NOVEMBER 2022

High Power Rectifiers

Providing the right chemistry for over a century

Max Francisco, Sales

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ABB High Power Rectifers

Over one century at the forefront of HPR Systems

1913 Arc Mercury Rectifier

1939 HVDC transmission system in 50kV

1958 Semiconductor Rectifier

1960 Rectifier Plant > 100kA

1968 Thyristor Rectifier for copper production

1970 Rectifier Unit > 100kA

1985 Thyristor Rectifier for aluminum production

1999 ABB takes over the HPR installed base from Siemens

2003 AC 800PEC2 controller dedicated to rectifiers

2007 Qatalum Project 10 x 85kA@1750V (designed to 2000Vdc)

2010 Rectifier unit 105kA @ 1750V (Ma'aden Aluminium - Kindgom of Saudi Arabia)

2012 Diode Crowbar System 250kA 1500V

2018 AC 800PEC3 controller

2020 Diode Rectifier 100kA@2000V

2020 The biggest Rectifier for Zinc in SAM

2020 First Rectifier System 230kV without down step transformer

Our Customers

Main Industries

High Tech Solutions for DC current / voltage supply

Chemistry	• Hydrogen • Chlorate • Chlor Alkali	750+ DC power supplies for hydrogen and chlorine production up to **350 MW per plant**
Nonferrous Metals	• Copper EW/ER • Zinc EW • Nickel EW • Aluminum smelting	
Others materials	• Silicon Carbide • Manganese • Graphitizing • Arc furnaces	

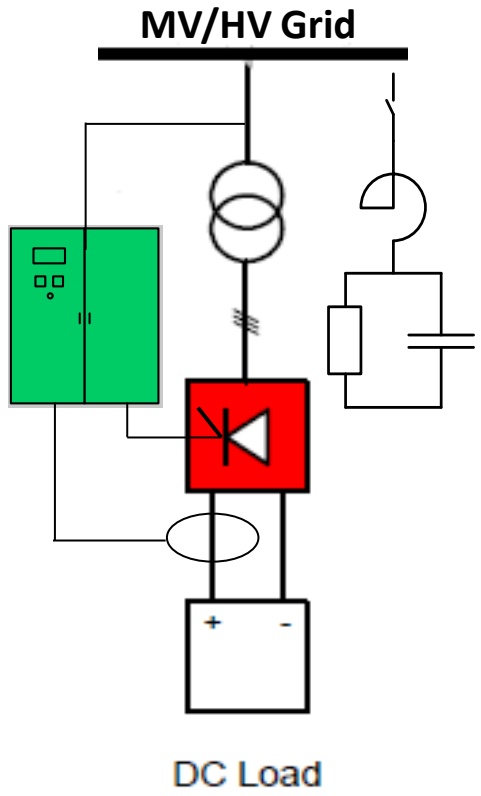

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ABB High Power Rectifier Product Group

