framatome

RODLINE

The most used digital rod control system in the world


1 RGL 014 AR
LNE 230V AC
LMA 230V AC
FAULT
Cycler State / Sequence
Double-hold
SG Test
MG Test
LC Test
Exit Test
Hold
Withdrawal
Insertion
Release
Ful Current
Reduced Current
Zero Current
Data-link Activity
Test Lamps
Power Cabinet Faults
Operation Fault
Power Supply Fault
Non-blocking Fault
Cycler Operation Faults
Input Fault
Software Fault
Hardware Fault
Output Fault
Cycler Power Supply Faults
LNE Power Supply Fault
LMA Power Supply Fault
Realignment Mode
Realignment
Rod 1
Rod 2
Rod 3
Rod 4
Faults Management
Fault-Clearing
Exit Double-hold

Principles

A complete Rod Control System control, cycler and power modules & cabinets.

The aim of the Rod Control System is to carry out the insertion and withdrawal of control rod clusters to regulate the power of the reactor and provide negative reactivity margin when the reactor is shut down.

A Rod Control System is mainly composed of a control cabinet and several power cabinets.

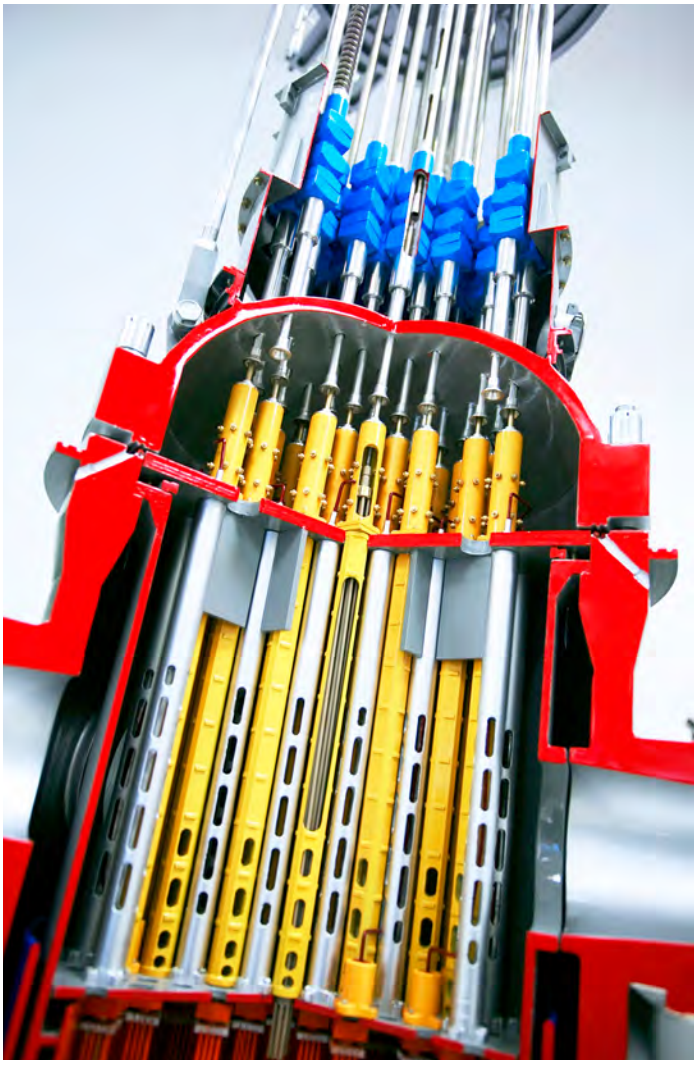
The control cabinet manages the movement of sub-banks, according to its input signals, position interlocks and the predefined individual and overlap programs. It provides withdrawal or insertion command pulses per step and per sub-bank to the power cabinets. The frequency of those commands corresponds to the speed of motion.

According to movement commands from the control cabinet, each power cabinet produces appropriate currents to the CRDM coils it controls, in order to hold the clusters in place or make them move. They represent the main part of the system equipment. For example, a modern system for a 61-cluster reactor comprises 16 power cabinets of 19-inch type, one per sub-bank.

Rodline is the result of more than 40 years of experience in more than 80 nuclear reactors. Rodline is a robust and reliable digital technology, easy to operate and maintain.

Rodline has been chosen by main programmes worldwide, such as the construction of 18 new CPR1000 reactors in China, or the modernisation of 20 reactors in France (1300MW fleet).

A robust, standardised and proven technology.



Architecture

Simple architecture for simple and effective use.

