

# Shunt Reactors



Global Top Energy, Machinery & Plant Solution Provider

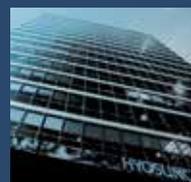


# Our Business

## Brief introduction of Hyosung Power & Industrial Systems PG

While Hyosung is an established name for world-class electrical equipment and solutions, it also maintains a strong leadership in distinct products such as tire cords, textiles, and ATMs, which it produces in 35 plants in 12 different countries around the world.

Hyosung Power & Industrial Systems PG is a division under Hyosung Corporation, which consists of seven Performance Groups (PGs). Hyosung Power & Industrial Systems PG is divided into four business areas or Performance Units (PUs): Power Systems PU, Industrial Machinery PU, Hyosung GoodSprings PU, and the Wind Energy Business Division.



## Power Systems PU

Hyosung Power Systems PU provides a full range of electrical power infrastructure services, from engineering design to maintenance services. Key products and solutions include transformers, circuit breakers, and comprehensive engineering solutions for power substations and energy storage systems.

Commitment to creating what the customer needs has driven Hyosung to offer reliable solutions to the highest voltage range. With a legacy of commitment to R&D, Hyosung Power Systems PU was the world's first developer of the 800kV-class double-break gas-insulated switchgear (GIS) and Korea's first developer of the 765kV ultra-high voltage transformer.



## Hyosung Shunt Reactors

### CONTENTS

02 Our Business

03 What is a Shunt Reactor?

04 Hyosung's Shunt Reactor Offering

05 General Construction

08 Advantages of Hyosung Shunt Reactors

10 Experiences

11 Other Offerings

# WHAT IS A SHUNT REACTOR?

Shunt reactors improve the efficiency of the AC grid by compensating for the reactive power generated by the line capacitance, and preventing overvoltages at a lightly loaded grid (a problem referred to as the Ferranti Effect).

## Shunt reactors are playing an important role in the expansion and transformation of transmission and distribution systems worldwide

Connected in parallel to the grid, the shunt reactor can improve the overall stability of the line, or be mechanically switched in whenever a light load condition occurs. A shunt reactor can also have a varying reactive power rating, dynamically adjusting reactive power consumption depending on changing load conditions.

Shunt reactors have been a key component for efficient energy transmission. In recent years, shunt reactors have become even more important, as our electricity grid is undergoing several changes:



### Increased use of underground cables

Underground transmission cables are becoming the preferred option for better security, or especially due to limited space in urban areas with less space for multiple overhead lines. In addition, offshore wind farms are connected with sub-marine transmission cables. These applications increase the need for shunt reactors because underground cables produce more reactive power than overhead lines due to higher capacitance.



### More renewable energy generation

The grid faces the increasing challenge of maintaining efficiency while connecting various energy sources such as wind power and solar power, which tend to generate more fluctuating power than conventional power sources. The shunt reactor can offer an economical solution for such challenges by compensating reactive power and thereby stabilizing the overall active power transmission.

# HYOSUNG'S SHUNT REACTOR OFFERING

In the 1990s Hyosung started supplying shunt reactors up to 345kV 200MVar, and has since expanded to deliver shunt reactors with a maximum voltage level of 765kV and reactive power of 250MVar.

In its state-of-the-art factory in Changwon, Korea, with a production capacity of approximately 100,000MVA per year, Hyosung manufactures both power transformers and shunt reactors.



## Variable shunt reactors

### Description

Flexible reactive power compensation for better voltage control.

### Benefit

- Less voltage changes when switching during operation.
- Adjustable to seasonal loads and varying daily loads.
- Provides flexibility to meet future developments and changes in the grid.

## Shunt reactors with auxiliary winding

### Description

Similar construction to a power transformer by the addition of an auxiliary winding.

### Benefit

If a power station is installed far from a low voltage power line, this is a more economical way to obtain station service power.