Scope of expertise

Control System

1 Filters, SVC & Compensation

2 Switchgear

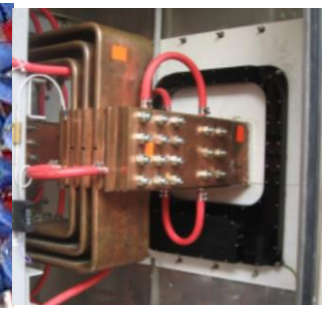
3 Regulation Transformer

4 Rectifier Transformer

5 Rectifier

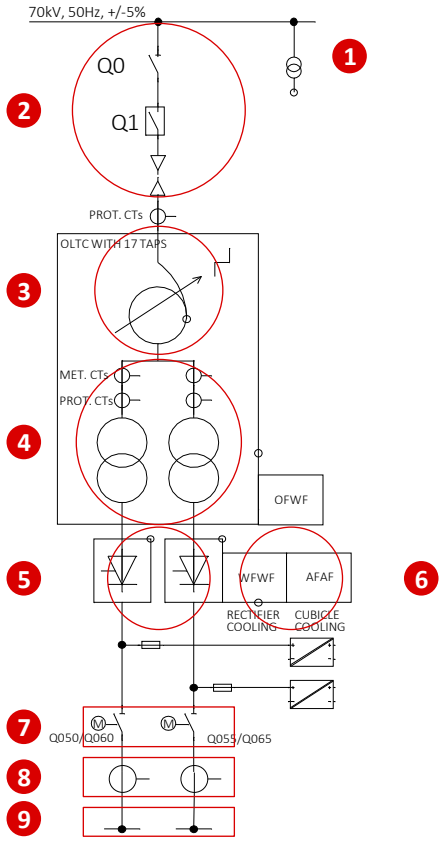
6 Cooling

7 DC Isolator



8 DC measurement

9 DC Busbars



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Global Footprint

Local Engineering Center

We serve you faster and better
24 hours per day, 365 days per year (toll free 0800 12 2500)

- Center of Excellence
  - Switzerland
- Sales and execution centers
  - China
  - USA/Canada
  - Brazil
  - South Africa
  - India
  - Australia
- Regional support
  - Chile
  - Peru

ABB has operations in more than 100 countries

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Competence center of power electronics
Switzerland

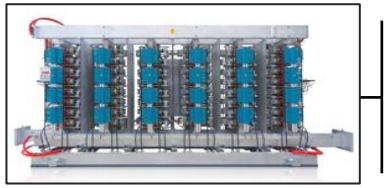
Our Key for the Success

Research and Development

1. USD 1,00 Billion invested in Research & Development
   Collaboration with more than 70 universities
   4 R&D centers (Switzerland, India, Singapore and China)

2. 4 inches semiconductors
   Protection ring

3. AC800PEC (MTBF 25 years)
   Fiber optic links without signal converters



4. Next generation HCR > 2500Vdc

At ABB, innovation is our lifeblood.
Leadership built on consistent Research & Development.

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Market trends

High Power Rectifiers

Phase out of the Chlor-Alkali Hg / Diaphragm electrolyzes will demand:

1) Greater electrification of primary production processes.
2) Phase out from Hg to membrane.
3) Phase out from Diaphragm to membrane.
4) Chlor-Alkali compact / modular plants

ABB can support this with:

- DC Power supplies for chlor-alkali production by electrolisys (LCR) < 10MVA
- DC Power supplies for chlor-alkali production by electrolisys (MCR) > 10MVA
- Overall automation and digitilization solutions

Decarbonization of the mining industry will demand:

1) Greater electrification and automation to optmize the ernergy use and production cicles.
2) Production of "Green" H2 for Hyibrid Truck BVEH2 (Nugen Pilot 1 ton H2/day).

ABB can support this with:

- DC Power supplies for H2 production by electrolisys (MCR) > 10MVA
- Overall automation and digitilization solutions

Decarbonization of the steel industry will demand:

1) Greater electrification of primary steel production.
2) Use of renewable energy weakening power grids.
3) Production of "Green" H2 for DRI processes.

ABB can support this with:

- DC Power supplies for Green H2 production used in H2-direct reduction of iron ore (H2-DRI)
- DC Power supplies for Iron ore and/or Molten oxide electrolysis
- DC Power supplies for DC EAF applications
- Overall automation and digitilization solutions

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Product Portfolio

The No. 1 choice for a total HPR system approach

ABB portfolio provides a wide range of rectifiers systems and solutions for different industries. We’ve supplied over than 2000 HPR systems around the world.

Our customers expect better quality, high reliability and long-term services. With more than one century of experience and expertise, ABB's rectifier meets each customer’s specific needs and provides unique benefits.

