Power transformers
and reactors

GRID

We are shaping the future

ALSTOM
With strong references up to 800 kV and 2750 MVA in major power networks worldwide, Alstom Grid is one of the world leaders in power transformers and reactors. A pioneer in the field, our expertise extends to all types of applications from power generation and transmission to electro-intensive industrial and railway applications.

A world leader in transformers for over 100 years

Alstom Grid has thirteen dedicated facilities for manufacturing power transformers on four continents, with a current production capacity of more than 130,000 MVA. This global manufacturing footprint, coupled with efficient technology transfer programs, enables us to offer the most adapted solution - for every need, everywhere and with the same top level of quality.

Our intensive research into new products and solutions drives the process of continuous improvement. As proof of the technological leadership of Alstom Grid, our experts actively participate in internationally recognised workgroups and conferences.

Our expertise in power transformers extends to all levels - from generation to HVDC systems and all kinds of special industrial applications
The right transformer for the right application

From low to ultra-high voltage - From small to extra-large power ratings - From standard to the most complex designs... Whatever you need, we have the right solution.

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**CONVENTIONAL POWER TRANSFORMERS**
up to 1500 MVA & 765 kV
- Generator step-up transformers
- Small & medium power transformers
- Large power transformers
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Conventional power transformers

GENERATOR STEP-UP TRANSFORMERS

The generator transformer is an essential element of all nuclear, thermal or hydraulic power stations. Generator transformers are step-up transformers with delta-connected LV windings energised by the generator voltage, while star-connected HV windings feed the transmission lines.

This type of transformer is constantly faced with voltage changes, either due to load rejection or switching operations, followed by generator overexcitation. It must also maintain the ability to withstand overloads, which means that winding gradients must be adjusted and cooling capacity must remain sufficient. The high-rated current involved requires absolute control of the magnetic field inside the tank in order to avoid localised overheating of associated metallic parts. All of these situations are taken into account during the design process of your specific unit.

Generator transformers require very specific know-how, production equipment and testing capabilities, as high or very high voltages and rated power are often required.

We have designed, manufactured, tested and delivered generator transformers with the largest rated power possible for many power stations all over the world.

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HERMETIK: THE LOW-MAINTENANCE TRANSFORMER

Created in Germany a decade ago, hermetically-sealed power transformers without oil conservator are Alstom’s field-proven answer to today’s needs, maintaining a high degree of operations reliability and a longer service life.

Thanks to the innovative design of the radiators, the oil expansion vessel is not needed and thus the oil is prevented from coming into contact with ambient humidity. Service life is also increased with the use of a vacuum-switch on-load tapchanger (OLTC) that eliminates contact erosion. With minimal oil and OLTC aging rate, the Hermetik does not require any particular maintenance or works over its service life, speeding up the return on your investment.

MAKING THE DIFFERENCE
INTERCONNECTION POWER TRANSFORMERS

The most common transformers in networks, the interconnection transformers (step-up or step-down), connect AC networks or systems of different voltages to allow power exchange between them. They must be designed to handle the specified requirements of each transformer unit.

These transformers offer galvanic insulation between primary and secondary networks and can be designed as 3-phase or single-phase banks, depending on the end-user priorities and transportation constraints. They are also often designed to offer a wide voltage regulation range, by incorporating either an on-load or a no-load tapchanger.

Our conventional transformers offer high adaptability to expected levels of performance and/or specific site conditions. The design and rating of tertiary windings, couplings and arrangements will be adapted to your specific needs. Our customised design can incorporate all specific physical constraints such as transport limitations.

According to power and voltage ratings, and especially according to their constructive design, conventional power transformers can be classified as:

- **Small and medium power transformers**: While those with the lowest ratings can share some design characteristics of large-size distribution transformers, our medium power transformer offer covers a wide range that stretches up to 245 kV and 100 MVA.

- **Large power transformers**: As a world-class specialist in the highest ranges of power transformers, Alstom Grid has supplied interconnection transformers up to the level of 765 kV ac - the world's highest in commercial operation - as well as several units above both 300 MVA and 500 kV.

