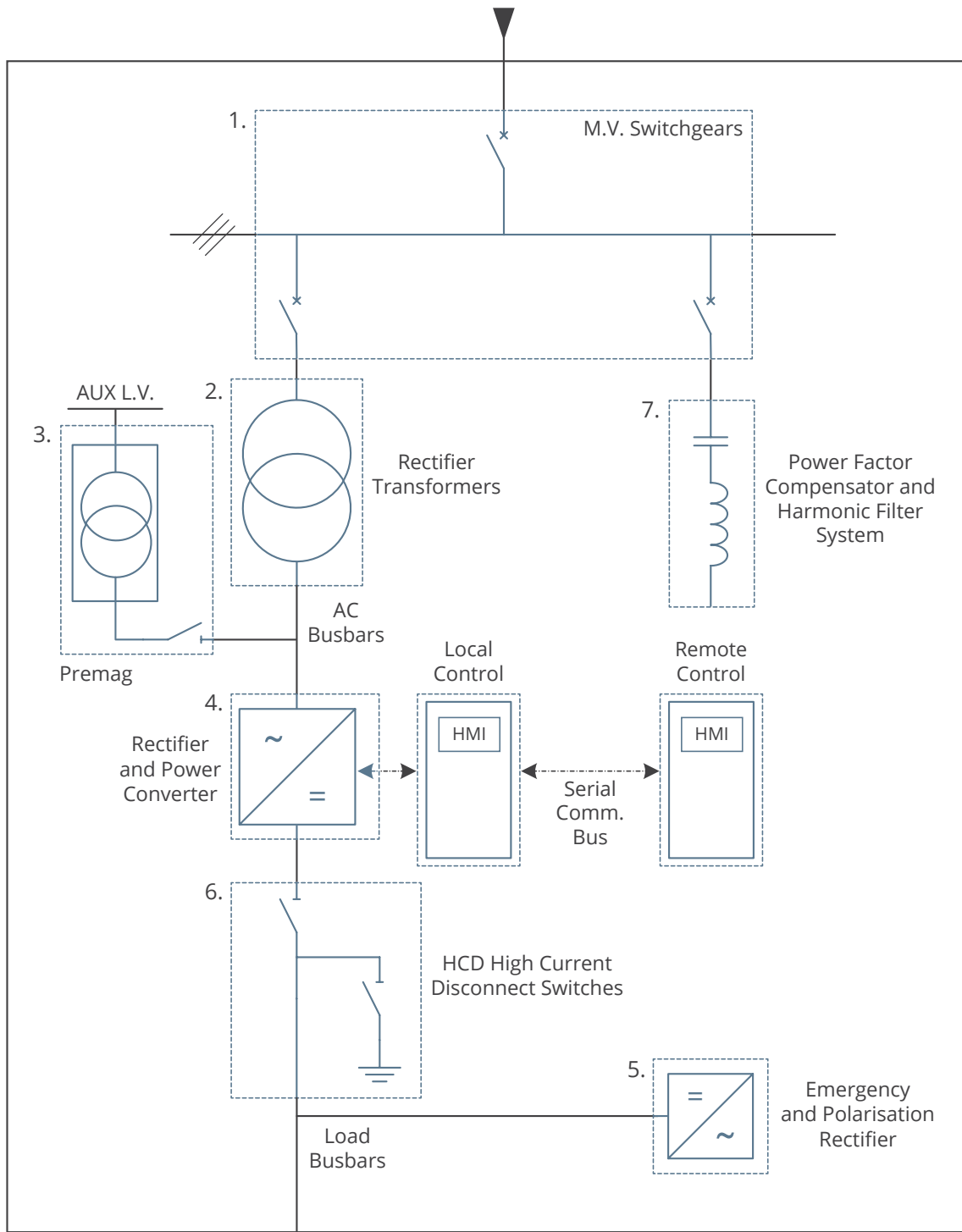




**RECTIFIER AND POWER CONVERTERS FOR
INDUSTRIAL APPLICATIONS**

Conversion Plant Single Line Diagram



CUSTOMER
PRODUCTION
PROCESS

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KNOW-HOW

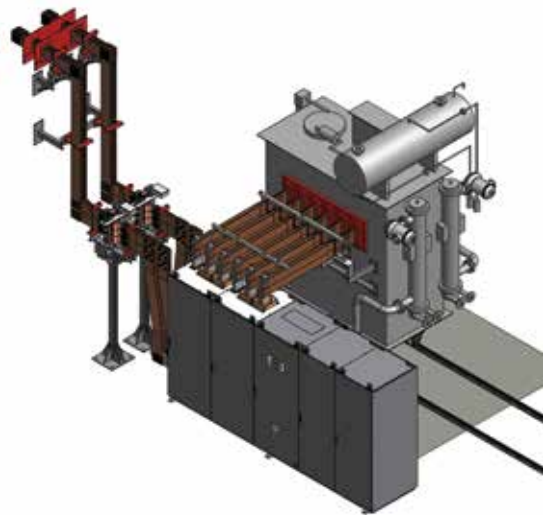
Rectifier and Power Converters for Industrial Applications

