UGS

ULTRACAPACITOR GRID STABILIZER
UPS VERSION

a technological innovation

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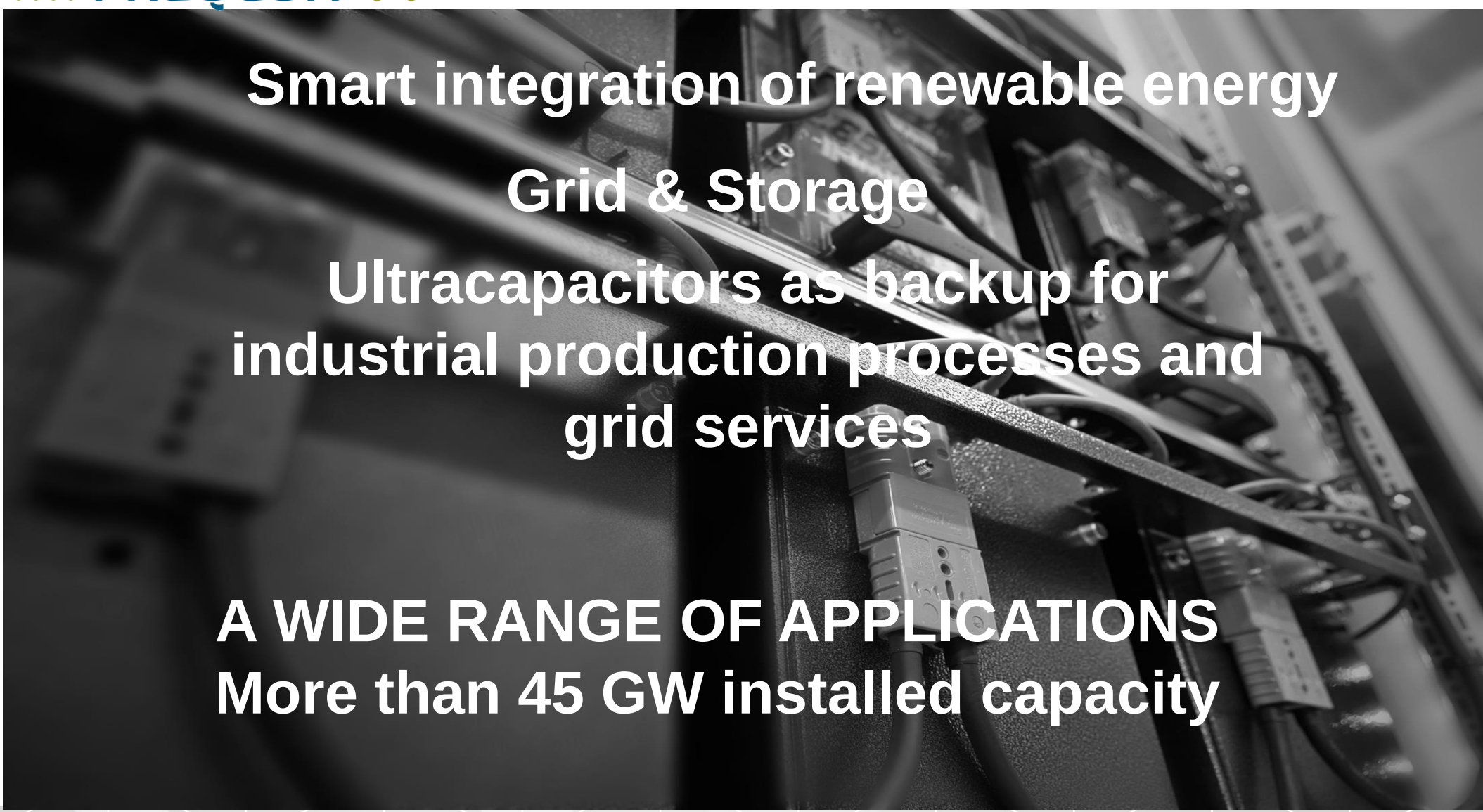
ATME SpA

Distributor for Freqcon

FREQCON



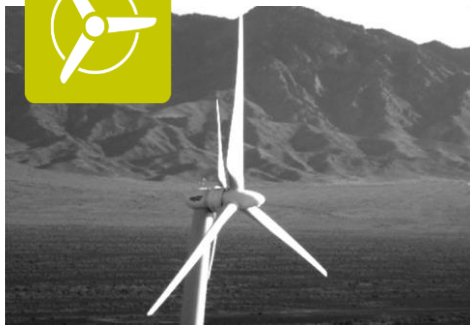
Smart integration of renewable energy

Grid & Storage

Ultracapacitors as backup for industrial production processes and grid services

A WIDE RANGE OF APPLICATIONS
More than 45 GW installed capacity

FREQCON Grid and Offgrid Solutions



Wind Energy

- Centralized Control System
- NGC Power Converter
- MSC Power Converter
- Certified Safety System
- Ultracapacitor Pitchsystem

Solar Energy

- MSC Power Converter Solar + Battery

Grid & Storage

- Battery 2 Grid Power Converter
- STATCOM Converter
- MSC Power Converter
- **Ultracapacitor Grid Stabilizer**
- **Ultracapacitor UPS System**

Microgrid

- MSC Power Converter
- MSC System
- Mini-MSC-Converter
- Mini-MSC-System

Change in energy supply

Current grid situation

- High share of renewables in public grid and reduction of conventional power plants

Consequences

- Instabilities in public grid (frequency fluctuation) and less rotating mass for compensation
- Especially problematic for island grids (Ireland, Sardinia, Canaries)

Solutions

- **Energy storage** for primary power regulation and fast frequency response (mostly battery applications) and **artificial inertia** **(Ultracapacitors, fly-wheels)**

UGS (Ultracapacitor Grid Stabilizer)

STACOM function of converters with IGBTs associated with Maxwell Power Ultracapacitors to stabilize the voltage and frequency of the networks, with a high amount of energy produced from renewable sources (FRNP).

The Freqcon NGC converters (Next Generation Converter) were originally developed for applications in the field of FRNP (over 15 GW installed).

UGS (Ultracapacitor Grid Stabilizer)

UGS is the most recent application of NGC systems.

The system operates at low voltage level and is intended for operation on public and non-public networks and, after commissioning and parameterization, operates automatically.

ACTIVE POWER GRID SUPPORT

Synthetic inertia

The frequency of a power system is a continuously changing quantity whose derivative indicates the balance between consumed and produced power.

A momentary imbalance between these results in a change of system frequency, where kinetic energy is stored or released in rotating masses in the system.

When a disturbance in the form of disconnection of load or production occurs, the frequency response of the system depends on size of disturbance, inertia and response of controlled frequency responses.

Synthetic inertia

Inertia prevents system frequency from experiencing sudden changes which can in turn cause stability issues, and today the bulk of inertia in power systems is made up of rotating masses in synchronous generators.

With more non-synchronous generation, inertia is reduced, since non-synchronously connected production units (modern wind turbine generators) are connected via power converters, their rotational speed is isolated from the system frequency.

They do not therefore deliver a natural inertial response and do not contribute to the inertia of the system.