AUTOTRANSFORMERS

Compared with interconnection transformers of equivalent power flow, the autotransformer presents a lighter and more economically optimised solution, which is possible whenever the voltage ratio is between 1 and 2. However, autotransformers have non-disconnected windings, so this means there is no galvanic insulation between the interconnected systems.

Characteristically for complex regulation arrangements, they impose a total mastery of dielectric phenomena. Designs for constant flux regulation at high voltages or booster schemes are part of the Alstom Grid know-how. For many years we have been supplying very high-rated autotransformers, such as single-phase units up to 500 MVA and with voltages up to 765 kV for networks all over the world.
Oil-immersed reactors

SHUNT REACTORS

Shunt reactors are used to increase grid stability and to maintain an economically acceptable level of insulation on networks with long transmission lines between power plants and consumption areas, especially if these lines are low loaded or buried.

Indeed, shunt reactors compensate the capacitive load of energy transmission lines and are adequate solutions for:

- maintaining an acceptable voltage, whatever the load
- limiting transient overvoltages induced by switching or sudden load decreases
- decreasing line losses by capacitive current reduction

Alstom Grid’s know-how and experience in the field of shunt reactors with air-gap cores and magnetic circuits provides our reactors with low vibration and noise levels. Our latest-generation tools for the design of shunt reactors allow optimised design for magnetic field distribution that provides safe behaviour.

Shunt reactors can be single or 3-phase according to your requirements. Our references include single-phase units up to 110 MVar for 800 kV and 125 MVar for 400 kV. We have also supplied 250 MVar, 275 kV 3-phase units that are currently in operation around the world.

VARIABLE SHUNT REACTORS:
POWER COMPENSATION MADE FLEXIBLE

Another valuable innovation from Alstom - variable shunt reactors equipped with tapped windings and on-load tapchanger (OLTC).

In contrast to common shunt reactors, variable shunt reactors are able to provide an adjustable MVar output: for example, 160 to 250 MVar at 420 kV or other special required regulation ranges. Such shunt reactors are 3-phase units, oil-immersed and conceived for outdoor use.

Variable shunt reactors are connected to the end of a high voltage line or to a substation busbar and provide a flexible solution to cope with the evolving needs of electrical systems.
SERIES REACTORS

Series reactors are used in line series connections as current limiting devices to reduce fault currents to required levels. They can be single-phase or 3-phase and their construction can be unshielded, magnetically shielded or non-magnetically shielded.

Special attention is paid to the core/coil clamping system. Extremely large ratings require expertise to satisfactorily contain problems presented by the stray magnetic fields. Our experience in this field covers reactors with throughput ratings up to and over 2000 MVar.

EARTHING REACTORS AND TRANSFORMERS

Neutral earthing reactors allow the connection of the neutral point of power transformers to ground through an impedance, in order to limit (in case of a phase-earth fault and for safety reasons) both the short-circuit current and the increase of voltage in the healthy phases.

When the neutral point is not accessible in the transformer (e.g., delta connection), an artificial neutral can be created by means of an earthing transformer, which consists generally of a zig-zag winding and is connected between the main transformer and the reactor.

Both earthing reactors and transformers are also part of the Alstom Grid offer.

SMOOTHING REACTORS FOR HVDC

Dedicated to HVDC transmission, smoothing reactors are used to reduce the flow of harmonic currents and transient overcurrents in the DC system thanks to their two functions:

- Compensate voltage ripple at the 12-pulse converter bridge
- Decrease the short-circuit current in the DC link

With insulation principles based on the same special design as a transformer, Alstom Grid oil-filled smoothing reactors offer a low level of electromagnetic radiation outside the tank.

However, to protect the environment - and particularly motors, relays and switchgear - against magnetic flux density effects, a magnetic shield is placed against the internal wall of the tank.

Smoothing reactors benefit from the same measures as the HVDC converter transformers to ensure that they will withstand short-circuit stresses. The clamping structure of the active part is reinforced in order to conform with these requirements.
Special transformers for transmission networks

HVDC CONVERTER TRANSFORMERS

High Voltage Direct Current (HVDC) systems allow the transmission of energy over long distances and are also solutions for the interconnection of networks with different characteristics and frequencies.