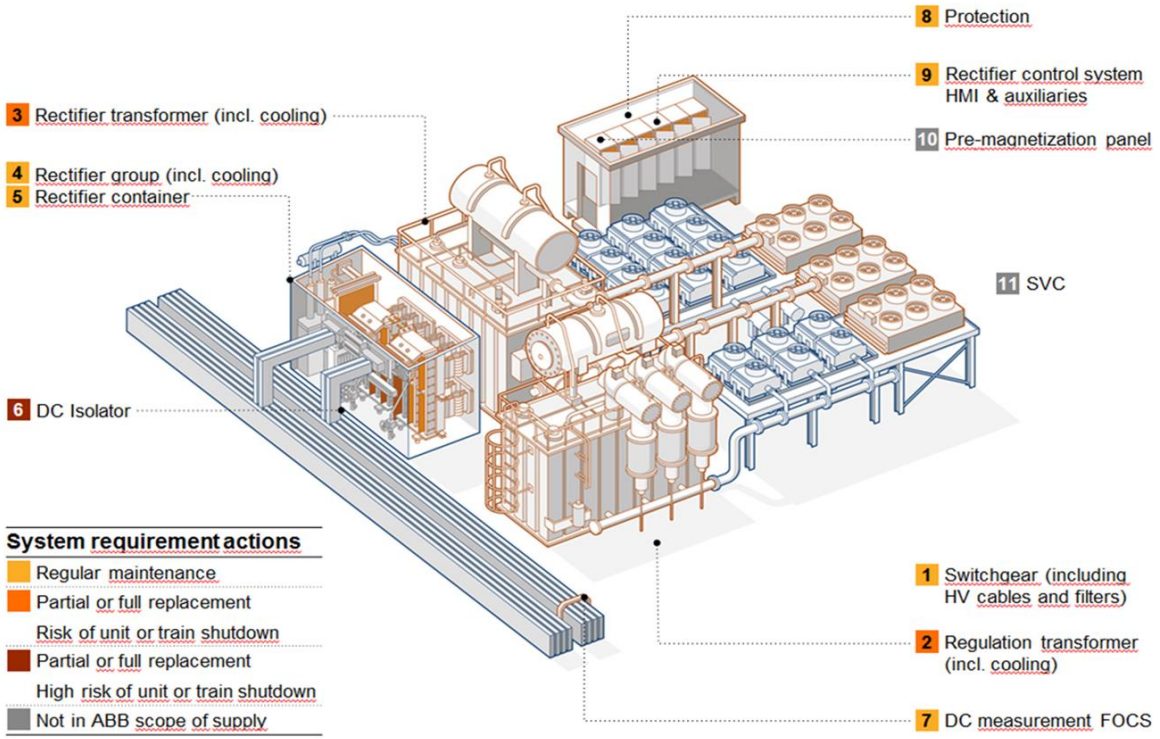
Safety is an integral part of our daily working business.

Our local presence around the globe to keep your plant running at all times.