Synthetic inertia response

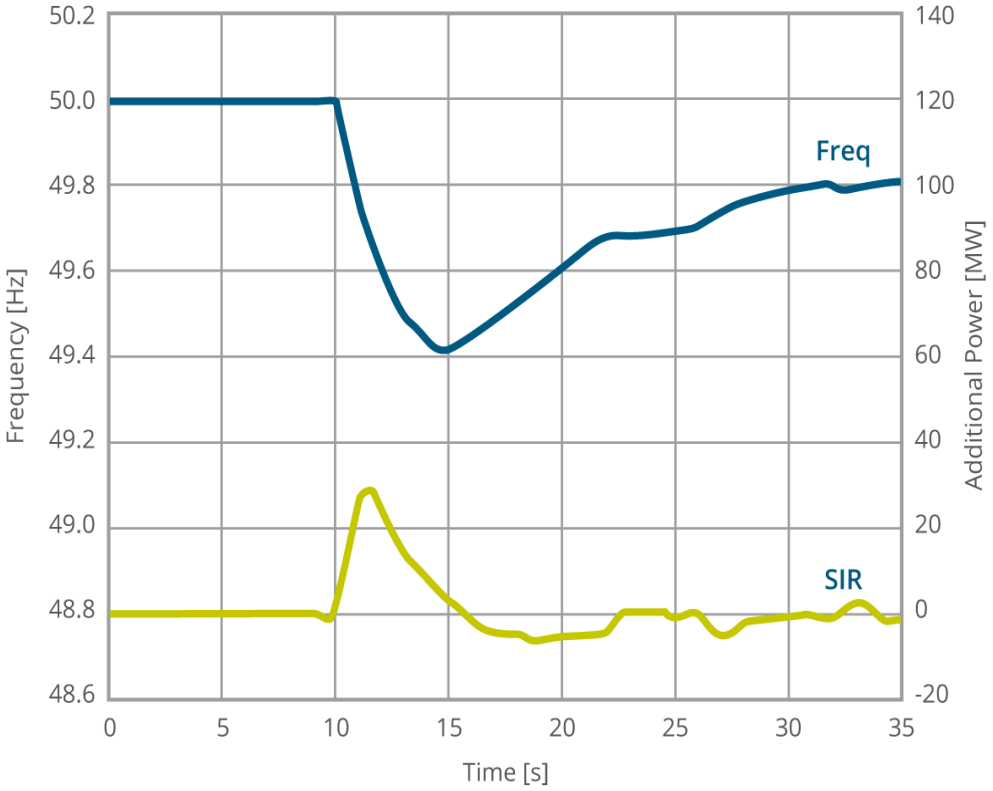
Synthetic inertia is the contribution of **additional electrical power** from a source which does not inherently release energy as its terminal frequency varies, but which mimics the release of kinetic energy from a rotating mass.

This provides an electrical torque which is **proportional to RoCoF**, which resists changes in frequency.

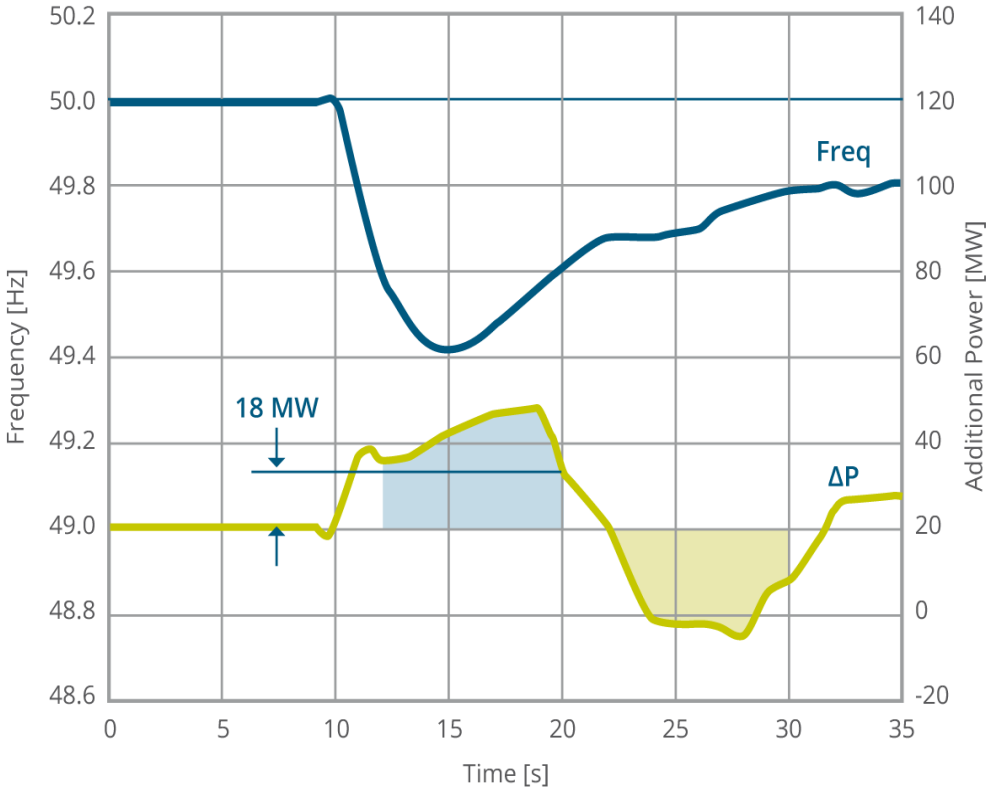
To operate a power system securely, the frequency of the system must remain within a narrow band.

Active Power Grid Support

Synthetic Inertia Response

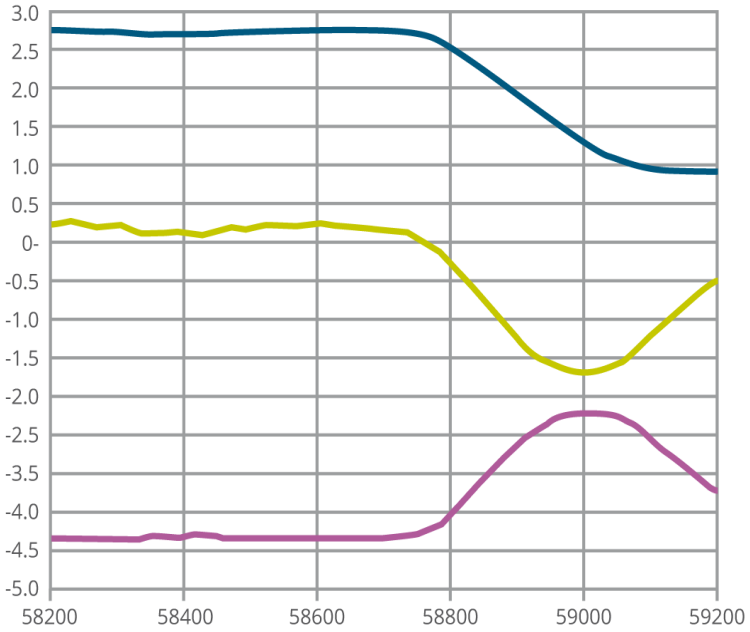


Fast Frequency Response



ROCOF Rate of change of frequency

Function used for fast load shedding, to speed up operation time in over- and under-frequency situations and to detect loss of Support (Rate of Change of Frequency)



ROCOF Test with gen set

Frequency: Drop from 50Hz to 49,3Hz

ROCOF: -2Hz/s

Response of Converter System: prompt active power support

UGS : possible fields of application

DDR (Dynamic Reactive Response): compensates for voltage dips and micro-interruptions within 20 ms .