## Low noise shunt reactors

### Description

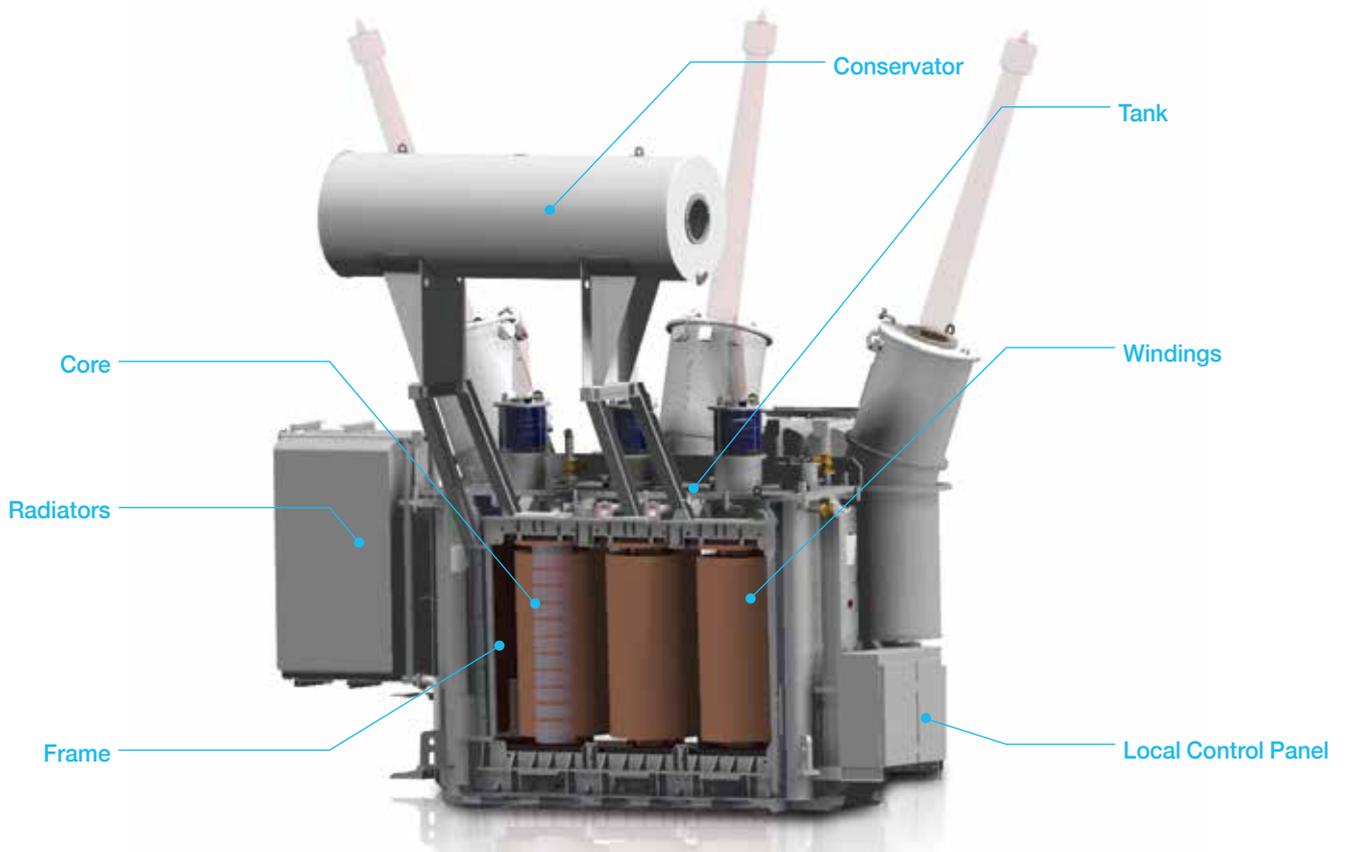
Low noise level for operation in residential areas.