The HVDC converter transformer, an important element of these systems, transforms the AC supply voltage from a 3-phase network to the required converter bridge input voltage and compensates for voltage drop through on-load tapchangers.

Direct voltage components superimposed on the AC ones appear during service and factory testing and induce high levels of stress on the valve windings connected to the rectifier bridge. The design and manufacture of HVDC converter transformers requires a fine mastery of insulation structure. The high harmonic content of the load current also demands a very specific knowledge of thermal design. We are experts in this field and have HVDC converter transformers installed in Europe, India and Canada with ratings up to 310 MVA and voltage levels up to 500 kV.

In 2009, we were awarded an order for a 600 kV dc bipolar for the Rio Madeira project in Brazil. This will be the world’s longest power transmission line, with a total length of 2,375 km. Alstom will supply the 28 Ultra-High Voltage DC (UHVDC) converter transformers for all the converter stations, proving our position at the forefront of complex HVDC converter transformer manufacturing.

ALSTOM Grid experts have mastered the analysis of complex phenomena to design and manufacture the safest transformers for your network

800 kV dc

A full-scale 800 kV UHVDC transformer model by Alstom Grid was successfully tested in July 2010 and validated in compliance with the applicable IEC standards.

This achievement is the result of more than 40 years of experience and a focused R&D program in the field of HVDC power transformers, marking a further step towards 800 kV dc transmission.

(photo: the UHVDC power transformer team in Wuhan laboratory, China)
PHASE-SHIFTING TRANSFORMERS (PST)

As high voltage network systems are connected to each other at several points, the necessity of controlling the flow of energy increases. Classical voltage regulation without phase-shifting is no longer sufficient for these situations.

For this reason, phase-angle regulating transformers are necessary. Phase-shifting transformers are divided in two families: PST with one active part (single core) or PST with two active parts (dual core). One active part provides independent phase angle and voltage regulation and is suitable for a limited voltage and power level. For higher power and voltages, a PST with two active parts is ideal.

The use of phase shifters is always a special case, where design criteria will vary from one customer to another based on individual network specifications and requirements. As these transformers generally have large ratings with heavy units, the manufacturing limits as well as the transport constraints must be taken into account. Some of our major references for links in Europe are the constant-modulus type phase-shifting transformers with two active parts offering no-load phase-shifting angles of +/-21.4°, for a voltage level of 225 kV with rated power of 312 MVA and +/-10° regulation for a voltage level of 400 kV with rated power of 1180 MVA.

TRANSFORMERS FOR SVC

Alstom Grid Static VAR Compensators (SVC) provide an elegant and flexible solution when improvements of power system efficiency and control of the reactive power balance of the network are imperative.

The SVC transformers are used to connect SVC equipment to transmission lines. These transformers combine the complexity induced by DC components - even if moderate - with high levels of harmonic and rated currents. Mastery of insulation structures, thermal behaviour and magnetic field distribution are all part of the know-how behind Alstom Grid SVC transformers.
Special transformers for electro-intensive industries

RECTIFIER TRANSFORMERS

Rectifier power transformers supply the extra-high currents required for industrial applications such as electrolysis processes for aluminium and electrochemical processes for zinc, copper and chlorine.

Alstom Grid has supplied rectifier power transformers to more than 80 industrial projects all over the world for more than 35 years and has developed unique skills and experience to propose solutions adapted to any specific industrial process, whether for new installations or refurbishments. Rectifier transformer combinations can be made with all active parts grouped in one single tank or in two tanks, with the regulating (auto) transformer and its tapchanger in one tank and the rectifier transformer assembly in the other.

We offer a complete range that fits your rectifier:

- 100-500 V dc and up to 140 kA dc for zinc, copper and chlorine electrolysis
- 450-1600 V dc and up to 110 kA dc for aluminium electrolysis

ELECTRICAL ARC FURNACE (EAF) TRANSFORMERS

With more than four decades of proven expertise, Alstom Grid is the indisputable leader in extra-high power EAF transformers and the quality and performance of our products are field-tested every day at steel production sites around the world.

Arc furnace transformers deliver high currents over a wide range of voltages. While power ratings between 10 and 300 MVA and secondary currents of more than 100 kA are quite common, our EAF transformers are precisely adapted to the extreme thermal, mechanical and dielectric constraints of the furnace load cycles.