The **control cabinet** receives multiple signals: operation mode selection and manual control from the control room, temperature-control-bank speed from the process instrumentation system and authorization signals from the Reactor Protection System.

Each power cabinet comprises a logic unit – the cycler – and a set of power converters.

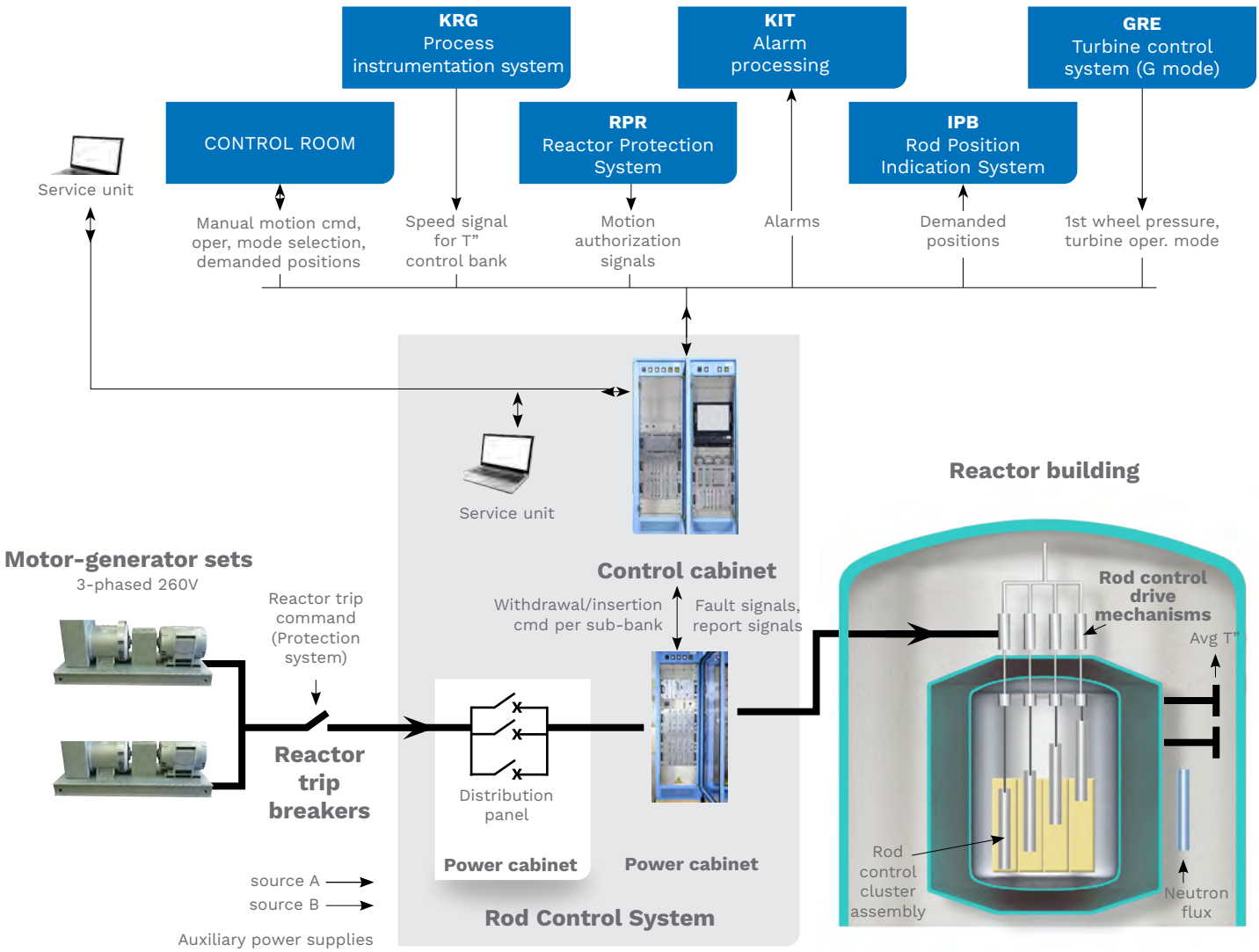
The cycler produces logical setpoints to the converters, coding the required current per coil at any time. In response to a movement command, the cycler produces a predetermined sequence of setpoints; in absence of movement command, it produces a steady reduced-current setpoint to the converters assigned to stationary grippers.

For Framatome systems, power converters are 3-thyristor half-bridge rectifiers. The power source, zigzag-coupled alternators, can withstand the high homopolar DC component of current resulting from this converter topology.