### Advanced technology includes

- Advanced design to control the flux density in the magnetic circuit to minimize vibration and sound level.
- Addition of sound barriers on tank walls for isolating the internal noise.
- Utilization of dampers on the tank walls to reduce vibration and noise.

# GENERAL CONSTRUCTION

Hyosung's shunt reactors are single-phase or three-phase, oil immersed and, gapped-core type.



General construction of a shunt reactor

## Core

The cores are designed as a gapped-core type magnetic circuit consisting of three columns of gapped-core legs (also called bundles) and two return legs. Single-phase cores consist of one column of gapped-core leg and two return legs.

A gapped-core leg consists of ultra-thin, high-quality, grain-oriented silicon steel sheets bonded with gap spacers. The volume of the air-gaps, together with the winding geometry and number of electrical turns, controls the reactance of the shunt reactor. The volume of each of the components of the core leg are arranged to ensure that axial movements, due to the magnetic pull effect, are minimized, which leads to lower vibrations and sound emissions from the shunt reactor.





## Frame and Tie Rods

The frame and tie rod's design features are key elements designed to minimize the vibration and noise from the reactor. Non-magnetic steel rods equipped with special springs maintain constant pressure on the core and coil so that any vibration caused by the magnetic flux is minimized.

## Windings

All windings are designed and manufactured to withstand the electrical, mechanical and thermal stresses of all possible faults and overvoltage conditions such as lightning impulses and switching surges as specified by the IEEE, IEC standards and customer specifications.

Windings are designed and constructed with insulated copper conductors in rectangular or continuously transposed cables. The conductors are transposed at sufficient intervals to minimize the circulating current.

Hyosung's winding rooms are access-controlled, positive-pressure clean rooms designed to minimize dust and other contaminants during the winding process. The winding rooms are equipped with both horizontal and vertical winding machines to provide greater manufacturing flexibility.

## Tank

The tank of a shunt reactor is similar to that of a power transformer. Hyosung's shunt reactor tanks are designed to exhibit extreme durability while ensuring easy and safe maintenance.

Manholes and hand holes of appropriate sizes are built-in to afford easy access to the lower ends of bushing terminals, upper parts of the windings, and tap changer. All surfaces are thoroughly cleaned by shot blasting and any rough surfaces are filed before painting.

## Conservator

Hyosung's conservators come with a diaphragm type oil preservation system.

This system serves as an oil expansion tank and utilizes a Nitrile rubber or a similar rubber bladder to completely isolate the oil from the atmosphere while holding the oil at a constant pressure as the oil changes in volume. The outside of the bladder is in contact with the oil and the inside is in contact with the air.

## Radiators

Radiators are constructed on stamped steel sheets, welded together to provide a large surface area and internal vertical paths for oil circulation. Each radiator is equipped with lifting lugs for lifting the radiators during reactor assembly as well as upper and lower threaded plugs for oil draining or venting.