Founded in 1950 to design and manufacture High Power Converters, FRIEM continued to develop its know-how in energy conversion particularly for the electrochemical industry.

In 1956 FRIEM produced and installed its first 50kA Rectifier Unit for application in Chlor-Alkali industry. Thanks to the experience matured, in the 60's FRIEM was able to manufacture units rated up to 110kA and, at the absolute forefront in technology, to design the first Thyristor Rectifiers.

With continuous investments in research and development, FRIEM is leader in the new technologies of High Power Converters, Diodes, Thyristors or IGBTs type, with the most advanced Digital Regulations and electronics.

Today FRIEM forms a Group of Companies specialised in Electromechanical Equipment, able to provide the best solutions for Industrial, Traction and Renewable Energy applications.



MV Switchgears



MV Switchgears are used in Power Distribution and Industrial plants for supplying, protecting and switching the main power by means of the following equipment combined according to system requirements:

- Circuit Breakers
- Load Break Switches
- Disconnecting Switches
- Contactors
- Multifunction Protective Relays
- Voltage Transformers
- Current Transformers
- Fuses

A full line of Switchgears, available in Metal Clad and/ or Metal Enclosed execution, can be offered for a wide range of voltages and currents allowing to comply with the most demanding requirements:

- Un: 3,6/7,2/12/17,5/24/36/40,5 kV
- In: 400/630/1250/1600/2000/2500/3150/4000 A
- Isc: 16/20/25/31,5/40 kA up to 3 sec

Our Switchgears are tested in independent laboratories according to the latest relevant IEC standards. The switchgears are manufactured by AKTIF ELEKTROTEKNIK, a company which joined our group in 2009, in its factory located in Ankara under ISO9001/2008 quality system. More than 20.000 Medium Voltage Switchgears have been produced and installed in substations all over the World since 1989.



Rectifier Transformers



FRIEM designs the complete Rectifier System granting reliability, availability and performance. The Rectifier Transformer is fully integrated in the System through a detailed Technical Specification and optimising the connection to the Rectifier.

- Specialised, experienced and well-proven manufacturers
- Type: liquid-filled or dry-type cast-resin
- Capacity: up to 200 MVA
- Primary Voltage: up to 220 kV
- Connections: full-wave (bridge) and half-wave (double star) with IPT
- Tap changer: No-Load (NLTC) or On-Load (OLTC)
- Multi-pulse topologies available: 6, 12, 18, 24 and more pulses
- Cooling system: ON-OFF/AN-AF-WF
- Regulating autotransformer available in the same tank to allow on-load coarse voltage regulation.
- Saturable reactors available in the same tank to allow on-load fine voltage regulation.
- Design, manufacture and tests according to IEC and IEEE/ANSI standards.

Designed to meet all types of environmental conditions

- Extreme temperatures from -50°C to +55°C
- Altitude over 4000 m asl
- Corrosive atmospheres
- Seismic zones
- Hazardous areas

All cooling system types available, by means of mineral oil or less-flammable fluids, air or water external cooling mediums, natural or forced circulation.

Protection Features

- O/C, O/V, U/V, Phase Sequence Protection
- Full Temperature Monitoring and Thermal Protection
- Cooling Circuit Monitoring (Pressure, Flow, Leakage, Conductivity)
- On-line oil gas analysis (option)

Special design for Rectifier Application

- Stray losses reduction: transposed cable
- On-Load Tap-changer: MR
- Stainless steel wall for high current bars
- Connections to Rectifier optimised: reduced bars and losses
- Interphase Transformer oil cooled
- Saturable Reactors oil cooled

PREMAG

Transformer Premagnetization Unit



During the uncontrolled energisation of transformer, the large transient current due to flux saturation in the core, which is called inrush current, can reduce the transformer's life due to the high mechanical stresses involved, and can also lead to the unexpected operation of protective relays and power quality reduction. This transient current affects costing time and money as the engineers have to examine closely the transformer and the protective system, to check for faults. The large transient current also causes serious electromagnetic stress impact and shortens the life of transformer. The over-voltage resulting from the inrush current may cause damages to other power apparatus. FRIEM dedicated engineering to provide a solution to avoid magnetization peak current during start-up of main rectifier transformer: the Premag unit. Concept of premagnetization is to pre-magnetize the transformer core from an independent source in order not to have a huge voltage variation at the insertion, thus limiting the inrush current. The Premag has a specific design for each transformer or set of transformers.