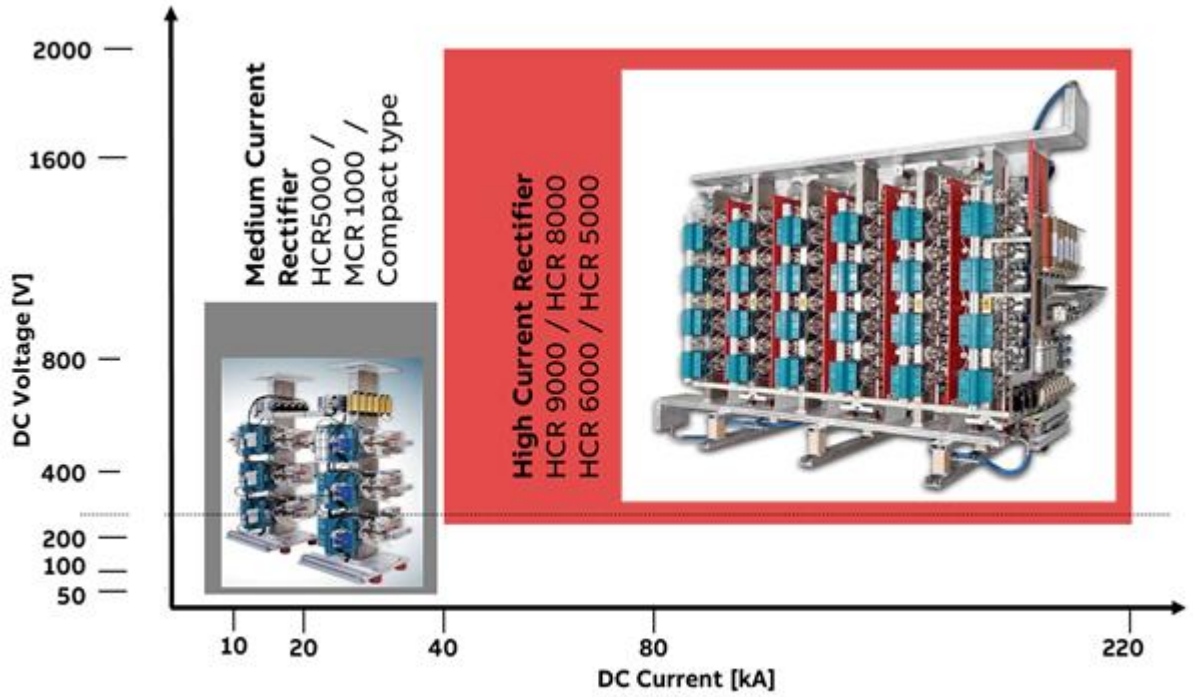
Product Portfolio

The No. 1 choice for a total HPR system approach

From HV/MT to DC busbars



Comprehensive DC power range.



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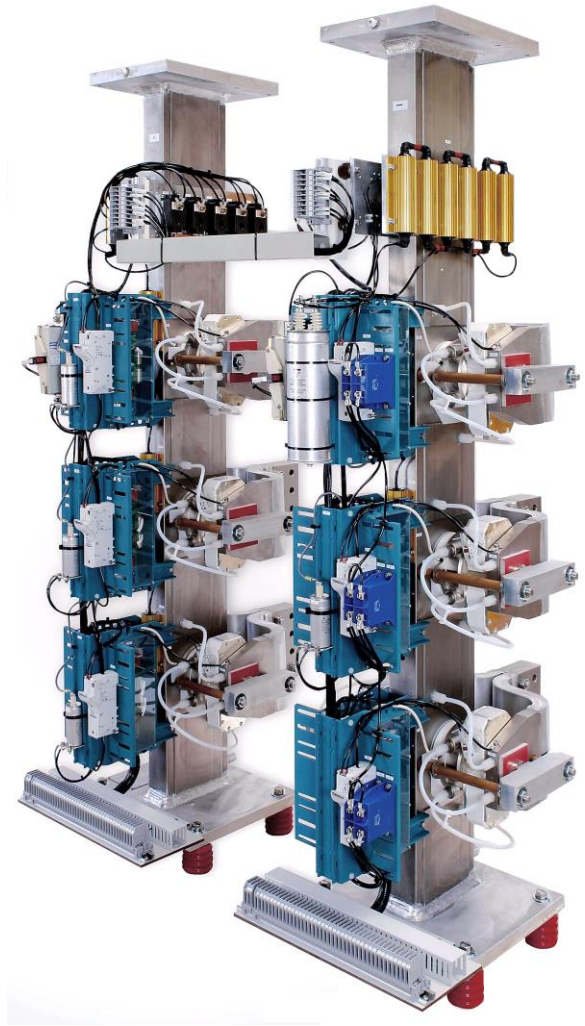
Product Portfolio

Medium Current Rectifiers (MCR) - since 1999 with more than 250 in operation

MCR1000 - Main Technical Data

Power Ratings	Up to 1000Vdc Up to 100kA 50/60Hz
Connection	3” or 4” thyristor or diodes DB or DSS 6 or 12 pulses Deionized water / glycol mixture
Installation	Indoor IP00 Indoor IP21 (enclosure) Outdoor IP54 (container)



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Product Portfolio

Medium Current Rectifiers (MCR)

MCR1000, Chlor-Alkali

Outdoor 15kA 200Vdc Thyristor 6 pulses

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Product Portfolio

Medium Current Rectifiers (MCR)