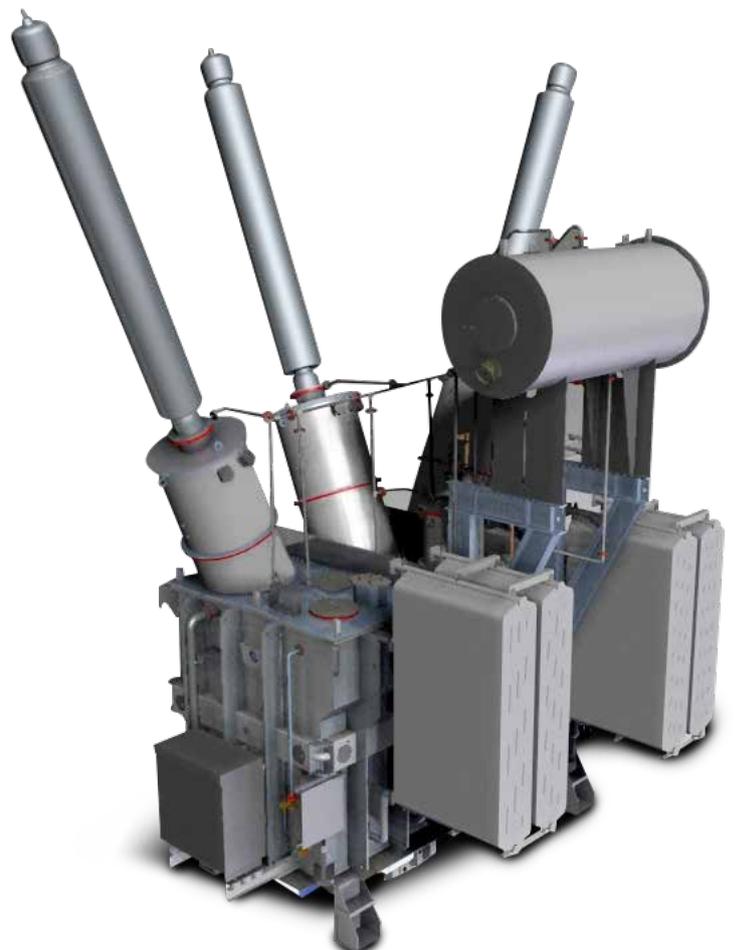
Larger reactors are equipped with radiator support structures to reduce mechanical stresses on the radiator piping joints.

## Local Control Panel

The reactor is equipped with a local control panel that gathers all signals of the auxiliaries, such as the Buchholz relay, current transformer, thermal indicator, and oil level gauge.

Hyosung manufactures the control cabinet in-house, allowing a good integration with the main equipment as well as flexibility in the design.

Each control cabinet design is built for easy access and is always designed to the customer's specifications or preferences.

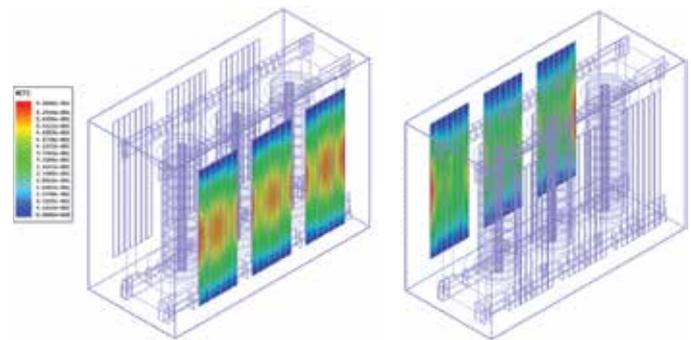
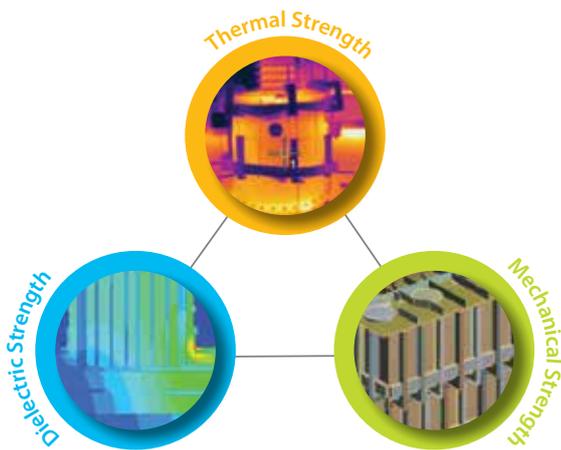


# ADVANTAGES OF HYOSUNG SHUNT REACTORS

## Design Competence

Through our extensive project experience around the world we have accumulated advanced engineering knowledge for shunt reactors. Our engineering team analyzes dielectric strength as well as mechanical and thermal strength optimized to the specific operation conditions of the shunt reactor, and proposes the most cost effective and reliable solution to the customer.

