

## Thyricon™ Excitation System

### The intelligent choice



**Voith Hydro is a global leader in hydropower plant equipment and services for both new and modernization projects.**

Our reputation for excellence in products and services is based on reliability, trust and commitment in long-lasting, partnering relationships with owners and operators around the globe.

This applies to overall plant engineering, as well as to single component and system design in electrical and hydraulic machines, including the entire range of hydropower plant control concepts and systems. We offer hydro automation from a

single source to ensure complete service and seamless availability for your hydropower plant and all of its components and systems.

Our automation solutions are based on a variety of subsystems that ensure a safe, reliable and cost-effective operation through our long-term process know-how and control system expertise in hydropower applications.

Thyricon, the Voith Hydro excitation product line, ensures excellence in generator control. This modular system can be customized to provide an optimized solution for HP-Generators and motors from 0,5-800 MW.

## At a glance

Today's technology meets long-term experience. Our tailor-made solutions help you to control the power generation process. The proven control philosophy applied in Thyricon Excitation Systems has been successfully implemented in a vast number of hydropower plants of every type and size all over the world.

The ability to control a hydropower unit and the quality of the electric power to provides largely depends upon the performance of the excitation system.

Voith is providing excitation systems now for more than 40 years. Only between 2009 and 2013, Voith Hydro has equipped more than 140 generators with state-of-the art excitation systems worldwide, controlling more than 10.000 MVA of power generation. The mechanical power of the hydropower plant is generated by the turbine. The connection to the electrical grid is done by the generator, and here the excitation system makes it possible to generate the electrical power and to control voltage and reactive power.

The Thyricon Excitation System is designed as an integral part of our HyCon Control System family. It provides the same look-and-feel and operation philosophy as our HyCon control systems and HyCon governors, and therefore reduces overall training, maintenance and spare parts handling effort.

By using the best hardware and software at hand, it offers the highest availability. Because of its modular and flexible design, the excitation systems can be customized to satisfy the requirements of every type of generator / motor and every type of grid requirement. Our excitation systems are designed to meet the high level of safety standards embedded in all Voith products. The Thyricon Excitation System has included all control modes required for any type of generator/motor.

### Remarkable features of the Thyricon Excitation System

- + Wide range of excitation current, accurate voltage control
- + Fulfills fast grid response and stability demands
- + Reliable technology and engineering
- + Low energy consumption
- + Easy integration into existing power stations and control systems
- + All operation modes available
- + Open communication standards
- + Independent local operation
- + Wide range of redundancy concepts
- + Hot Standby
- + Hard- and software diagnosis in the PLC controller
- + Flexible remote access solutions

## Thyricon controller

The Thyricon controller is based on highly reliable hardware and is designed for easy operation and maintenance.

All regulation and control software is engineered according to IEEE standards, which is your guarantee to obtain the best system behavior as well as reliable and safe operation within the generator limits.

The controller is designed to cope with all application ranges. Interaction with the controller is provided by a user-friendly Human Machine Interface (HMI). Easy handling is provided by means of a touch panel.

The system status and alarms can be monitored both remotely and locally. As additional function, trend displays on the operator panel are provided. All these features make this HMI an excellent diagnostic tool to accelerate commissioning and maintenance of the Voith Thyricon controller.

### Main control and regulation functions

- Automatic voltage regulator
- Field current regulator
- Field voltage regulator
- Reactive power regulator
- Power factor regulator
- Field flashing supervision and control
- Soft-start with adjustable rise time
- Fast generator field de-excitation, by inversion of excitation voltage
- Follow-up between automatic and manual channels
- Follow-up between redundant regulators

### Thyricon limiters

Thyricon limiters assure the operation of the excitation system, generator and/or the step-up transformer within their operational limits. The following limiters are implemented within Thyricon:

- Under-excitation limiter
- Instantaneous and time delayed over-excitation limiter
- Stator current limiter
- Volts/Hertz limiter