If there is a fault that may result in a rod drop, the power cabinet energizes both grippers of the CRDM it controls, to avoid a spurious reactor trip: this is the double-hold function.
The power cabinet also includes maintenance functions to allow troubleshooting and repairing while the reactor is in operation.

The sizing of the power source is typically 400 kVA.

When the power source is connected to power cabinets by means of cables rather than a busbar, a distribution panel with breakers is needed to protect these cables.




Realignment Mode
Realignment
008LA
Rod 1
Rod 2
Rod 3
Rod 4
Normal
Inhib
001CC
002CC
003CC
004CC
005CC
Faults Management
Exit
Fault
ALSYN
MDP
A or B source fault
Output voltage fault
260V-source phase fault
A source on
B source on
±15V control on
±15V monitoring on
Double hold
Setpoint change
Current fault
Full Current
Reduced Current
Zero Current
FC max
FC min
RC max
RC min
ZC max
On
Output
Gnd
SG Rack

Rodline power cabinet

Thanks to Rodline design, there is no need for an additional DC-Hold cabinet.

Rodline power cabinet usually features 1 cycler rack, 3 power racks a nd 2 transformer plates. It is also possible to build a cabinet with a single power module – i.e. 1 rod cluster control.

Rodline power module

Power modules are standardized: a same module can be used for all coils type.

Rodline technology comprises 2 types of power modules: MDP power modules and ALSYN modules. MDP modules action the CRDM by powering associated coils. ALSYN modules provide separate power supplies for current control part and surveillance part of power modules.

Each cabinet comprises 12 MDP modules and 3 ALSYN modules.

Standardised power modules
The same module is used for the 3 types of coils: SG, MG, LC. A power module includes 3 sets of parameters. At power on, the modules automatically selects the set of parameters, depending on the rack it is mounted in.

Parameters: current setpoints for the control part, current thresholds and timeouts for the surveillance part.

These modules can also be used for mechanisms with more than 3 types of coils.

MDP module

Hot-swappable power modules
When modules are unlocked on a power rack - for ex. SG - the corresponding output currents are shut off, to avoid arcing on backplane connectors.

Rods are then held by an available rack – for ex MG - the cabinet is then in double-hold state.

The operator shall initiate the double-hold before starting the operation, or the double hold will be triggered automatically.

At system level, the control cabinet is informed that the power cabinet is available for movement or not.

ALSYN module

Reduced spare parts types, optimized operational and storage costs, eased maintenance.

Rodline cycler

A large number of functions that address customer needs.

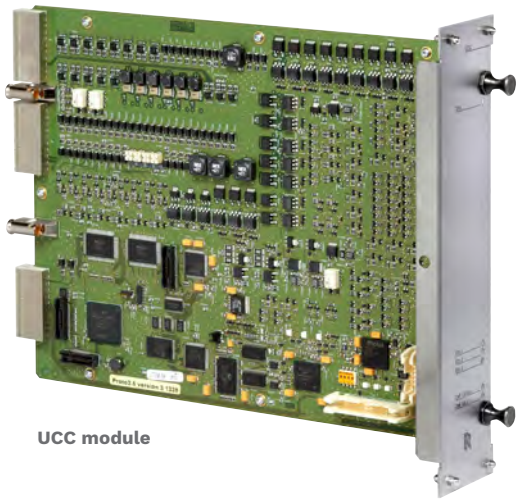
Each power cabinet comprises a logic unit – the cycler – that produces logical setpoints to the converters, coding the required current per coil at any time. In response to a movement command, the cycler produces a predetermined sequence of setpoints; in absence of movement command, it produces a steady reduced-current setpoint to the converters assigned to stationary grippers.

Rodline cycler is implemented using Framatome technology optimized for the Rodline power modules. It comprises 3 standardised modules: power supply (ALIC), Cycler main board (UCC) and HMI board (IHMC).

The cycler can also be implemented using non-proprietary PLC, the interface and size remain the same.