MCR1000, Electrowinning

Outdoor 25kA 250Vc Thyristor 12 pulses

7.9 MVA Rectifier Transformer OLTC vacuum 19 steps
HF and PFC; MV feeder GIS; walk in container
AC800PEC controller and Master Control Panel
Only 3 SCR 4” per phase
SCR unique "plasma containment" protection
N-1

As a swiss clock …

Efficiency (avg) : 98%
Power Factor : 0,989

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Product Portfolio

Medium Current Rectifiers (MCR)

MCR1000, Electrowinning

Outdoor 135kA 360Vc Thyristor 12 pulses

58 MVA transformer NLTC
MV Swichgear GIS
Walk in container
AC800PEC controller
AC800M master control panel
Only 6 SCR 4” per phase
SCR unique "plasma containment" protection
N-1

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Product Portfolio

High Current Rectifiers (HCR)

HCR8000 / HCR9000 - Main Technical Data

Power Ratings	Up to 2500Vdc Up to 220kA 50/60Hz
Connection	4” thyristor or diode DB or DSS 6 or 12 pulses Deionized water / glycol mixture
Installation	Indoor IP00 Indoor IP21 (enclosure) Outdoor IP54 (container)

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Product Portfolio

High Current Rectifiers (HCR)

HCR8000, Aluminum Smelting

Outdoor 60kA 1150V Thyristor 12 pulses DB

83.5MVA @ 230KV

AC800PEC controller

High overload capability

Only 10 SCR 4” per phase

4” thyristors unique "plasma containment" protection

N-1

The first one in the world!

230KV Rectifier Transformer without stepdown transformer

Real Time FAT at ABB Sorocaba, Brazil

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Product Portfolio

MCR and HCR Highlights

1 Customer Value

High Reliability and Efficiency

- Minimized number of components ~ 40% less compared to other standards
- High EMC immunity by optical transmission of gate pulse for the SCRs
- AC 800PEC controller MTBF 25 years
- Long-term stable contact surface for semiconductors, fuses and bolted connections by nickel plating
- Minimum amount of bolted connections
- Double side water-cooled for the semiconductors and fuses
- WCU parts made of stainless steel
- Longest lifetime, a properly maintained ABB rectifier can last more than 25 years

2 Customer Value

High level of protection and safety

- Integrated RC snubber
- Semiconductor and fuse I2T test
- Unique semiconductor protection ring
- Individual semiconductor temperature monitoring (optional)
- Fully integrated fused overvoltage and surge protection
- Fast and precise control by AC800PEC
- 3kV insultation level for FMU between control and power bridge

3 Customer Value

Low maintenance

- Minimum amount of cooling hoses by integrated manifolds and water channels
- Preloaded clamping yoke with true force indicator
- Few rectifier's components and control devices
- Extensive predictive monitoring
- Remote support ranging from software and control trouble shooting to full guidance in the field via virtual applications.
- Global presence for service

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Power is nothing without control ...

AC800 PEC - High-performance control for the toughest conditions

ABB’s AC 800PEC controller provides high processing power with very short cycle times. It has been specially designed for power electronic applications as the High-Power Rectifiers. It is a powerful hardware for better controlling that **meets the high-speed tasks required by power converters and low-speed tasks usually handled by PLCs**, all this combined into a **single device.**

AC 800PEC control systems provide state-of-the-art for control and regulation of High-Power Rectifiers. **One controller is able to control a 12 pulses** rectifier system.