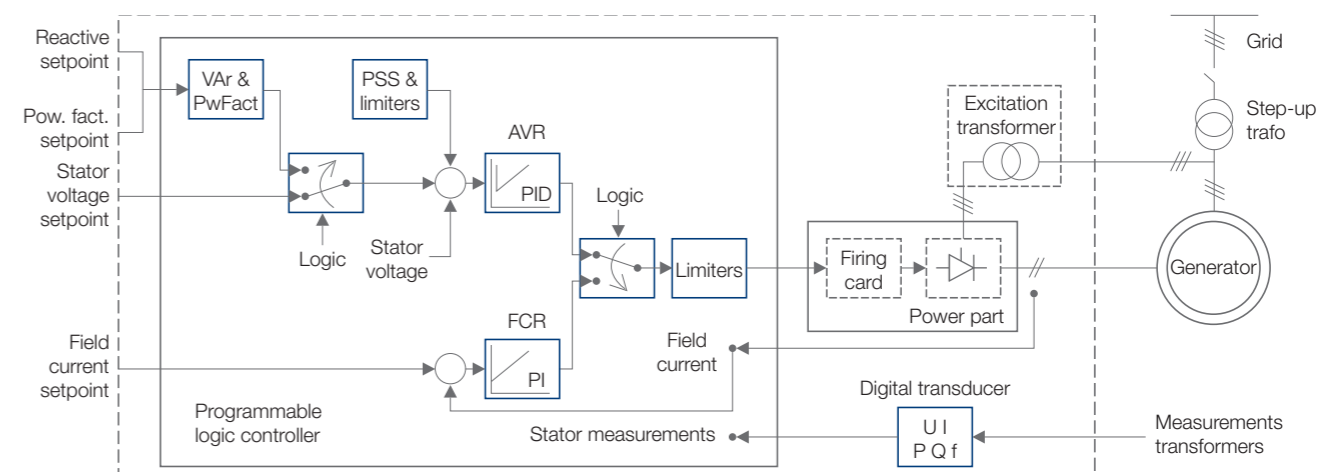
### Additional functions and options

- Trip and alarm detection and signalization
- Reactive power unloading
- Bridge and cubicle temperature monitoring
- Rotor temperature monitoring
- Excitation transformer temperature monitoring
- Excitation transformer over current protection
- Supervision and protection of main equipment parts
- Transient recorder
- Power system stabilizer according to IEEE PSS2B

High quality state-of-the-art software programming is provided by the Continuous Function Chart software tool, which allows easy visualization of control and regulation circuits in logical block format. The modular software complies with all IEEE standards, and was developed by highly experienced specialists to obtain the best possible controller for your needs. The power system stabilizer module is available as an option. It improves the stability in the grid by damping power oscillations. Voith's vast experience and powerful calculation tools ensures that the implementation of a Thyricon power system stabilizer module obtains excellent practical results.



## Thyricon Excitation System



### AVR (Automatic voltage Regulator) Hardware

The Thyricon system is based on high reliability controllers. The regulation and control software, as well as the power devices, were developed according to valid and up-to-date international standards in order to achieve a reliable and safe operation of the generator. Thyricon control routines are executed on digital Programmable Logic Controllers (PLCs) from the Siemens S7 family. Several configurations up to complex redundant solutions are available.

### Firing Board

The firing card is the interface between the AVR and the power circuit. This important task is done by the THYR4 – Bridge Controller developed by Voith Hydro. The firing card converts the control output signal from the PLC into Thyristor firing pulses, with correct phase shift in relation to the supply voltage.

### Software

The voltage regulator software consists of very clear and detailed structured modules. The detailed view of the modules makes the application easy to use. The software modules are built up from function blocks stemming from a library according to the Standard IEC 61131-1.

### Static excitation power device

#### Superior requirements on dynamic control characteristics and the need to improve the transient grid stability are clear decision criteria in favor of a static excitation system out of the Voith Thyricon family.

Low losses and fast de-excitation through a dedicated resistor that protects the generator in case of electrical faults are additional benefits making clear that Thyricon will fulfill and surpass your requirements on excitation systems.