Main functions of the cycler

- Management of power racks:
  - Produces logical setpoint signals to power racks: FC, RC, ZC
  - State/sequence: simple hold, withdrawal, insertion, double-hold,
  - SG test, MG test, LC test, 1st step withdrawal, release (ATWT)
  - Manages faults from power racks
  - Produces the double-hold command if needed – fail-safe signal.
  - Produces LC-inhibition signals to the LC rack for realignment
  - Manages the test of a power rack while rods are held with another available rack. The test is performed using push-buttons – on an HMI board (IHMC)
- Communication link with the control cabinet & computerized HMI
- Fault management for the cabinet
- Spare fault inputs
- I/Os to the local HMI (IHMC)



UCC module

IHMC module

ALIC module

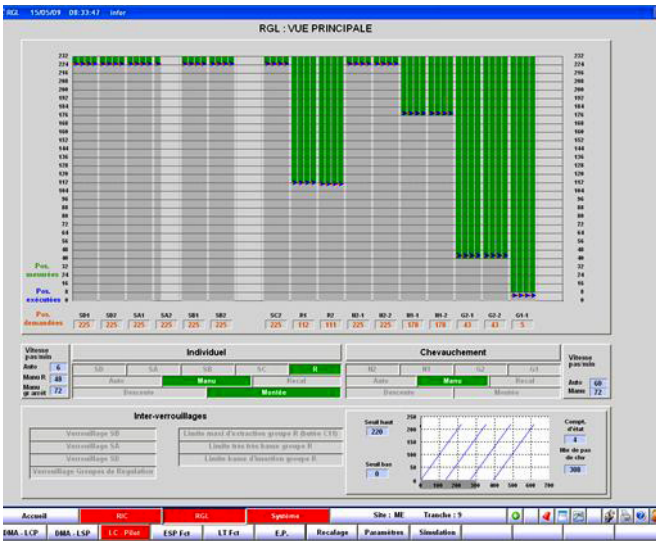
Rodline control cabinet

Cycler and control can be implemented with Framatome technology or third party PLCs.

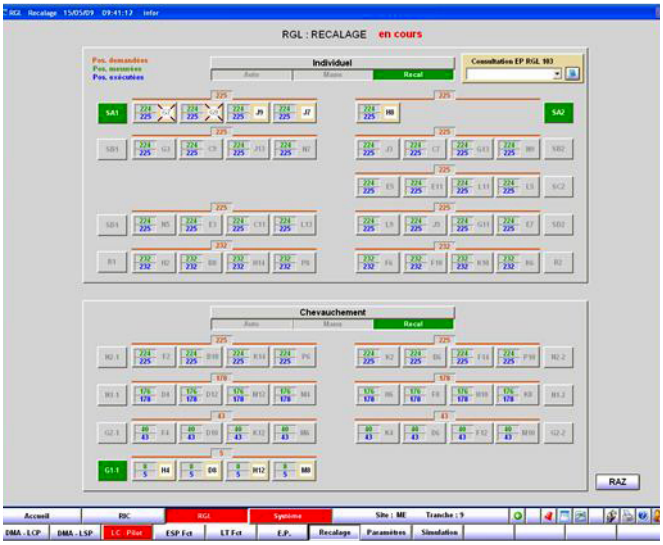
The control cabinet receives multiple signals: operation mode selection and manual control from the control room, temperature-control-bank speed from the process instrumentation system and authorization signals from the reactor protection system.

The control cabinet is custom designed. It can be implemented with Framatome safety platform Spinline, or with off-the-shelf PLC meeting performance requirements.

A customized HMI can be provided on demand



Operator main view



Realignment commands

Benefits

Greater performance in terms of precision, response time and reliability.

Rodline is a reliable, available, easy to operate and maintain digital technology.

Rodline is the culmination of over 40 years of experience of Framatome in Rod Control Systems, with operational implementation for various scope, customers and regulators.

Rodline is already installed and operating in many plants in France and China.

Main advantages

Easy Troubleshooting

- Diagnostic: in case of a current fault, the operator knows immediately which coil and module are concerned
- Repairing: when replacing a power module, nearly everything concerning a coil is replaced: control & power functions, surveillance functions, current sensors

Small size of modules – only one coil

- A power module is made of a single PCB manufactured industrially
- Few manual operations, no wiring

Few kinds of spare parts

- Only one kind of power module for the 3 kinds of coil
- Lower manufacturing cost, lower inventory cost