UPS function: allows short compensations for power outages.

Harmonic filtering (up to the 11th harmonic).

RoCoF support: ability to provide active power to compensate for frequency drops within 5 ms.

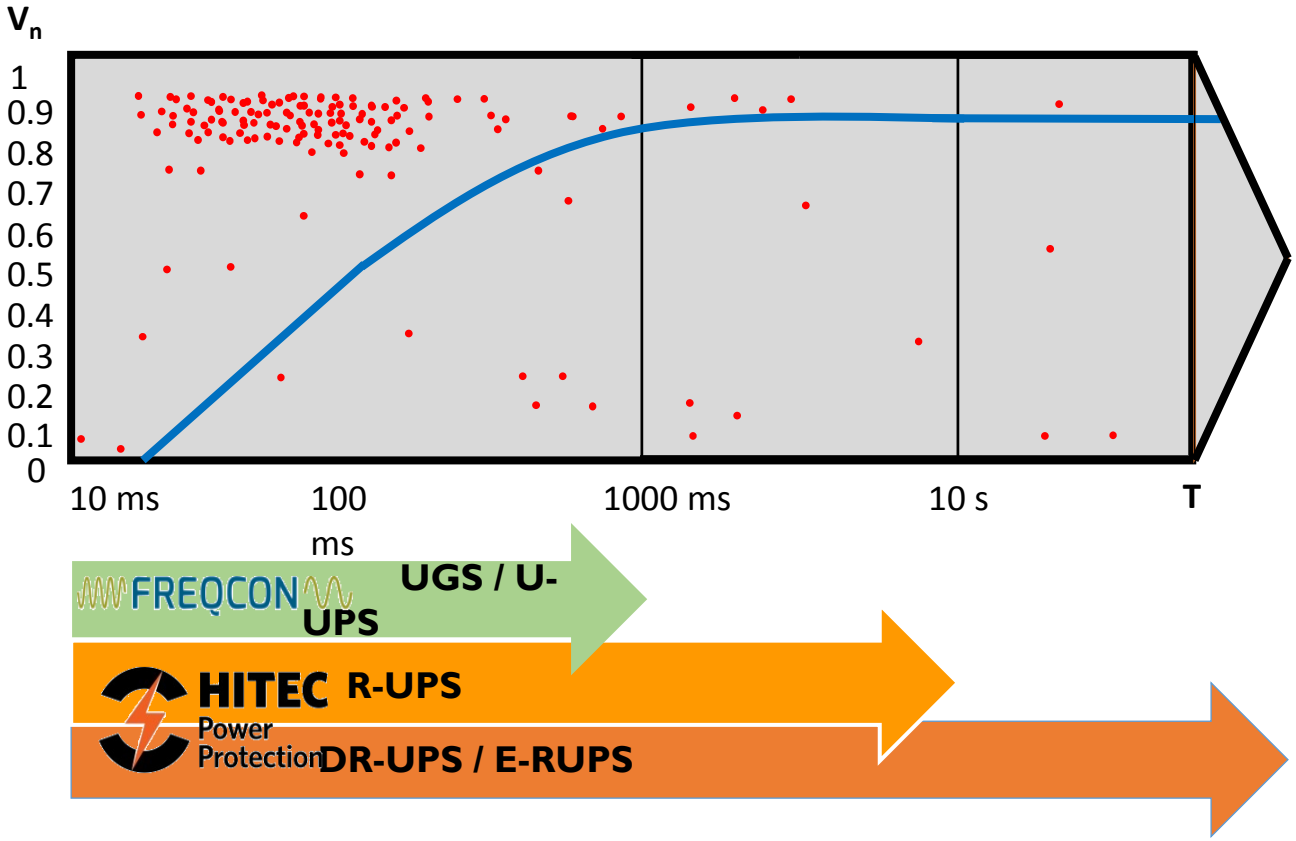
FFR (Fast Frequency Response): increases the synthetic inertia of the network by delivering active power in a time interval between 2 and 10 s to stabilize the frequency

Primary Operating Reserve: delivers active power to stabilize the frequency up to 15 s

POWER CONDITIONING

COMPENSATION OF VOLTAGE DIPS AND MICRO-INTERRUPTIONS

MICROINTERRUPTIONS IN THE ITALIAN GRID



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Applicazioni Tecnologiche Motoristiche ed Elettriche

is the Italian official dealer and engineering company for these products

Voltage dips: sudden decrease in the effective value between 90% and 1% of Vn, followed by a recovery within a short period of time - CEI 110-22)
"Transient" interruptions or micro-interruptions: cancellation of the supply voltage caused by the rapid re-closing cycles (opening / closing) of the line switch (typical duration between 300 and 500 ms).

They represent 65% of the events complained by users as a sign of poor quality of energy

Function DRR
(Dynamic Reactive Response)

Voltage dips are detected by the control system within 10 ms and it takes another 10 ms to fully compensate them within 20 ms.

After the event the system synchronizes with the grid within 200 ms. This time is automatically included in the capacity.

MV plants: UGS are used to compensate **voltage dips** with a maximum depth of 80% and they are inserted in the network through an injector transformer.

LV plants: U-UPS are used to compensate **voltage dips and micro-interruptions.** They belong to the UGS family and are programmed with a specific software.