The Hyosung Reactor Design Program is Hyosung's proprietary design software that assists engineers with various analysis, such as transient voltage analysis and electromagnetic field analysis, reducing design lead time and human error.

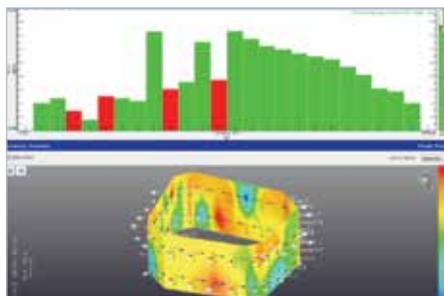


Shunt reactor magnetic shield temperature analysis

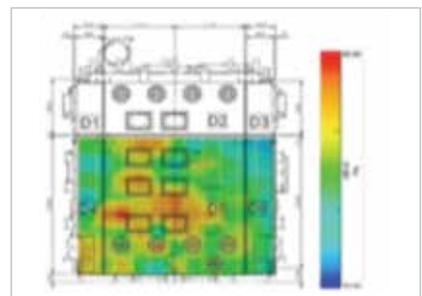
Sound pressure and sound intensity measurements are conducted according to the IEEE C57.12.90 and the IEC 60076-10, and the results are used for various analysis to assure superior low noise performance.



Sound Intensity Measurement



Octave of Sound



Noise Map

## Large manufacturing and testing capacity

Hyosung's customers benefit not only from the company's large manufacturing capacity, but also from its large and efficient testing facilities. Our three high-voltage testing labs, which handle tests for multiple units simultaneously, allow us to have flexibility in test arrangements.



**Test Lab #1**

- Size: 1,500 m<sup>2</sup>
- Testing capability up to 765kV



**Test Lab #2**

- Size: 1,500 m<sup>2</sup>
- Testing capability up to 154kV



**Test Lab #3**

- Size: 2,400 m<sup>2</sup>
- Testing capability up to 765kV



# EXPERIENCES

Extensive experience in supplying shunt reactors enables Hyosung to meet the customers' unique technical demands and successfully carry out major aspects of the project implementation process.



**400kV transmission network, Kuwait**

Three phase shunt reactor  
250MVAr 400kV



**Variable shunt reactor, USA**

Three phase variable shunt reactor  
34~60MVAr with OLTC 345kV



**Rapid delivery for Australian customer**

Three phase variable shunt reactor  
40~50MVAr with DETC 275kV



**765kV transmission project, India**

Single phase shunt reactor  
110MVAr 765kV and 80MVAr 765kV



**400kV Transmission project, Denmark**

Three phase shunt reactor  
100MVAr 400kV



**Substation for offshore wind farm, UK**

Three phase shunt reactor  
64MVAr 135kV



**500kV Transmission network, Peru**

Single phase shunt reactor  
66.66MVAr, 43.44MVAr,  
and 33.33MVAr 500kV

# OTHER OFFERINGS



## Power Transformers

- Up to 765kV
- Core form or shell form type
- Step-down transformers
- Generator step-up transformers
- Special industry applications



## Substation Turnkey Solutions (EPC)



## Oil-immersed Distribution Transformers



## Cast Resin Transformers



## FACTS Systems



## Energy Storage Systems



## Circuit Breakers and Gas-insulated Switchgear



## Substation Automation Solutions



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[www.hyosungpni.com](http://www.hyosungpni.com)



**HEAD OFFICE** 119 Mapodaero, Mapo-gu, Seoul, Korea 121-720 TEL : +82-2-707-7000  
transformer@hyosung.com www.hyosung.com

**HICO America** Three Penn Center West, Suite 300, Pittsburgh, PA 15276 USA TEL : +1-412-787-1170  
sales.team@hicoamerica.com www.hicoamerica.com