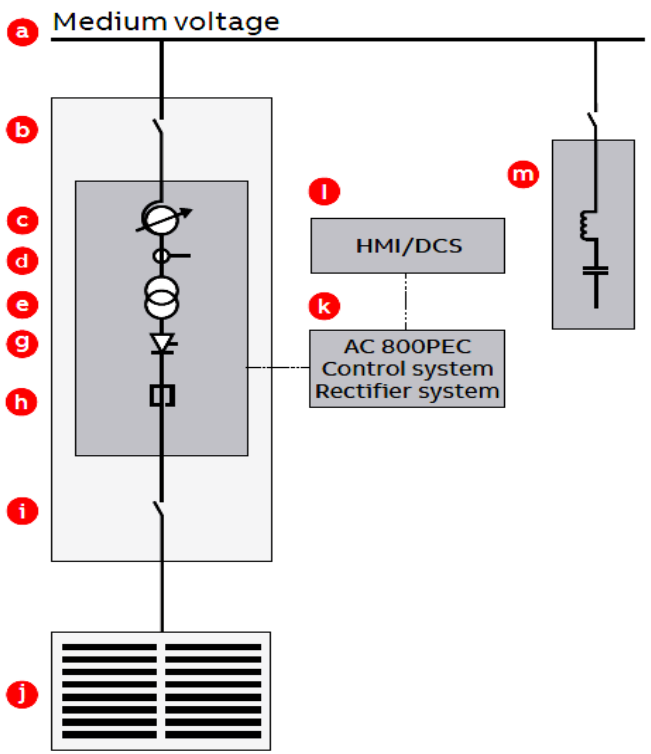
Get yourself and your plant ready for the digital future.

PSR1 → PSR2 → AC 800PEC Gen3

Product Portfolio

AC 800 PEC Controller G3

High-performance control



AC800 PEC – Unique Benefits

25ns for very fast tasks (FPGA tasks) cycle regulation time.

- 40.000 times faster than conventional PLC
- 10 ms to reduce the DC current to 0kA (thyristor rectifier)
- 1 ms to send trip signals for instance to the MV breaker
- N-2 mode at reduced load without rectifier shutdown
- No shutdown in case of primary undervoltage up to 100 ms

Fiber optic links without signal converters

- For fast communication between controller and I/O devices
- CPU completely isolated from I/Os
- All peripheral devices including the thyristors' firing boards are linked via fiber optic connections directly with the main CPU
- High immunity to electromagnetic interference

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Service Portfolio

Tailored to fit your needs

Life cycle services for your plant…

ABB is your universal partner. We cover the entire high power rectifier service portfolio of all product types. Our experts will support you throughout the whole life cycle of your equipment in order to evaluate the best possible solution.

With more than 100 years' experience, ABB is your partner for reliable equipment and a successful future. Whatever rectifier services and solutions you need, we have the answer. We know how to ensure safety and reliability for your complete high power rectifier system which is essential to your success – from start-up and commissioning through its entire life cycle

Local Service Centers in South America:

- Sorocaba, Brazil
- Santiago, Chile
- Lima, Peru

Overview of ABB's service offering …

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Control upgrade for High Power Rectifiers

Extend the life cycle of your assets

ABB's control upgrades are a cost and time-efficient answer to improving performance and extending the life cycle of its High-Power Rectifiers. The control upgrades are an attractive alternative to the more comprehensive spare parts and maintenance programs.

HPR control platforms are designed with specialized electronic equipment. In an age of rapid technological progress such equipment can become obsolete relatively quickly, while rectifier and its transformers can last decades.

The upgrades deliver the latest in controller technology to extend the life cycle of your assets,
along with complete life cycle support services guaranteed under ABB's Product Life Cycle Management model.

"I haven't got ABB rectifiers. Can I upgrade them to AC800 PEC control?"

For sure!

HPR Control Upgrade

Extend the life cycle of your assets

Equipment and Material

ABB Local Control Panel AC800PEC

- Containing all the components for constant current control, protection and supervision, HMI PP883 and communication protocol according to ABB standard. The control panel will be ddesigned to comply with the existing cabling terminals.

ABB LTC Pulse Amplifier Boards

- It will link the new AC 800PEC hardware to rectifier unit by means fiber optical cables. Each board (24V or 48V) triggers two SCRs. Minor installation material is included.

ABB USC Fuse Monitoring Unit

- In order to make the existing system compatible with the new AC 800PEC and includes its minor installation material is included. Insultation level 3kV.