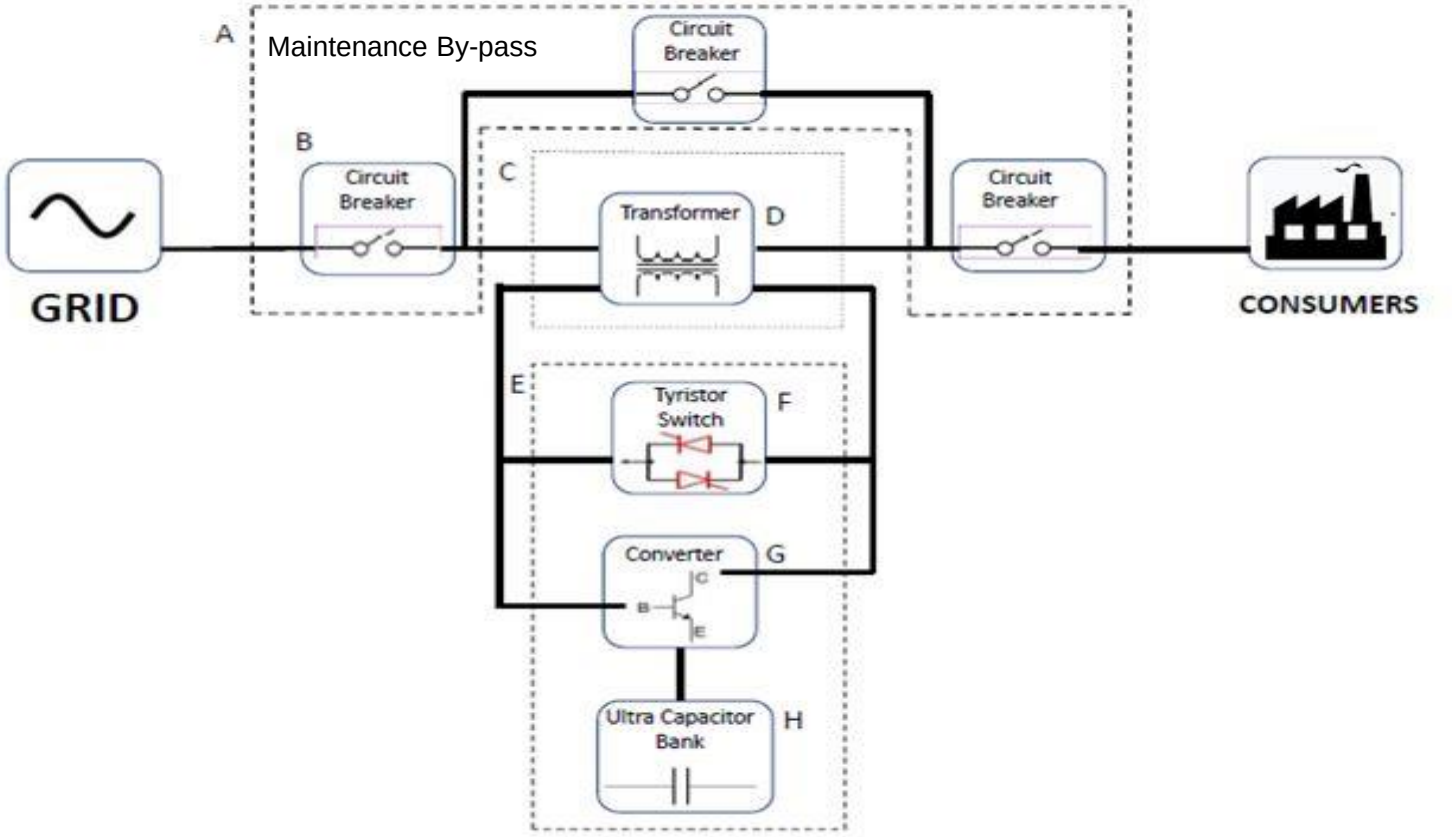
Compensation: how long?

Normally the duration of the voltage dips and micro-interruptions does not exceed 1000 ms.

Freqcon sizes the devices for a standard protection ≤ 1000 ms, that can be extended according customer's requirements.

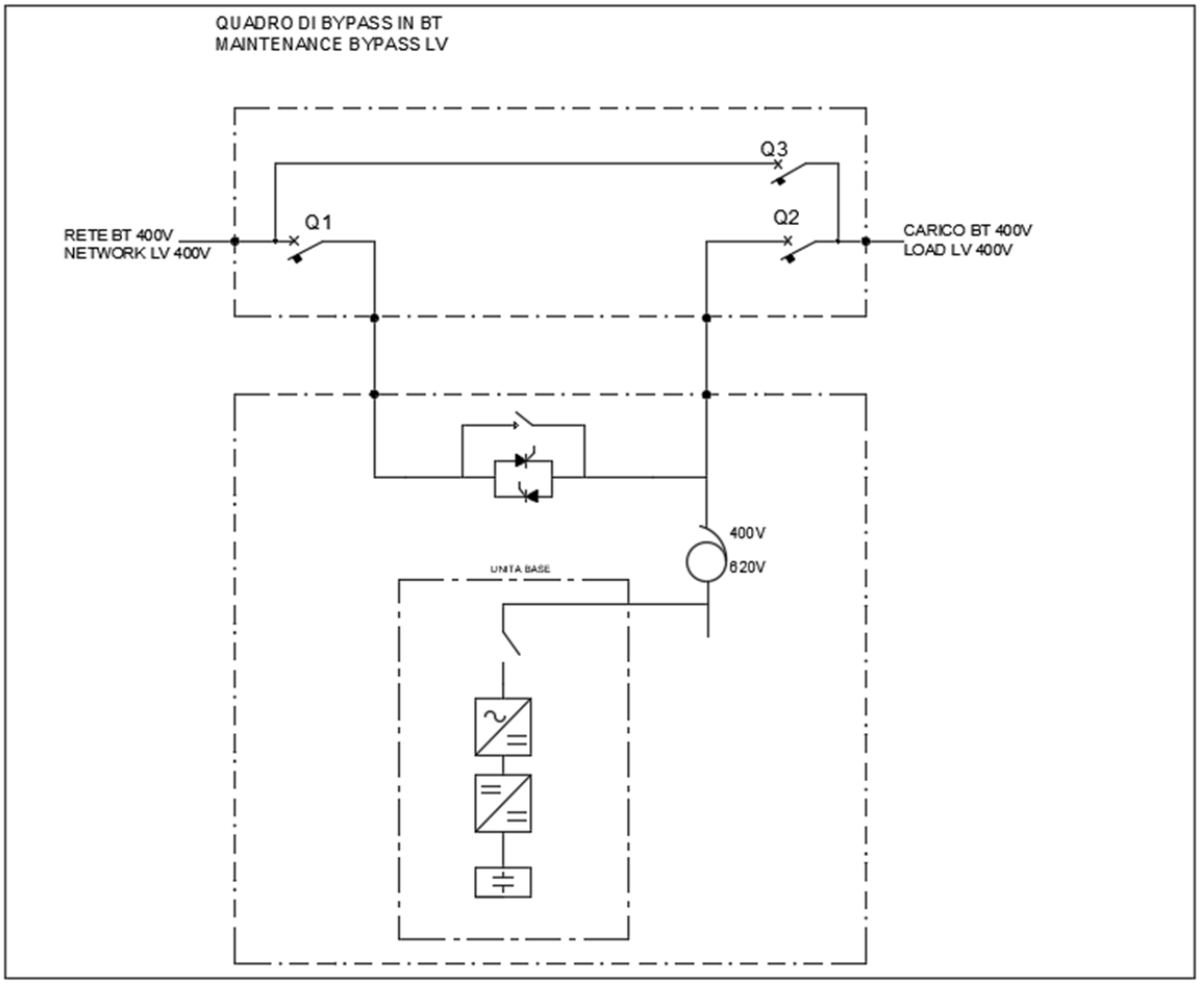
UGS in MT

voltage dip compensation up to 80%



U-UPS in LV

microinterruption compensation



CEI 0-16; V2 of 2016-07 technical reference rule for connections

The static compensators installed to improve the mains voltage quality in relation to voltage dips and interruptions are not part of the storage systems, if they use ultracapacitor systems able to supply energy for a few seconds.

They therefore fall within the exceptions pursuant to Art. 3.76 bis of the V2 variant of the CEI 016 Standard.