In order to improve the efficiency of the service currents and to maintain the system’s stability, furnace series reactors may be also added, which can be housed in the same EAF transformer tank.

300 MVA

In 2010, Alstom Grid delivered the world’s highest-rated EAF power transformer for MMK/Atakas

(photo: celebrating the success at the Gebze factory, Turkey)
Special transformers for railways

TRACKSIDE FEEDER TRANSFORMERS

Alstom’s trackside transformers are key components for railways, supplying power to electric rolling-stock that use single-phase AC networks (see scheme below).

These transformers are designed to withstand the high mechanical and electrical stresses due to inherent fluctuating load current characteristics and frequent short-circuit conditions created by passing trains. Our trackside feeder transformers can reach up to 60 MVA rated power and with the HV connected to 220kV or even 400kV networks for high-speed train supplies.

‘Hermetik’ transformers (see page 4) are especially suitable for these uses and have proven their performance for years on some of the most demanding European railways.

AUTOTRANSFORMERS AND BOOSTERS FOR CATEGARY

To improve transmission efficiency and system regulation while reducing earth current and electromagnetic interferences, catenary feeding systems use – in addition to the trackside power transformers – booster transformers or autotransformers at regular intervals along the track. These schemes are extensively used for high-speed trains, typically for those of the French TGV.

ON-BOARD TRACTION TRANSFORMERS FOR ROLLING STOCK

With 50 years of experience and more than 5,000 on-board transformers produced, Alstom Grid has developed a solid track-record in designing equipment dedicated to high-speed trains, locomotives (freight & passenger) and electrical multiple units (tram-trains, urban & suburban).

Through close cooperation with rolling-stock manufacturers and final customers, we design and manufacture reliable and optimised traction transformers. With multi-high voltages (up to 4), power up to 10 MVA and installation according to customer equipment, our transformers are tailored to meet all challenges.

574.8 km/h

Alstom Grid equips the locomotives of the new French high-speed line “TGV EST”, which achieved the world’s rail speed record in 2007
Broad technical expertise built on strong R&D

Innovative solutions for evolutive transformers and reactors

Research and development drives the design, manufacture and continuous improvement of transformers. Leading the technical evolution in the energy industry for decades, Alstom Grid has committed to major financial and human resource investments in research and development. Our central technical department, with its 70 senior R&D engineers, are always searching for innovations in the power transformer and reactor domain.

Alstom Grid’s senior engineers address issues such as partial discharge monitoring and diagnostics, transformer modelling, transient behavior, frequency response analysis and dielectric system development for the validation of innovative insulating structures for up to 1200 kV ac and 800 kV dc.

In addition, they draw on their expertise both in the field and with the technical committees of major international standards bodies such as the CIGRE and IEEE.

Guaranteed global quality

Customers can expect the same excellent quality from all Alstom Grid transformer facilities. All of our design and manufacturing sites are guided by the same design quality and production rules, complemented by standardised design software and manufacturing tools, and equipped with the most modern, high-performance testing equipment available. When a transformer leaves the Alstom Grid factory for your site, you know that every step has been taken to ensure its quality and reliability and that the performance meets your specific requirements.

We work at the cutting edge of manufacturing techniques

The Alstom Grid quality management program goes beyond the ISO 9001:2000 certification. Thanks to a dedicated central technical management team, we guarantee that the highest expertise is implemented in all our factories to ensure the same world-class level of quality in all our power transformer facilities and from all our engineers throughout the world.

We have a long track record of power transformers of different designs that have successfully gone through short-circuit testing and are proud that most of our transformers and reactors have long surpassed their life expectancy are still in service. The quality of our design as well as the manufacturing processes and controls have been validated over time.

Manufacturing of a 1125 MVA 330/275/33 kV autotransformer for Middle Ridge s/s (Australia)
From the factory to daily operation, all is under control

A transformer's reliability is crucial to your installation and network. This is why we use standardised and proven designs, along with processes and testing methods to ensure the quality of our products.

When required, we do not hesitate to submit our transformers and reactors to special tests to further ensure the high level of quality that you would expect from a world-class manufacturer such as Alstom Grid.