### Power converter

The power converter is a fully controlled three-phase rectifier bridge assembled in B6C-connection.

Depending on the required output, the thyristor rectifier may consist of a single or several bridges in parallel.

The thyristors are protected by ultra fast fuses, RC circuits, and monitoring devices.

Each converter is equipped with either natural cooling or forced cooling. For maintenance reasons the cooling fans for the forced cooling are mounted in removable racks.

### Field breaker

An AC breaker is used as an excitation field breaker. It is a highly reliable, low voltage circuit breaker, requiring minimal maintenance. The circuit breaker has one or two trip coils.

Trip coils, closing coils, and motors are available in all standard voltages. A DC field breaker can be provided as an option.

### Excitation transformer

This device is specially designed and built for feeding rectifier bridges. As our standard, a high-quality cast resin transformer is provided, which withstands high short-time, is flame-retardant, and self-extinguishing.

### De-excitation

The de-excitation circuit and field over voltage protection are designed to drain the field winding energy in order to prevent damage in the generator and excitation system.

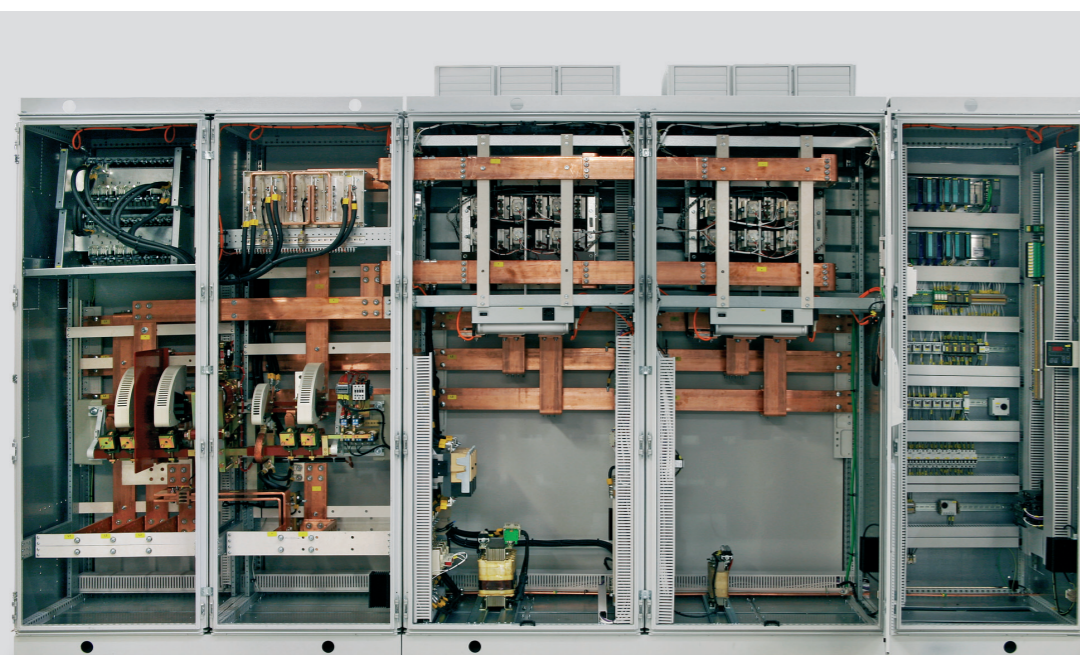
### Field flashing device

Independently of the generator remanent flux, the field flashing device provides the initial energy to the field winding during the machine starting. It can be adapted to different power supplies depending on battery and/or station supply.