UGS: main components

Maxwell supercapacitor bank

Bidirectional DC / DC converter

Bidirectional inverter with IGBT and control system

Auxiliary equipment: electrical and thermal protection, remote control, remote diagnostics and liquid cooling

- UGS in MT: injector transformer (MT / 620 V) and tyristor switch
- U-UPS :Autotransformer (620/400 V) and static switch

(AC disconnector)

Maxwell ultracapacitor bank

They combine the capacity of electrostatic and electrochemical charge/discharge and have a very high-power density even if with a relative low energy density.
They discharge and recharge very quickly
They are the ideal system for high power injections in ultra-fast times with a long-life expectancy (up to 500,000 charge / discharge cycles).
The supply includes the **VMS** (Voltage Management System) to equalize the voltages on the individual modules.
Dispensing capacity in MJ = MW s

Ultracapacitors

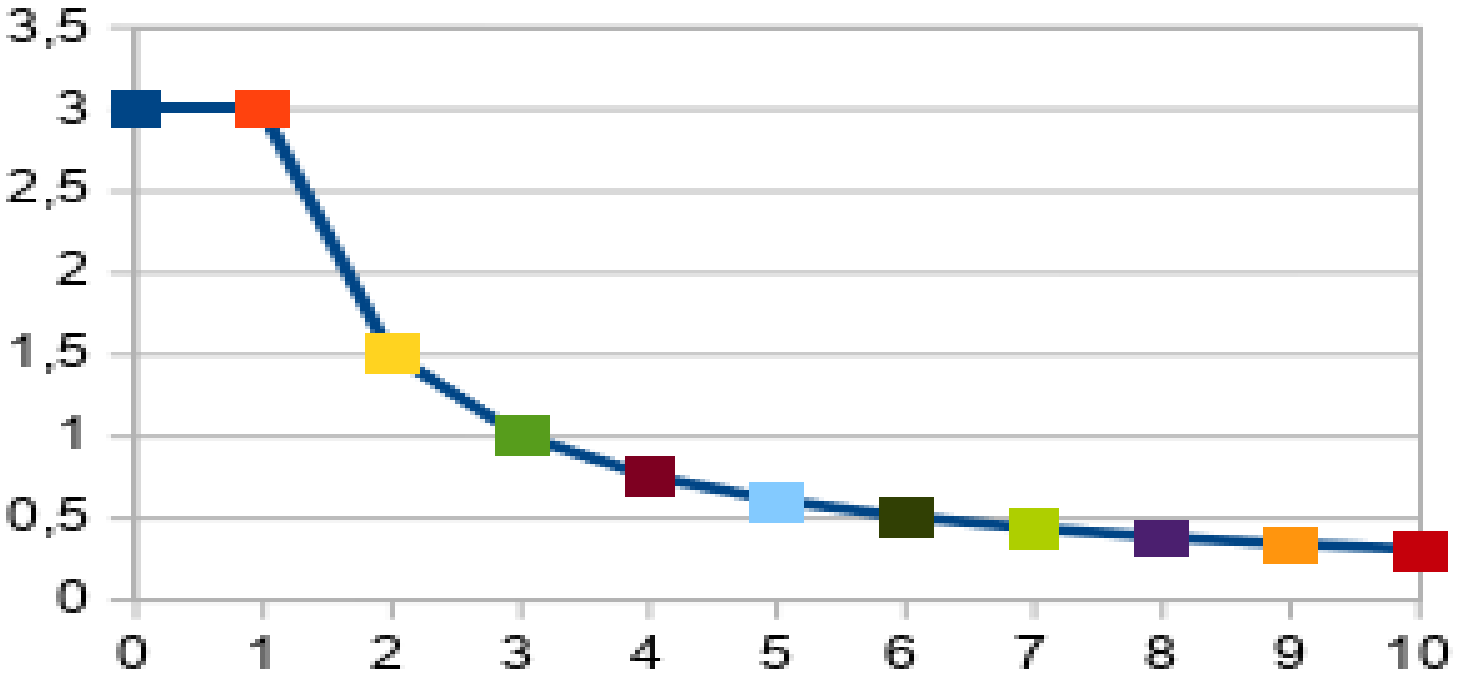
Are assembled in modules consisting of elementary capacitors connected in series and parallel to reach the desired voltage, current and capacity and encapsulated for a greater mechanical strength and higher protection level against moisture and dust.
Parameters to set: Start voltage of compensation- Minimum recharge time.
The recharge is carried out through the bi-directional inverter, and a DC / DC converter, also bi-directional.

Main technical data

SUPERCAPACITORS

Maximum Voltage (CC)	**1250V**
Active Power available	Rated power for 1 second
Expected life at 25 ° C	1.000.000 cycles

Ultracap protection time
3 MJ with a 3 MW inverter



On the abscissa: time in seconds
In ordinate: power in MW

ULTRACAPACITOR OUTPUT VOLTAGE

A very undesirable feature of ultracapacitors is the fact that the voltage drops as the capacitor is discharged.

An ultracapacitor only provides energy as its voltage decreases and absorbs energy as its voltage increases. The output voltage is dependent on the state of charge.

DC-DC converters are employed at present to convert the voltage of the ultracapacitor to constant voltage.

DC to DC converter

- **DC-to-DC converter** is an electronic circuit **device** that converts a source of direct current (DC) from one voltage level to another.
- They are utilized to regulate the output voltage of the ultracapacitor bank.
- Freqcon utilizes bidirectional converters

Bidirectional 620V inverter with ultrafast IGBTs

The inverter is always synchronized with the grid and it is activated within a few milliseconds to restore the mains voltage in amplitude, frequency and phase equal to that preceding the disturbance.

The power, expressed in Wp (peak Watt) or in its multiples (no overload accepted) and corresponds to the active peak power that the ultracapacitor can transfer to the network.

Main technical data

CONVERTER

Basic component	IGBT
Rated output voltage DC	620V trifase
IGBT switching frequency (kHz)	2 … 4kHz
Three-phase voltage dissymmetry	≤5%
THD at nominal power	< 3%
Rated power factor	1
Power factor range	0.95cap … 0.95ind
yield	≥ 98%

Control Unit

It continuously analyzes the wave form of the main voltage and, as soon as its parameters deviate from the reference ones (intervention level), it immediately gives the inverter the power injection command necessary to bring the voltage value back to the preset levels.
When the voltage returns to nominal value, the inverter stops supplying power and starts recharging the supercaps, to handle another event.