From the conception to the commissioning of your projects, we help guarantee the overall reliability of your installation with a local presence throughout the world.

Based on over 100 years of experience in power transformer handling, our expert Service teams are fully qualified for all works involving your transformer's transportation.

Ensuring that your transformer is installed properly will guarantee your investment. Our dedicated and skilled teams of transformer service engineers take care of complete transformer installations - from erection works to commissioning, on-site final testing and energising.

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MS 3000
CONDITION MONITORING & EXPERT SYSTEM

After more than 10 years of experience in transformer monitoring systems, and following the acclaimed MS 2000, Alstom Grid has just launched the MS 3000 online condition monitoring and expert system.

This new generation offers innovative features like dissolved-gases analysis (DGA), a built-in simulator and expert system software that provides data and recommendations on transformer operation and maintenance. It also allows multiple transformers to be managed with only one system.

Like its predecessor, the main features of the MS 3000 include a user-friendly operation interface, the possibility of adaptation to both new and existing transformers from any manufacturer, and a wide range of communication protocols now including the IEC 61850 standard certified by KEMA.

Plug your transformer into the smart grid with MS 3000!
Asset management: a broad portfolio of services

Power transformers constitute a large capital expenditure and are one of the most critical components in electrical systems. Even if they are generally very reliable over a long lifecycle, normal aging or external agents can bring on damages which, if not detected and treated properly, can produce serious failures. This is why regular attention to detail is very important.

Alstom Grid Service teams provide specialised technical services covering the complete lifecycle of your transformer. We undertake extensive on-site investigations and repairs when required and modernise aging transformers, replacing key components with modern equivalents.

On-site mobile workshops or factory refurbishment facilities around the world offer our customers comprehensive transformer services designed to meet their needs.

Remote monitoring (MS 3000)
- Online access to your transformer by our experts for preventive maintenance
- Essential for substations which require particular attention - such as oil & gas platforms, offshore rigs, power plants, etc. - or have no local personnel on site

Spare parts
- Recommendation and supply of strategic spare parts for in-house stock
- Reverse engineering for old products

Transformer life extension & retrofit
- Pro-active asset management
- Taphchanger retrofit
- Cooling system upgrade
- Accessories upgrades and renovation
- Refiling with vegetable oil

On-site intervention
- Erection & commissioning
- On-site maintenance & repair
- On-site upgrade/refurbishment
- Technical audits
- Emergency support

Diagnosis and expertise
- Inspection and testing
- Upgrade and modernisation:
  - Increase power
  - Increase safety
  - Reduce losses
  - Reduce noise
  - Modify voltage levels

Training
- Seminars
- Practical training
Committed to the environment

Alstom is committed to providing market-leading power, transmission and transport products, systems and services to communities across the globe in a responsible and sustainable way. Our innovative approach allows us to offer solutions which help overcome some of the world’s greatest challenges.

Alstom’s main contribution to environmental protection lies primarily in the technologies we offer, but we also focus on offsetting the environmental impact of our activities. As proof of this aim, our recently built plant in Wuhan (China) is the world’s first power transformer factory to have obtained the internationally recognised certification of ‘green building’ by LEED®.

In the field of green products, Alstom Grid has much to offer too: we have developed an environmentally-friendly range of eco-efficient Green Power Transformers which include a series of innovative functionalities to help customers with today’s eco-management challenges.

Discover what Alstom Grid can do to turn your transformer needs into an economically efficient and environmentally responsible investment!

GREEN POWER TRANSFORMERS
by ALSTOM Grid
from 10 to 200 MVA and up to 245 kV

A Green Power Transformer is a sustainable, eco-efficient transformer designed with one or more of the following functionalities that contribute to major energy efficiency levels and reduced environmental impacts:
use of an ester oil instead of mineral oil, hermetically-sealed tank,
reduced acoustic energy (low noise), optimised low loss levels and online monitoring system (MS 3000).

Alone or combined, these technologies provide customer benefits like reduced pollution risks, increased fire safety, overload ability, noise and loss reduction, extended life and more.

Ask for our ‘Green Power Transformers’ leaflet and find out how Alstom Grid is shaping the future of power transformers.