Technical Features

- Premag is able to operate with transformer connected to HV or MV networks and at 50Hz or 60Hz
- Premag is suitable for Vacuum or Gas insulated Circuit Breakers
- Premag is able to operate with OLTC equipped Transformers as well with OCTC equipped Transformers
- The premagnetizing cycle will be managed by the PLC automatically at the act of commanding the closure of the MV circuit breaker (operation of the OPEN/CLOSE key on the rectifier control panel)
- At the act of commanding the closure of the MV breaker the PLC will receive the request for closing, will check for all the interlocks and then implement the premagnetization cycle
- Premag intervention can be inhibited, in case of need, using a dedicated function on the HMI

Rectifier and Power Converters



With more than 60 years experience FRIEM is World Leader in the design and manufacturing of Special Rectifiers and Power Converters. Reliability, availability and efficiency are granted by our dedicated solutions for the power section and for the control. Moreover we can test the Rectifiers up to more than 50kA and the Power Converters up to 1 MVA in our Test Rooms. FRIEM is capable of supplying air, water and deionized water cooled Rectifiers and Converters giving the customer a complete Conversion System tailored on his application and complying with IEC or ANSI/IEEE Standards.

Advantages and Protection Features

Reliability and Availability

- N+1 Semiconductors redundancy: standard
- Cooling System redundancy: standard
- Control System self-diagnostic: standard

Efficiency Short Delivery and Start-Up Time

- Proprietary Internal Busbar design with reduced losses
- Simplified design of Transformer-Rectifier Connection
- Optimised design for phases and thyristors balancing

Short Delivery and Start-Up Time

- Reduced delivery time thanks to Modular design
- Reduced installation and commissioning time
- Fast Start-up and operation turning with the dedicated Digital Regulator

Safety

- Latest IEC and ANSI/IEEE Standards
- FRIEM design protection devices

Protection Features

- O/C, O/V, U/V, Phase Sequence Protection
- Overcurrent and Short circuit protection at the Rectifier Input
- Semiconductor Protection and Alarm devices
- (N+1) or (N+2) Semiconductor redundancy
- Automatic Protection against Output Circuit Opening
- Supervision and control of current sharing between Electrolysis Cell Lines in parallel
- DC Earth Fault protection
- Arc Flash Protection
- Free Wheeling System
- Full Temperature monitoring and Thermal protection
- Thyristors/Fuses temperature monitor
- Cooling Circuit monitoring (Pressure, Flow Rate, Conductivity)

Rectifier and Power Converters



Design and Manufacturing

Power Section

- Exclusive Aluminium extruded Busbars
- High efficiency and high dynamic stress withstand
- High reliability and long life operation due to reduced operating temperatures
- Optimised Nr. of Semiconductors and N+1 Valves redundancy as standard
- Non-Magnetic material Rectifier Cubicle
- Simplified design of Transformer's Phases Connections
- Optimised Design for Thyristors balancing
- Easy maintenance

Cooling Section

- Deionised to raw water Cooling System (dWFWF)
- Deionised water to forced air Cooling System (dWFAF)
- Monitoring of temperature, under pressure, min flow, min and max level, high conductivity of deionised water
- 50% or 100% redundancy
- Open or enclosed section
- Easy maintenance

Control Section

- Digital regulation (FRIEM DRP) for Diodes, Thyristor and IGBT
- PLC and OP control and automation (different brands available)
- Hot and warm PLC redundancy
- Fiber Optics Thyristors and Control connection
- Redundant DC Current measure
- All PLC brands available
- Local, Remote and Master control
- Remote control via Modem/Internet

DRP Digital Regulation

- 15kHz Sampling Frequency
- High accuracy regulation of current, voltage and power
- Reading and recording of all main measurements and events
- Current and Voltage Oscillographic recording and Load Profile
- Easy and fast setting of the Regulation and Protection Parameters
- Reduced commissioning and start-up time