Main technical data

CONTROL UNIT

Main control system	**Siemens Simotion P320-4**
Control software	FRECQON Freamwork
Internal communications bus	Profinet
External communication interfaces	Ethernet / TCP/IP

CONTAINER INSTALLATION

ISO CONTAINER INSTALLATION

Main technical data

CONTAINER CHARACTERISTICS

Types of container	**According to ISO**
Certification of container	Germanischer Lloyd / Bureau Veritas, CSC
Dimension and weight	According to the model
Level of protection	IP54

UGS 1 MW / 1 MJ / 620 V AC

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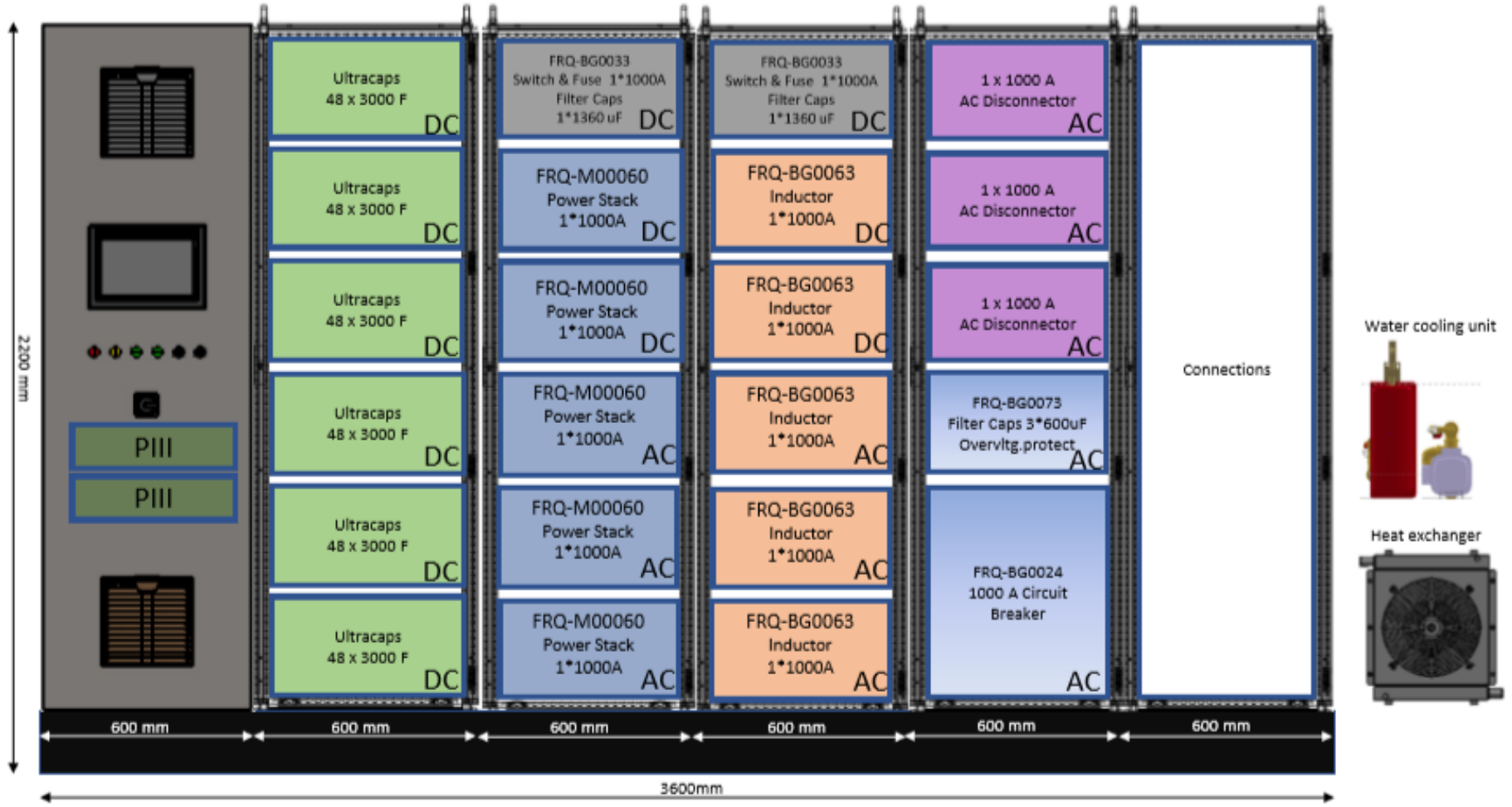

Main technical data

COOLING SYSTEM

Coolant	**Water-glycol (50-50)**
Operating temperature range	-20°C … +50°C
Operating pressure of the cooling system	3bar

UGS 1,5 MW / 1,5 MJ / 620 V AC

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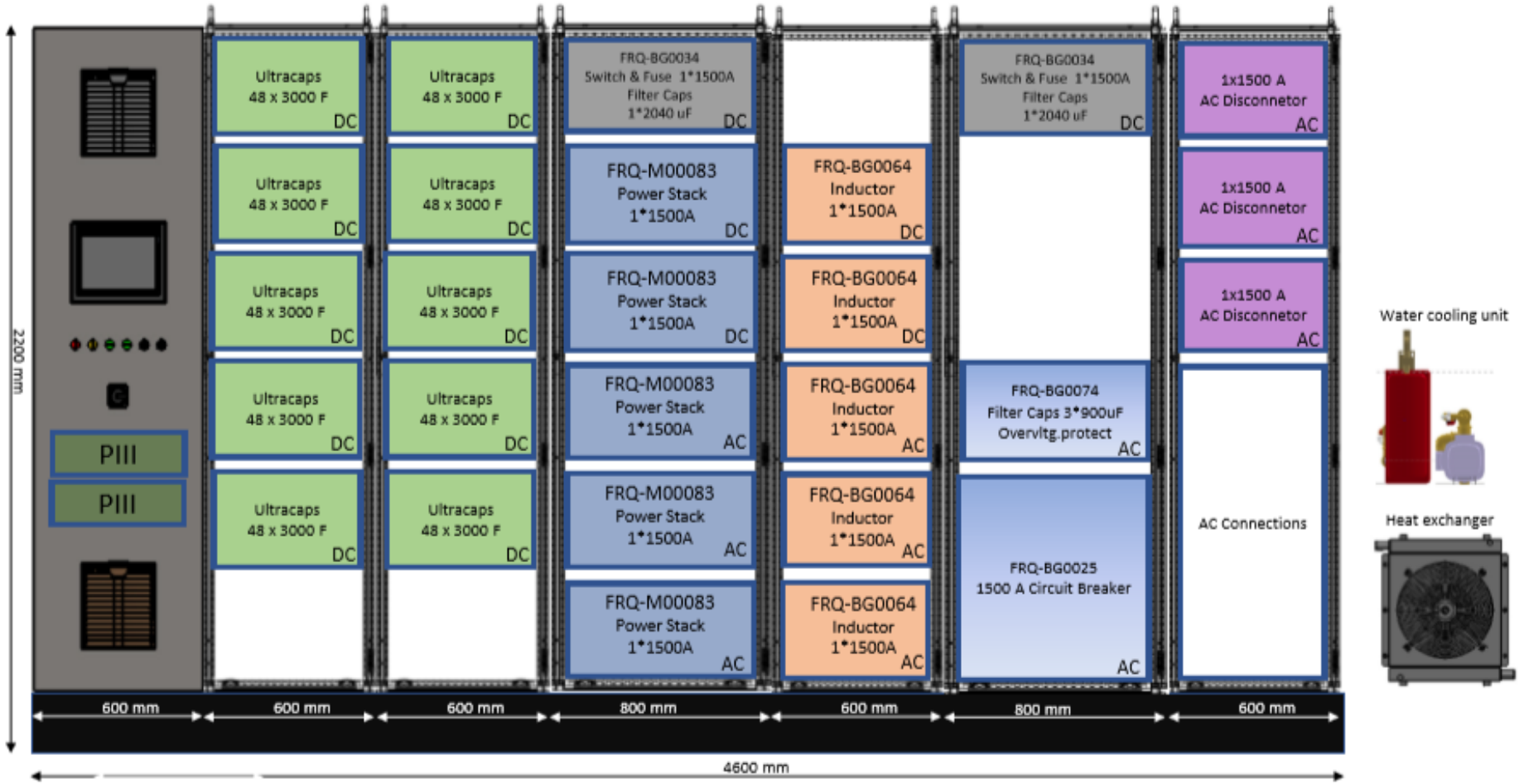
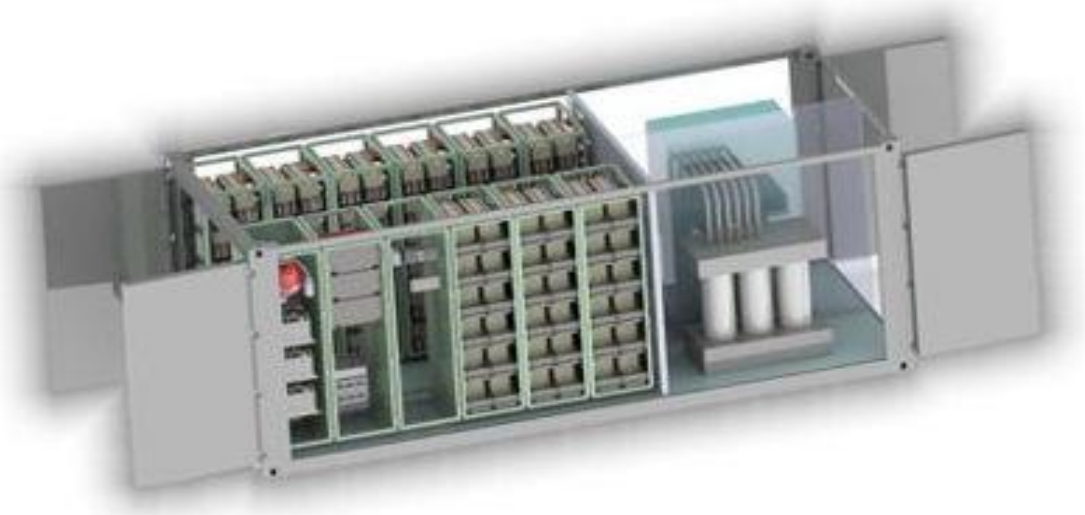