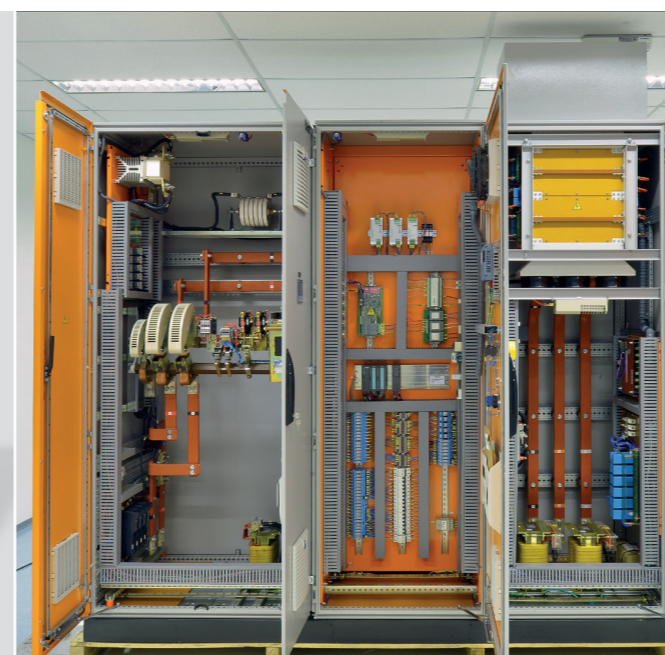
### Electrical brake

As an option, we also offer the electrical brake. This wear-free system reduces outages and increases the life time of mechanical brakes.

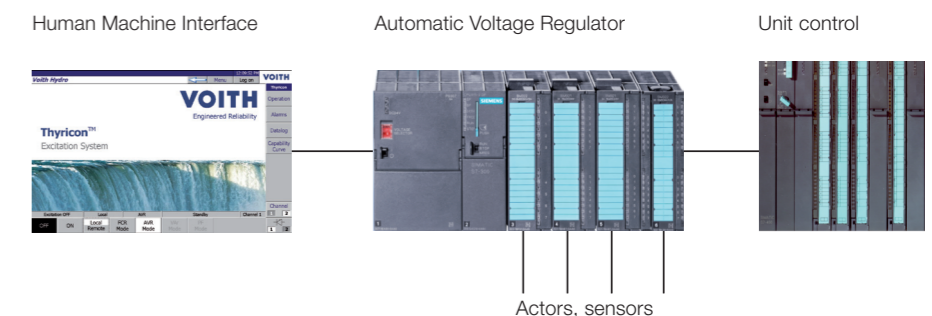
High-end static excitation for Karcham Wangto, India



Smaller size Excitation System, Serraria, Brazil



Hardware Integration



## Solution for added value

Thyricon Excitation Systems provide outstanding reliability, functionality and safety.

### Flexible system

Due to its modular structure, the Thyricon system can easily be applied to both large and small hydropower plants. In addition, the concept flexibility of the Thyricon system fits well for both new plants and modernization projects. It is our mission to have a solution for any hydropower automation challenge.

Thyricon is a highly flexible and adaptable product that can be easily implemented. With an application range up to 4,000 A rated current, at 50 or 60 Hz, it meets all protection and control requirements.

### Redundancy concepts

As a result of perfect design and the use of highly reliable components, single systems without redundancy offer an extraordinary high level of availability. In addition, we offer solutions to further increase the reliability of the system: many configurations are deliverable, including redundant controllers and fully or n+1 redundant Thyristor bridges or redundant sensors. All parts of the Thyricon family are factory-tested prior to shipment.

### Independent local operation

As an added value, our Thyricon Excitation System provides for independent local operation using an operator panel. This is helpful in cases like commissioning, re-commissioning after maintenance work or in emergency cases. All functionality to operate the system and detailed information about the status of generator and excitation is available at the panel. The comprehensive software also provides special features like high speed transient recording and special modules to support the service and commissioning team.

### Communication

To exchange information with different plant control systems, a digital communication interface is provided. Available protocols include:

- Profibus DP
- Modbus
- Profibus FMS
- Industrial Ethernet
- Dedicated point to point channel, for example Sinaut ST1, IEC 870-5-101, IEC 870-5-104, RP570

## Components for an optimum control

Intelligent Add-On modules implement our long-term process know-how to extend and optimize the usability of Thyricon Excitation Systems.