Operating characteristics

Connection	Full Wave: Bridge - Double Bridge (Series or Parallel) Half Wave: Double Star - 2x Double Star DC/DC Converters: Step-Down - Step-up
Type	Diode, Thyristor, IGBT
DC Output Current	More than 160kA in only one Rectifier Cubicle
DC Output Voltage	Rectifier: up to 1500V DC/DC Converter: up to 3000V Up to 15,000V for special applications
Cooling	Air, Water, Deionized Water
Modular Design	Flexible solutions
Control	±0,5% standard accuracy Digital Current
Regulation	Current, Voltage and Power
Installation	Indoor - Outdoor (containerised solution available)

DRP Digital Regulators



FRIEM has developed a comprehensive line of Digital Regulators for all the different types of Power Converters. The DRP-Line concept is derived from the former line of FRIEM Analog Regulators REGAS, but has been developed on a state of the art Digital Hardware with all the consequent advantages in terms of precision, easy configuration and complete diagnostic of the load and of the machine itself.

All the different models of the DRP-Line can be either used as separated flush mounting units or combined in the same 19" 3U Rack Panel.

Besides the most advanced and flexible PID Close Control Loop for Current, Voltage and Power Regulation, the DRP Regulators also offers parameters reading and setting with a Lap Top or Remote interface with a PLC/DCS.

Main Characteristics

- Modular draw-out and compact design for configuration flexibility and easy installation and replacement
- Real time recorded measurements
- Event recording: last 20 trips available (FIFO)
- Time/event Settable Load profile and Oscylographic waveforms of current and voltage
- Programmable outputs relays, Digital inputs and outputs

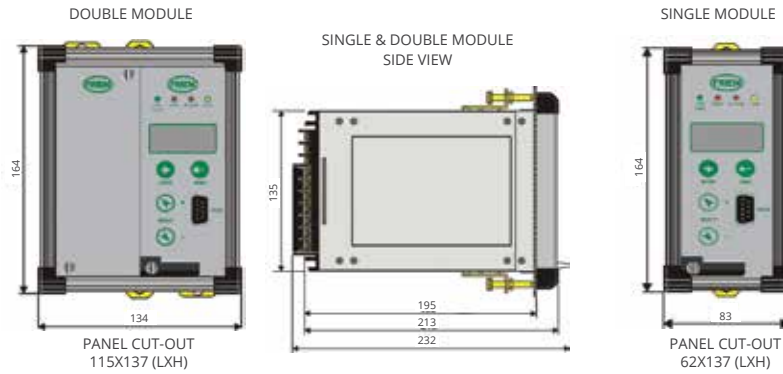
- Modbus-RTU or Pro bus-DP communication protocol for compatibility with RS485 or Fiber Optic Interface
- Internal Canbus communication protocol for I/O management
- Conformance to IEC Standards and CE Directive,
- UL-CSA approved

Protections

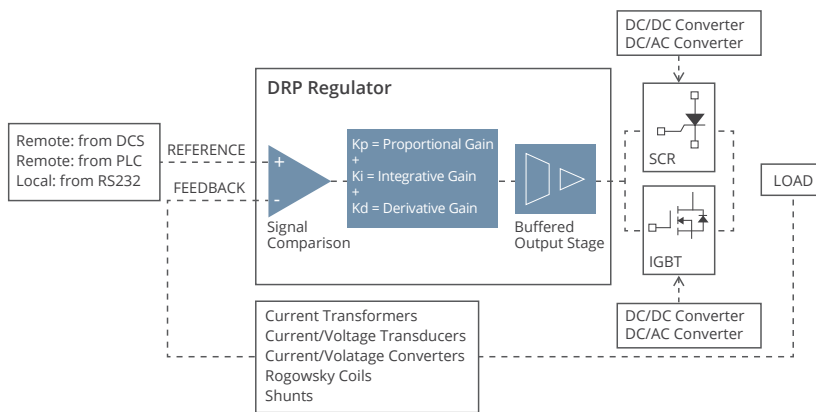
- Output Timed-current overload and instantaneous overcurrent
- Output Short Circuit and over/under voltage
- Line over/under voltage and Phase Sequence (MV side)
- Comprehensive self-diagnostic (not just memory checksums) periodically testing the complete regulator

Interface

- Simple and intuitive front user interface for parameters Interface reading and setting
- Front S232 Serial Communication Port for local interface with a PC
- FriemCom: full-comprehensive reading and setting SW for PC interface: easy and quick
- Serial RS485 Communication Port for Remote interface with PLC/DCS