- The UGS switch cabinets are integrated in one outdoor container, which is divided in two sections, one air-conditioned section and one without air-conditioning.
- The two sections are divided from each other by an insulated partition wall.
- In the air-conditioned section the temperature is regulated to 20°C



Operating costs

Electrical losses : practically negligible. The UGS absorb a very limited active power. The inverter is in stand-by, and it is activated only in the event of anomalies

Periodic maintenance: 2 visits per year

Check for any anomalies: it can be carried out by remote.

Range and versions available

Installation in ISO containers

- 250 - 500 -750 kW — in 10″ container
- 1000 -1500- 2000 - 3000kW — in 20 ″ container
- 4000 kW — in 40 ″ container

Installation in electrical cabinets

CASE STUDY

(PROJECT)

Case study (project)

Power to be protected	9 MW
Voltage	15 kV
Redundancy level	n+1
Installation	in outdoor containers

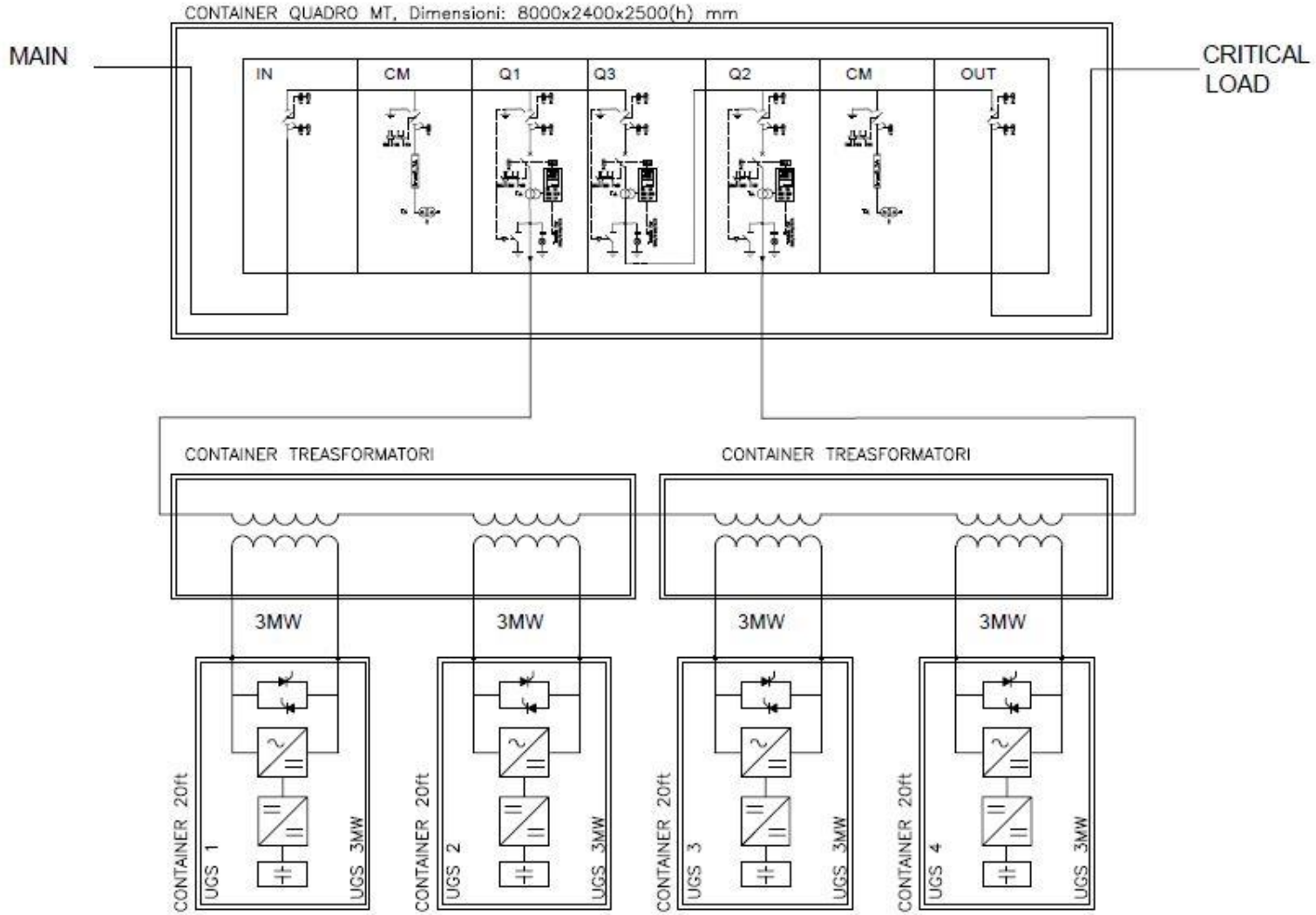
Scope of supply

4 UGS da 3MW connected in series

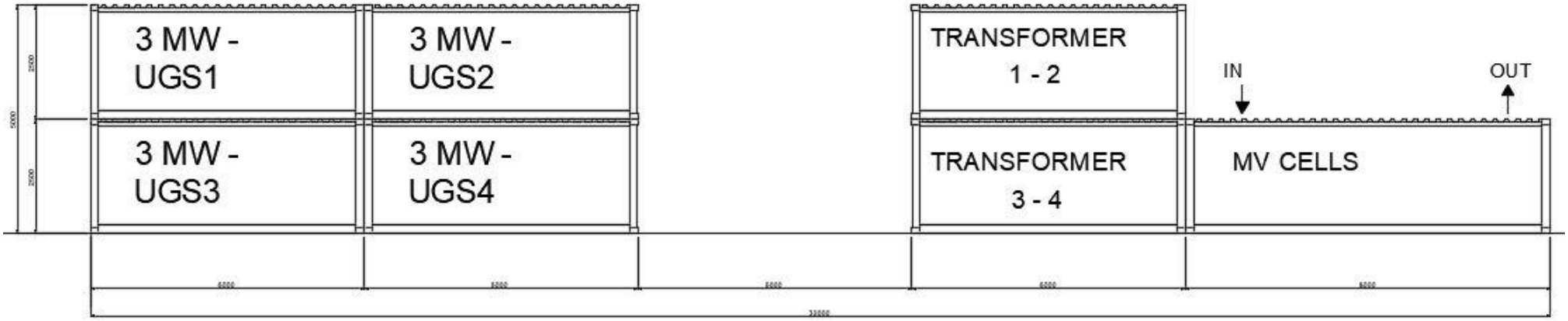
4 injector transformer Three phase 3 MVA (primary 2,2 kV-secondary 358 V)

1 MV panel installed in an 8 m container, air conditioned

Single line


CONTAINER QUADRO MT, Dimensioni: 8000x2400x2500(h) mm