Engineering and Services

Engineering and Project Documentation

- Site Audit.
- Concept of control development.
- Mechanical and electrical drawings including general arrangement, single line, schematic diagrams, terminal trip, cable list, control panel equipment drawings and material's list.
- Maintenance and operation manual, including control panel each part detailed description, tests certificates and revised wiring drawing.

Services

- The control upgrade is partly pre-assembled and tested.
- Installation, commissioning and start up
- Operation and maintenance training.

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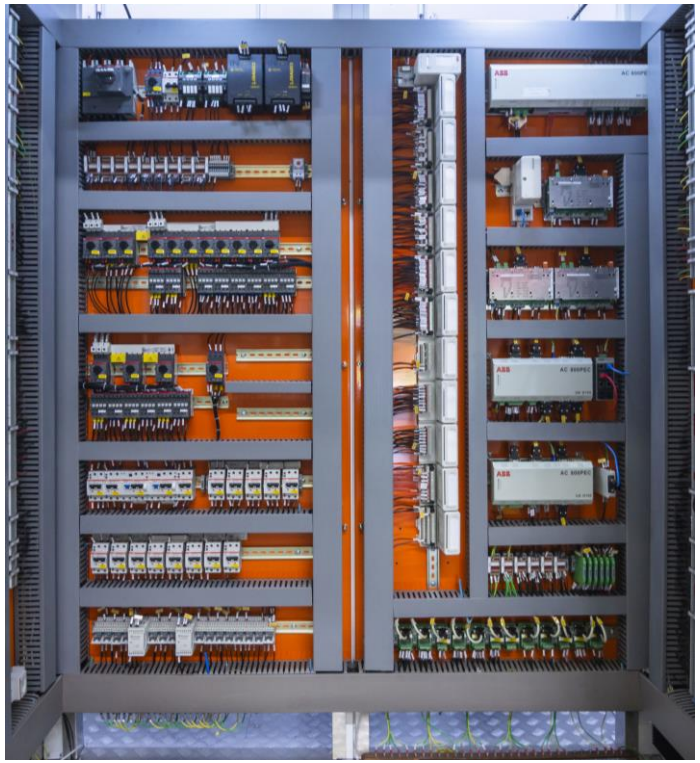
HPR Control Upgrade

Extend the life cycle of your assets

AC 800PEC High-performance control



Single Features translated to Unique Benefits

- 10 ms to reach 0kA (thyristor rectifiers)
- 1 ms to send trip signals
- N-2 mode at reduced load (rectifier needs to be checked)
- MTBF AC800PEC controller 25 years
- Predictive diagnostic functions and remote access
- Current regulation + PLC function combined in the same HDW
- High EMI immunity (fiber optic links from CPU to LTC)
- High insultation level (FMU 3kV)
- Lifetime extension of your asset and increased maintainability
- Long-term availability of spare parts, engineering and support
- Global service footprint and safe operations
- Re-use of existing terminals
- Mounting plate version (as optional) to re-use the cabinet
- Down to 40% less devices depending on the pulses number

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HPR Control Upgrade

Extend the life cycle of your assets

AC 800PEC High-performance control

Control Upgrades over the last 15 years

4 x Unipar Carbocloro (ABB)

7 x Unipar Solvay (ABB)

1 x Votorantim CNT (Siemens)

1 x Intern. Paper (Siemens)

1 x Nexa JF (Siemens)

4 x CBA (ABB)

8 x BHP MEL (ABB)

4 x BHP CMCC (ABB)

2 x BHP CMCC (Westinghouse)

4 x PDVSA (Siemens)

6 x Nexa Cajamarquilla (ABB)

2 x Codelco Salvador (ABB)

3 x Cachimayo (AEG)

2 x Lomas Bayas (Westinghouse)

2 x Quebrada Blanca (Westhingouse)

4 x Amsa Centinella (GEC Alstom)

1 x Nouryon Veracel (ABB)

1 x Nouryon Jundiai (ABB)

4 x Braskem (General Eletric)

2 x Canexus (Siemens)

2 x Antapaccay (Westinghouse)

2 x Braskem (ABB)

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