Regulation Loop Operation



Models Available

Type	Application	Main Features
DRP-2	AC/AC Static Voltage Variators	PID Regulation: Current Voltage and Power Protections: F50/51, F27, F59, F37
DRP-2D	DC/DC Converters	PID Regulation: Current Voltage and Power Protections: F50/51, F27, F59, F37
DRP-1Ph	Single Phase DC/AC Converters	PID Regulation: Current Voltage and Power Protections: F50/51, F27, F59, F47, F37
DRP-3Ph	Three Phases DC/AC Converters	PID Regulation: Current Voltage and Power Protections: F50/51, F27, F59, F47, F37
DRP-6T	Bridge & Double Star Rectifiers	PID Regulation: Current Voltage and Power Protections: F50/51, F27, F59, F47, F37
DRP-6/6T	Bridge & Double Star Rectifiers in Series	PID Regulation: Current Voltage and Power Protections: F50/51, F27, F59, F47, F37
DRP-2R	Diode Rectifiers with Saturable Reactors	PID Regulation: Current Voltage and Power Protections: F50/51, F27, F59, F47, F37

Outdoor Containerized Rectifiers



FRIEM has developed containerized rectifier suited for outdoor installation especially in harsh weather and climatic conditions to provide utmost reliability, availability and efficiency throughout complete process.

Technical Features

- Made of Metal or non-magnetic material, suitable for a dusty and industrial environment
- The Container is walk-in type, with door, providing enough space to perform all required rectifier maintenance activities inside
- The Container is provided with temperature sensor (two stages), lighting facilities, cooling system, and doors with safety bar
- Protection degree: IP65
- Redundant air conditioning or air-to-water system
- Containerized Rectifier from 15 kA - 120 kA (DC CURRENT)
- Approx. dimensions:
10000 x 2500 x H 2600/3200 mm

Emergency and Polarization Rectifiers



The Emergency and Polarization rectifiers are designed to operate in "Constant Current" mode giving a constant DC current output to electrolyser cells during the tripping/non-functioning of main rectifier, with maximum DC current clamping facility irrespective of output voltage. The Emergency and Polarization is continuously connected to the cells and operates in Stand-by mode. Thanks to the communication with the main rectifier control panel the system grants maximum performance in terms of time response, safety, availability and reliability. An Emergency and Polarization rectifier consists essentially of one dry type transformer, one thyristor rectifier with associated power, control and auxiliaries sections.

The equipment includes all the devices required for synchronization, control, signalling, alarm and protection necessary for a satisfactory operation of the unit. Thanks to FRIEM design and flexibility the emergency and polarization rectifier can be customized to meet and satisfy the different requirements of our customers.

Technical Features

- Latest IEC and ANSI/IEEE Standards
- Power supply: low voltage 3-phase
- Semiconductor: thyristor, diode or IGBT
- Protection degree: IP20 to IP54
- Cooling System: air forced
- Air conditioner as optional
- Dry type reactor on DC side as standard
- Digital Current and Voltage control as standard
- PLC and HMI as standard

Operating characteristics

Connection	Full Wave: Bridge - Double Bridge (Series or Parallel) DC/DC Converters: Step-Down - Step-up
Type	Diode, Thyristor, IGBT
DC Output Current	Up to more than 3000A in only one Rectifier Cubicle
DC Output Voltage	Up to 1500V
Cooling	Air, Water, Deionized Water
Control	±0,5% standard accuracy Digital Current
Regulation	Current, Voltage and Power
Operating mode	Stand-by on-line
Installation	Indoor - Outdoor (containerised solution available)

HCD High Current Disconnect Switches



FRIEM can supply a wide range of high current isolating/disconnect switches.

Identified case-by-case among different technologies, in order to achieve the most efficient and maintenance-friendly layout.

Protections

The isolating/disconnect switches can either use sealed contact assembly, to increase safety and withstand chemical environment, or mechanically independent mobile contact arms, provided with high-pressure springs. Electrical contacts are provided with silver to silver contact.

Upon request the isolating/disconnect switches can be customized with input and output terminals in aluminium or silver-plated copper, two-poles or change-over design by side association of two disconnects, manual, pneumatic or motorized actuators.

All high current disconnect switch manufacturing activities meet ISO 9001 standards.

Installation

Isolating/disconnect switches can be installed in any position and directly into the busduct system. Switches are available for connection either to Copper or to Aluminium busduct bolted or welded.