### Real Time Simulation

Due to its modular structure, the Thyricon Excitation System can be easily adapted to specific plant conditions based on sophisticated and well-tested modules.

For complex grid layouts and interconnections, Voith offers a hardware-in-the-loop simulation based on SimsenRT that provides the simulation of a complete hydropower plant for testing the specific excitation system implementation under realistic conditions. This can be done even in the factory.

SimSen and its real-time variant SimsenRT, both developed at Ecole Polytechnique Fédérale de Lausanne (EPFL), are software packages for simulation of hydropower plants and electrical grids including all components.

Using this tool, specific plant conditions can be investigated in detail including optimization of existing functions and the testing of new control strategies.

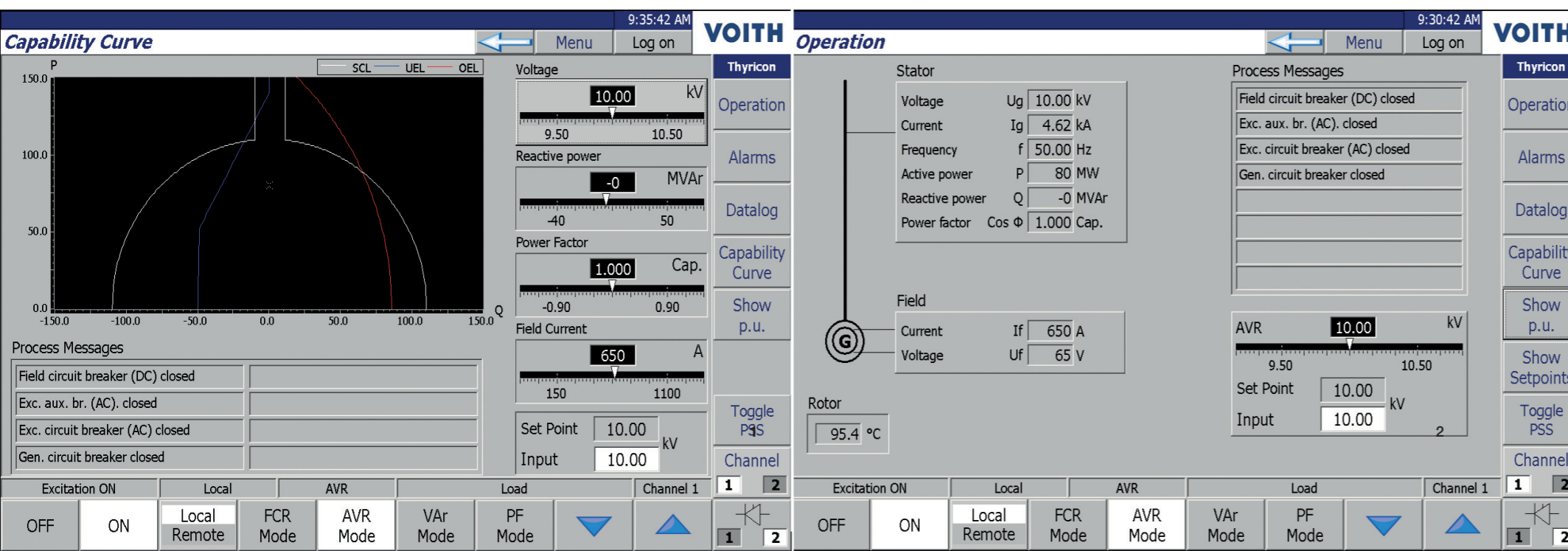
### Safety

Our Thyricon Excitation Systems are designed to meet the high level of safety standards embedded in all Voith products to ensure an optimum of safety for the user, the equipment and the environment.