MAIN
IN
CM
Q1
Q3
Q2
CM
OUT
CRITICAL LOAD
CONTAINER TREASFORMATORI
CONTAINER TREASFORMATORI
3MW
3MW
3MW
3MW
CONTAINER 20ft
UGS 1
UGS 3MW
CONTAINER 20ft
UGS 2
UGS 3MW
CONTAINER 20ft
UGS 3
UGS 3MW
CONTAINER 20ft
UGS 4
UGS 3MW

Installation



GERMAN RENEWABLES 2014 AWARD
TECHNOLOGY I SYSTEMS I MARKET

GERMAN RENEWABLES 2016 AWARD
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FREQCON
REFERENCE PROJECTS
GRID & STORAGE

Reference Projects Grid & Storage

2014 MEGA MSC

MEGA (Micro Electricity Generation Association), Ireland

- Design and delivery of 300 kW / 150 kWh electrical energy storage system.
- DS3 Grid Services and UPS
- Hybrid System:
  - 100 kWh Litium-Ion
  - 50 kWh Lead-Carbon
  - 50 kW-10sec Ultracapacitors

2017 Kilpaddoge MSC

2.0 MW DS3 Power Park Module Kilpaddoge, Ireland

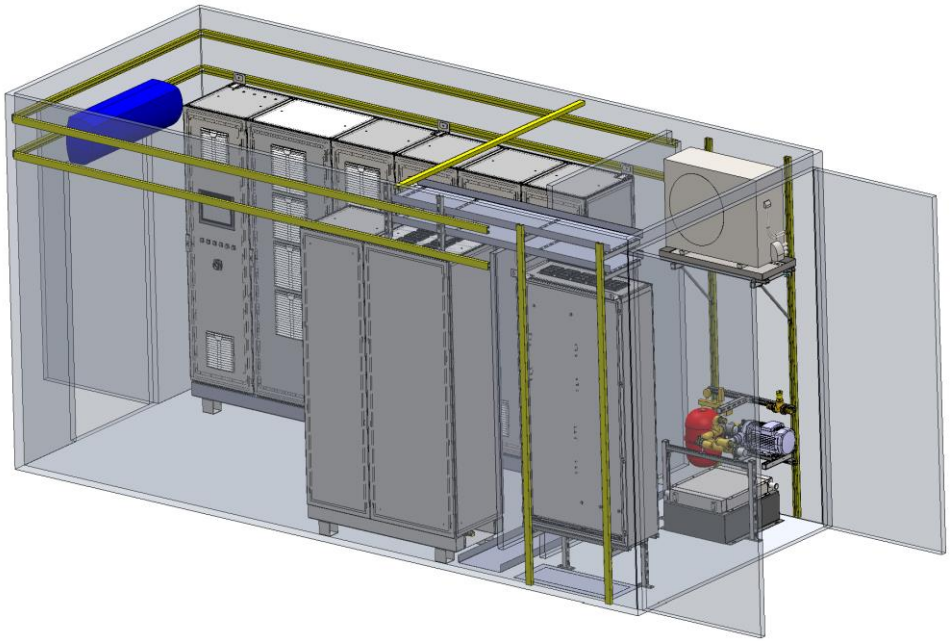
- Ultracapacitors for Fast Frequency Response
- Diesel Gensets for Operating Reserve + Ramping

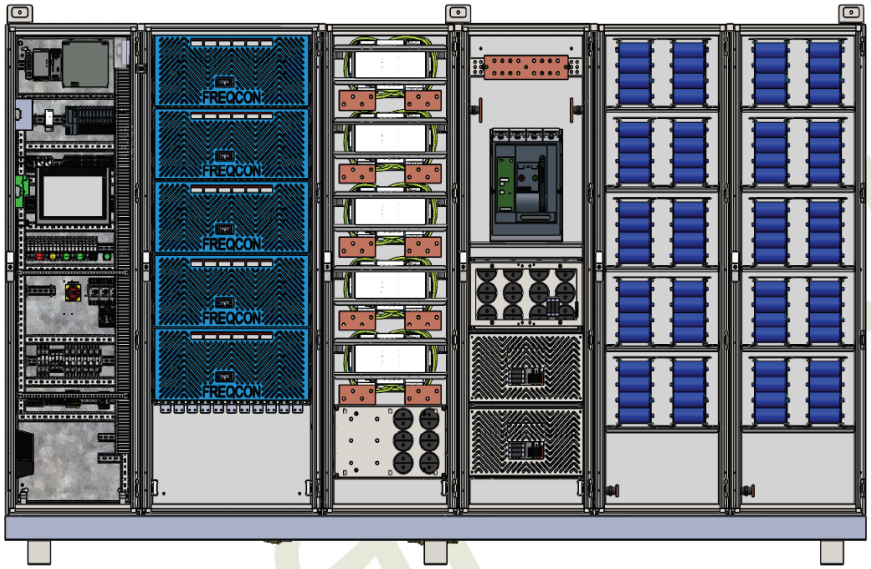
Reference Projects Grid & Storage

2018 Mlada Boleslav UGS

Siemens/e.ON/Skoda, Czech Republic

- Design and delivery of 1 MW / 1,5 s UGS
- Voltage dip compensation for automobile production
- 20“ Container





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