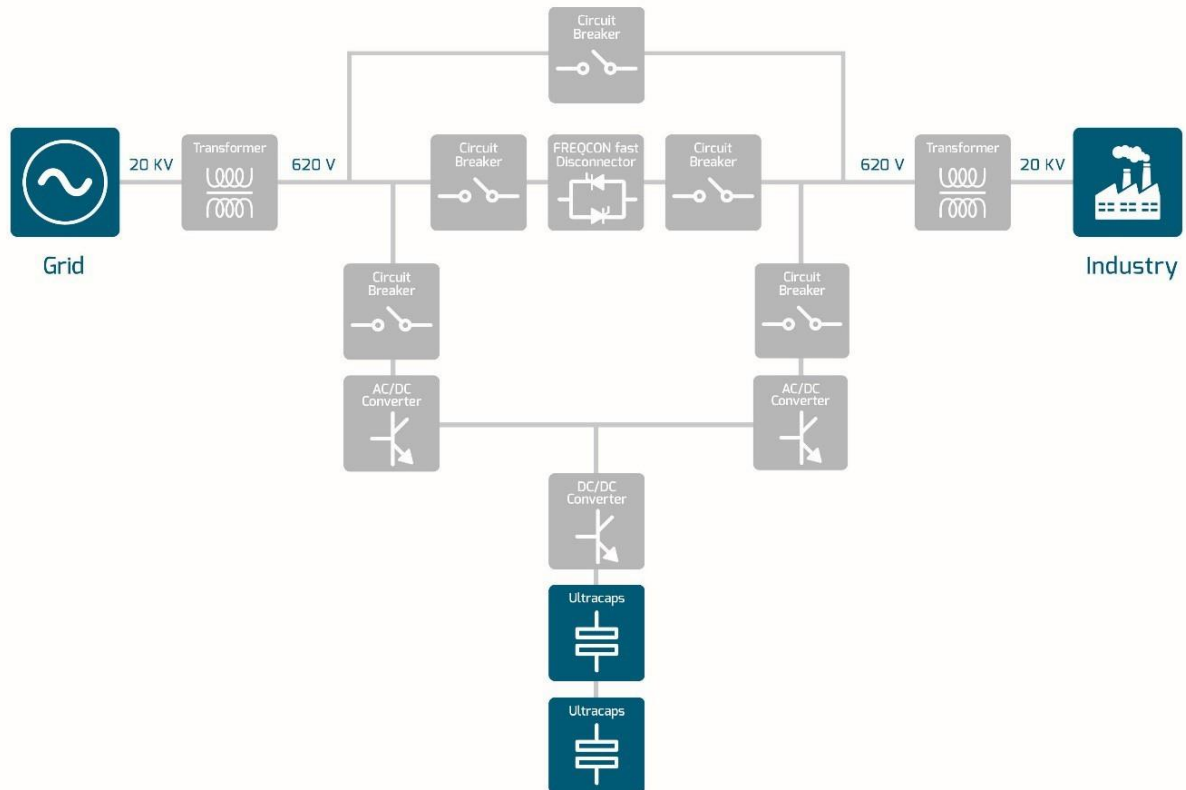


Fig. 4: System setup of U-UPS for medium-voltage applications

8 CONCLUSIONS

8.1 Proventus Global

Proventus Global was founded in 2019 in Canada. Its head office is located in Toronto, Canada with an Engineering department in Berlin, Germany. Proventus offers more than 60 years of industry experience, within the leadership team, and offers the following products and services:

- Power Quality Management
- AC/DC Microgrids

- E-Mobility
- Fully-financed solutions – Energy as a Service (EaaS)

Proventus has partnered with Maschinenfabrik Reinhausen (MR) to serve customers in North America with the “best in class” Power Quality products, systems and solutions.

8.2 Maschinenfabrik Reinhausen

MR is a global leader in niches of electrical engineering including transformer switching and power quality solutions. Founded in 1868 and trademarked in 1901, MR is an independent, majority family-owned company with most of its production in Germany. Over 50% of worldwide electricity consumption passes through MR products and more than 80% of all products delivered are still in operation today.

DOCUMENT INDEX

CHANGE HISTORY

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1.2	April 2024	Jessica Piirsalu	Minor updates to formatting and wording



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