Disconnects are self-supporting, however busbar supports must be designed to withstand the switch's

additional weight. All the engineering needed for the installation of the switches and their installation to the busduct is done by FRIEM.

The disconnect switches can be operated at no load (No-load Disconnect switches) or on load (Load-break Disconnect switches).

Technical Features

- Rated Current: up to 72 KA
- Very low contact resistance
- Low voltage drop
- Low contact heating
- Low maintenance
- High Electrical and Mechanical durability
- Easy connection to:
 - Aluminium busbar by welding
 - Copper busbar by bolting
- Wide modular range
- Load Break option up to 1200Vdc
- Large customization possible with:
 - Actuators (Motor, pneumatic, manual)
 - Accessories (limit switches, locks, temperature sensors...)
- Safe operation

Applications

- Output Rectifier Isolation
- Cells isolation for Electrolytic process
- Large Power Supply isolation

Power Factor Compensator & Harmonic Filter System



Aiming at energy saving and power quality FRIEM designs and supplies Power Factor Compensation & Harmonic Filter Systems dedicated to rectifying plants. Each system consists of a three-phase capacitor bank connected in series with three single-phase filter reactors connected to the MV line, in order to tune the relevant series resonance frequency of the circuit.

Technical Features

- Latest IEC, ANSI/IEEE and IS Standards
- Air insulated reactors designed for outdoor/indoor installation
- Oil insulated capacitors designed for outdoor/indoor installation
- Support frames made of hot dipped galvanized steel
- Connection bars made of copper conductors
- Vertical or Horizontal installation
- Metal-enclosed solution for outdoor/indoor installation

Accessories and Optionals

- Current Unbalance protection
- Over current protection
- Three phase multifunction microprocessor protection relay
- Optimized management of the system made by the rectifier control panel
- Disconnect switches for maintenance purpose
- Surge arresters

Service and Maintenance



We aim to be the partner of our Customers, sustaining their operations and results with our dependable solution, supporting them for the whole life of the equipment.

Since the early fifties, when FRIEM started to design and produce High Power Converters for all Industrial Application, continuity of production has always been FRIEM's main focus.

For this reason, beside designing and producing to the highest quality, FRIEM also developed an After-Sales Service and Assistance Organization, to provide a better and quick solution to different necessities.

FRIEM Service Department can actually count on a team of more than 20 technicians in more than 10 Countries are available to provide on-site support.

Dedicated training can be provided to the Customer's Engineers in FRIEM's Test Room or to the Customer's site.

This means to operate immediately on the equipment in case of fault, but also keep a record of each customer's machine, in order to provide the proper spare parts, or in case of obsolescence, to provide the most efficient technical and economical solution.

Our Service products are tailored on Customer's needs



Need assistance during the erection of your new equipment?

Erection supervision

Our installation supervisors can coordinate the installation company in order to minimize installation time losses and to proper follow FRIEM installation documentation.



Need to start-up your new equipment with no issues?

Commissioning & Start-up

Thanks to its team of specialized technicians and to a network of Local Service Partners, FRIEM can provide Commissioning and Start-up of its equipment all over the world.



Need to increase your equipment lifetime and prevent failures?

Yearly Maintenance Contracts

The right way to extend the lifetime of the equipment, by scheduling maintenance customized activities in advance, monitoring the spare parts stocks.



Need 24 hours/7 days assistance and top priority intervention?

On call service

A top class service assistance: 24 hours/7 phone days availability and minimized reaction times with an immediate feedback of our skilled engineers.



Need periodic specialized remote support?

Remote supervision

The remote monitoring of the equipment allows our skilled engineers to provide technical support via phone, e-mail and web connection.



Need to improve the energy efficiency of your plant?

Conversion system efficiency assessment

Our specialized technician will evaluate the actual efficiency of the conversion system with proper high accuracy metering devices, in order to propose how to improve its performances.



Need to minimize the risk of shutdown due to obsolescence of the equipment?

Revamping and Upgrade

FRIEM Service Department can propose the best technical and economical solution in order to defeat the obsolescence of the spare parts or to improve the actual operation of the old conversion system.



Need to know how to use and maintain a complete conversion system?

Training

Dedicated training can be provided to the Customer's Engineers in FRIEM's Test Room and facilities or to the Customer's site.







Power Supply System

FRIEM S.p.A. - Via Edison, 1
20090 Segrate - Milano - Italy
Tel.: +39 02 87235350 Fax: +39 02 26923036
sales@friem.com
www.friem.com



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