Technical benefits

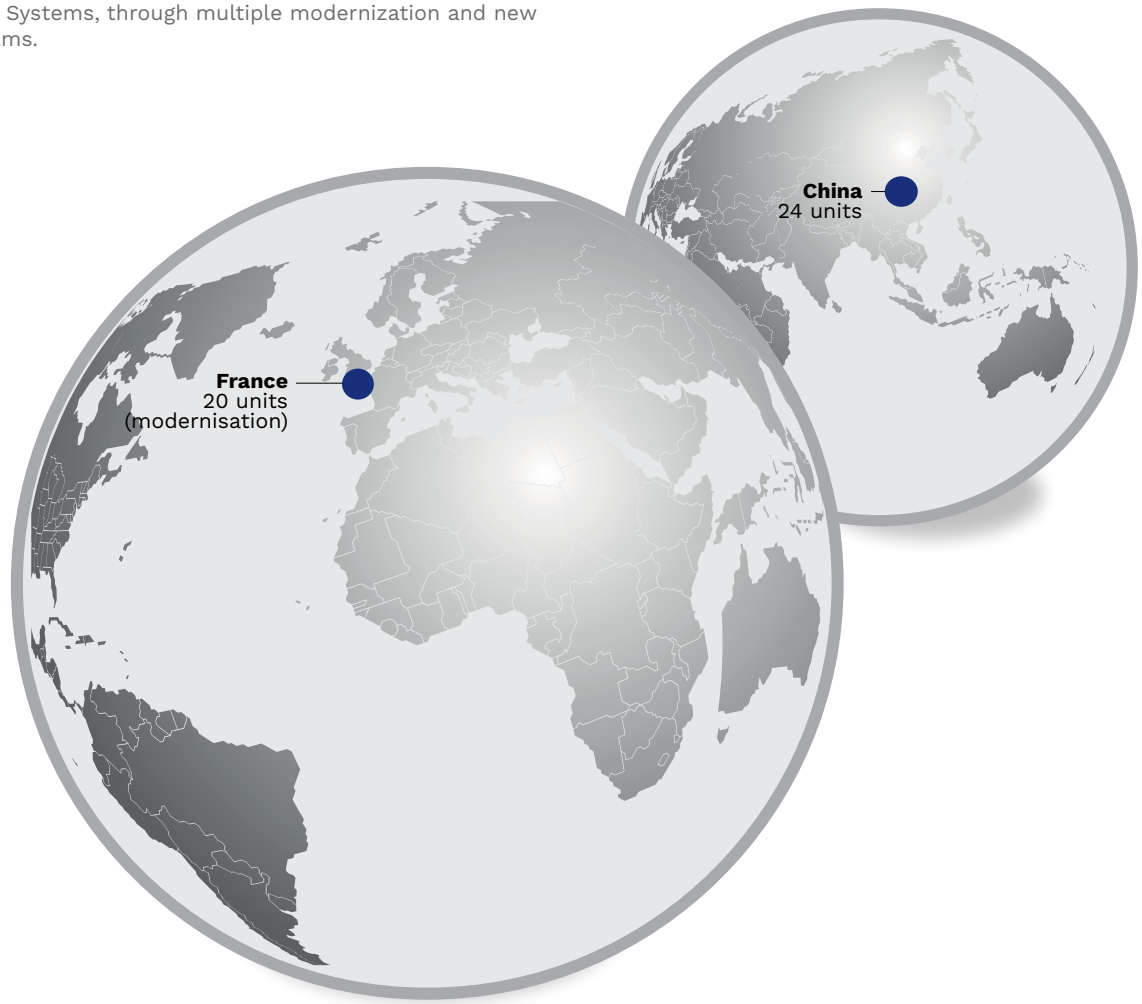
- Power modules are sized for LC, they are oversized for SG & MG
- No discrepancy of current between coils – due to T°, different CRDM vendors
- No need for LC-inhibition thyristors – Simplified system, reduced power losses
- Less hot spots in the cabinet

The reliability and safety of a modern and proven technology that can be adapted to meet customer needs and requirements of local regulators.

References

Framatome has more than 40 years of experience worldwide in Rod Control Systems.

Framatome has more than 40 years of experience worldwide in Rod Control Systems, through multiple modernization and new build programs.



China – CPR1000 new build programme
As of today, 20 CPR1000 nuclear reactors are operating with Rodline technology, for a total of 400 Rodline cabinets and 800 rod position sensors.

France – Global modernisation of 20 units (1300MW)
Framatome performs a global I&C modernisation of the 20 EDF 1300MW units, the largest current modernization project in the world. The modernisation projects covers Reactor Protection System, Neutron Instrumentation System, Rod Control System, interfaces with control room. 1000 Spinline and Rodline cabinets will be supplied during this project.

First installation has been performed in April 2015. Deployment will continue until 2023.

VD3 1300MW training platform

Framatome is an international leader in nuclear energy recognized for its innovative solutions and value added technologies for the global nuclear fleet. With worldwide expertise and a proven track record for reliability and performance, the company designs, services and installs components, fuel, and instrumentation and control systems for nuclear power plants. Its more than 15,000 employees work every day to help Framatome's customers supply ever cleaner, safer and more economical low-carbon energy.

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