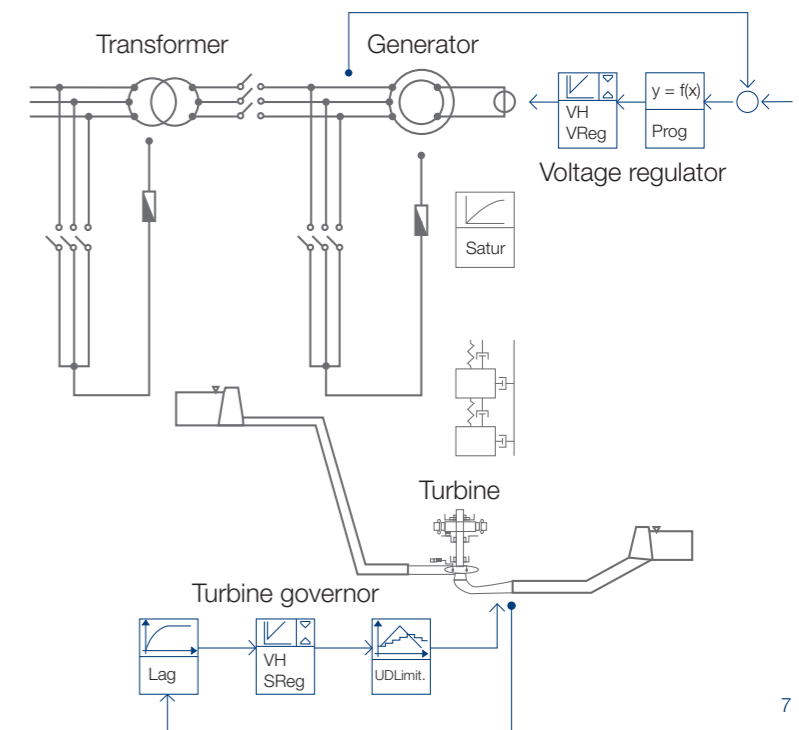
An alarm system provides detailed information for the operator. The clear representation of this data allows fast and efficient tracking of any faults.

Capability Curve

Operation Screen



Model of Power Unit within simulation



## Rotating excitation power device

Installing a rotating exciter is an effective way of eliminating maintenance costs and risks, introduced by carbon dust caused by the wear of brushes feeding the generator rotor via slip rings.

### AC machine

The exciter is a three-phase AC machine of external pole-type, mounted on the same shaft as the main generator. The exciter stator is supplied with DC voltage and thereby a three-phase AC voltage is induced in the rotor. This AC voltage is then rectified in a diode bridge and fed to the rotor terminals connected to the main rotor poles.

The rotor diameter and power output of the rotating exciter can vary from 1,200 mm and 1,500 A up to 2,200 mm and 2,500 A. The adaptation of the required excitation voltage is realized by variation of the core length.

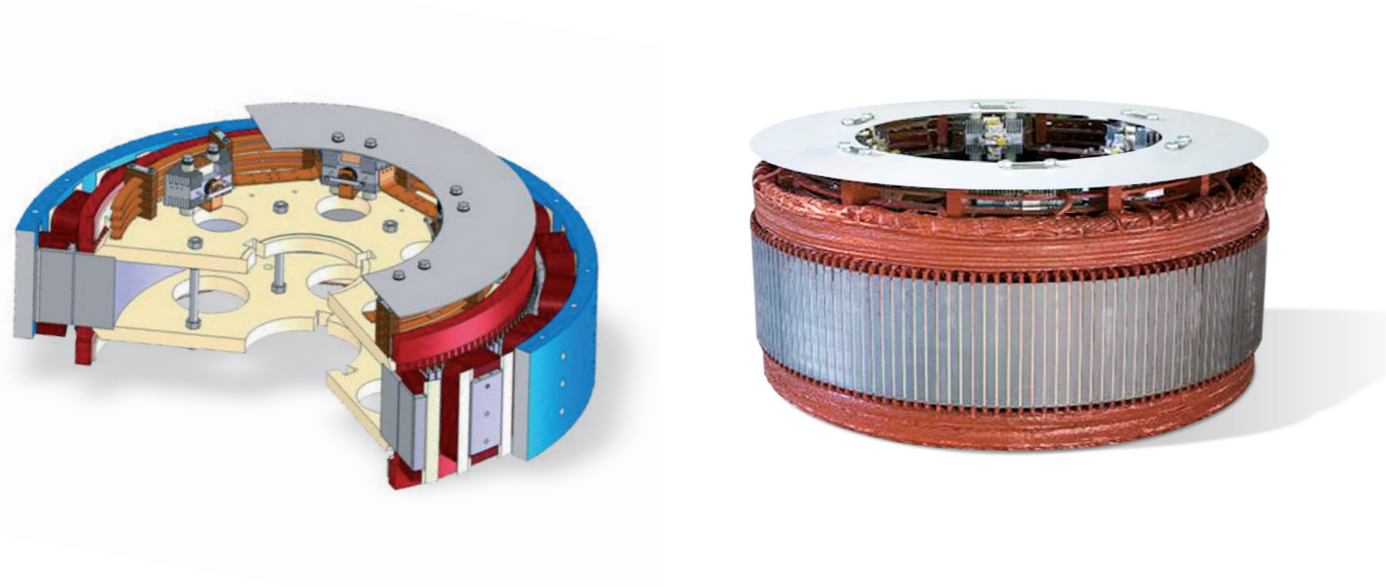
### Pulse width modulation

The DC to the exciter stator is controlled by a highly reliable Pulse Width Modulating module (PWM). The closed regulator loop is formed by measuring transformers and converters, a Programmable Logic Controller (PLC) with a Human Machine Interface (HMI) named Thyricon controller, breakers and the PWM module.

### Power diodes

The cooling blocks with power diodes act as a fan during rotation and provide sufficient ventilation of the exciter power electronics, rotor and stator. The RC-snubber modules are arranged close to the diodes in order to reduce the commutation notches.

## AC machine



1 Cannelton, USA  
2 Gigel Gibe, Ethiopia

- |             |   |             |   |
|-------------|---|-------------|---|
| <b>2003</b> | Perucica, Montenegro<br>4 x 40 MVA Thyricon 500                   | <b>2006</b> | Kiambere, Kenya<br>2 x 85 MVA, Thyricon 500   |
| <b>2003</b> | Omkareshwar, India<br>8 x 80 MVA, Thyricon 500                    | <b>2007</b> | Picote, Portugal<br>1 x 270 MVA, Thyricon 600   |
| <b>2003</b> | Vinje, Norway<br>3 x 125 MVA, Thyricon 500                        | <b>2008</b> | Brokke, Norway<br>4 x 100 MVA, Thyricon 500   |
| <b>2003</b> | Habu, Jor, Who, Cameron Highlands<br>Several plants, Thyricon 500 | <b>2008</b> | Cannelton, Smithland, Willow Island, USA<br>3 x 33 MVA, 3 x 30 MVA, 2 x 24 MVA,<br>Thyricon 600 |
| <b>2005</b> | Gilgel Gibe II, Ethiopia<br>4 x 125 MVA, Thyricon 500             | <b>2008</b> | Ingula, South Africa<br>4 x 375 MVA, Thyricon 600   |
| <b>2005</b> | Akköy, Turkey<br>3 x 41 MVA, Thyricon 500                         | <b>2009</b> | Turlough Hills, Ireland<br>4 x 87,5 MVA, Thyricon 600   |
| <b>2005</b> | Naturns, Italy<br>1 x 110 MVA, Thyricon 500                       | <b>2010</b> | Rånåsfoss II, Norway<br>1 x 53 MVA, Thyricon 600  |
| <b>2005</b> | Waldeck 1, Germany<br>1 x 84 MVA, Thyricon 500                    | <b>2011</b> | Teles Pires, Brazil<br>5 x 400 MVA, Thyricon 600  |
| <b>2006</b> | Salto Pilão Brazil<br>2 x 101 MVA, Thyricon 600                   | <b>2014</b> | Rodund II, Austria<br>1 x 345 MVA, Thyricon 600   |

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