



Transformers

Three Phase up to 1500MVA



with Primary Plus™

Pre-engineered solution set that digitizes XD|GE primary equipment and provides factory installed and configured protection, monitoring, diagnostics and communications.



GE
Digital Energy



Crane Capacity of 800T at Port of Export



800kV Converter Transformer in Xiangjiaba, Shanghai

Revolutionizing the High Voltage Transformer Segment

For over a century, utilities around the world have relied on GE products and services to increase power system reliability and improve grid resiliency and responsiveness. As a global leader in grid infrastructure products and services, GE supports a broad set of utility applications ranging from transmission and substation automation to distribution networks and smart metering, enabling greater safety, connectivity and increased security.

Through an alliance with XD Electric®, GE has extended its portfolio to include high and ultra high-voltage power equipment, supporting the highest transmission voltage levels in the world.

XD Electric is one of the world's largest primary equipment manufacturers dedicated to the research, application and development of high and ultra high-voltage power transmission equipment. XD Electric is also one of the premiere high-voltage transformer manufacturers in China with world-class design capability and a significant installed base for ultra high-voltage (UHV) AC and DC technologies. Their designs are well established and XD has a large installed base for selected power transformer and reactor technologies.

XD|GE provides a suite of transformer products that offer a wide range of voltages and capacities to support the highest voltage levels available around the world. The XD|GE products are designed to meet a variety of customer

applications including generator step-up (GSU) transformers, substation step-down transformers, auto transformers, HVDC converter transformers, rectifier transformers, arc furnace transformers, railway traction transformers, shunt reactors, phase shifting transformers and resin cast coil dry type.

Designed to Optimize Performance

With units operating in some of the most demanding electrical environments around the world, XD|GE designs and delivers technology solutions that provide among the highest level of performance and reliability to meet customer's operating requirements. XD|GE's large technical staff of subject matter experts in various facets of engineering have developed an advanced, integrated and proven design and manufacturing technology for its entire transformer portfolio of products.

XD|GE designs and delivers technology solutions that exceed customers' critical and demanding performance and reliability requirements.

These advanced systems have produced first to market and innovative products including the first 1000kV, 1000MVA dual-column ultra high-voltage auto transformer in the world.



Key Benefits

The transformer and reactors development efforts are consistently focused on maximizing performance to:

- Decrease electrical stress in the insulation structures and help prevent of partial discharge initiation
- Improve winding impulse voltage distribution characteristics with in-depth studies and performance analysis
- Reduce leakage flux density control and stray loss
- Control over heating of the high current leads by redesigning the structure and lead arrangement
- Improve the operational reliability of transformers by increasing the short circuit withstand strength of the windings
- Minimize the effects of DC biasing on the transformer core by analyzing currently used methods
- Decreased noise levels, down to 65dB, with advanced core stacking technology
- Minimize oil flow to reduce the temperature rise of windings
- Improve tank design to meet and/or exceed transportation strength requirements

Advanced Technology Platform

XD|GE has developed an advanced 3D Computer Aided Engineering (CAE) system for 3D design of transformers, 3D assembly simulation, and quick generation of engineering drawings. The 3D CAE system performs design optimization, analysis of the electrical and electromagnetic field and thermal design. This ensures high reliability in our transformers and shunt reactors.

The 3D CAE system has been used in the development and manufacturing of all transformers, including several key new products such as:

- 750kV and 1,000kV transformers and shunt reactors
- 500kV, 50 MVAR and 750kV, 140MVAR adjustable shunt reactor
- Converter transformers and smoothing reactor for the $\pm 500\text{kV}$ and $\pm 800\text{kV}$ DC transmission project

Primary Plus



XD|GE offers Primary Plus on all its primary equipment. Primary Plus is a pre-engineered solution set that provides utilities with a means to reduce the time and labor associated with substation construction and expansion, while at the same time utilizing technologies and methodologies familiar to existing resources.

XD|GE's factory installed and configured solutions include:

- Digitized primary equipment by replacing labor-intensive, individually terminated copper wires with standardized physical interfaces and open digital communications
- Electrical protection systems optimized for the equipment and application to monitor and react to fault conditions
- Monitoring and diagnostics of transformers to predict problems and proactively manage performance
- Highly secure and ruggedized communication network equipment including industrial strength wireless, fiber optic multiplexers, and Ethernet switches for an advanced and reliable communications infrastructure

Power and Auto Transformers, and Reactors

Power and Auto Transformers

XD|GE offers a broad line of power transformers with three phase ratings from 20 to 1500 MVA, voltage ratings from 69 up to 765kV, and single phase ratings to 1000 MVA, 1000kV. Three phase auto transformers are available with ratings to 765kV, 1500 MVA, and single phase auto transformers to 1000kV, 1500 MVA.

The GSU transformer is a key technology for electric power generation and power transmission. The generator transformer, designed and manufactured by XD|GE, fully complies with the requirements for power generation islands with excellent performance and exceptional reliability for low loss, low noise, low partial discharge and high short-circuit withstand.

The size and performance of the power transformers available from XD|GE are world class, such as the first 1,000MVA / 500kV ASA high impedance autotransformer installed in China...the first of its kind.

XD|GE provides a broad range of products that align with the many types of thermal power and water power sets, including 200MMW, 250MW, 300MW and 600MW configurations.

To meet specific requirements, customers have the flexibility to customize their transformers. A range of options are available, including:

- A variety of de-energized and on-load tap changers from approved suppliers. Control and monitoring systems are available for the on-load tap changers that allow for parallel operation and remote control
- A wide range of monitoring and diagnostic options are available including bushing monitoring, dissolved gas analysis, hot spot winding temperature, oil hot spot, and both UHF and ultrasonic partial discharge
- Gauges are available from a variety of suppliers. Available options include analog gauges as well as digital gauges that work with remote monitoring systems
- Pressure relief devices are available with or without an oil flow director that can be routed toward the bottom of the tank
- Buchholz relays are available as well as fire extinguishing systems that release nitrogen to the inside of the tank and a shut off valve when an event is detected
- Typical oil preservation systems used for power transformers are also available. A corrugated stainless steel conservator that goes up and down and requires no breather or air bag is also available
- Cooling systems, utilizing panel radiators, fans, oil pumps and coolers are available from approved vendors
- Water cooling is available for rectifier transformers and hydro-power applications. Radiators can be controlled to turn on sequentially with increasing temperature

Power Generation Double Split Transformer Design

To meet and exceed the transformer requirements for power generation, XD|GE specially designs and manufactures low voltage radial double split transformers. This design enhances the ability of short circuit withstand of the

transformer and the starting/spare transformer used at the power station. The voltage class covers a range from 35kV to 500kV with a range of the capacity from 31.5 MVA to 130 MVA.

The structure will be designed to the impedance specified by the customer, providing a high capability to withstand short circuit force and to supply reliable power.

Reactors

Shunt reactors are core to XD|GE's portfolio, with more than 600 units installed, at 500kV or higher, in various regions around the world. As part of XD|GE's ongoing initiatives for continual product improvement, extensive research on shunt reactors has resulted in an improved core design. These improvements have reduced the total losses to less than 100kW,



610 MVA, 1700kV Testing Transformer

Rectifier Transformers

significantly reducing partial overheating. Additionally, there have been reductions in the core noise and vibration, enabling high levels of reliability.

Smoothing reactors, used in HVDC systems, are available with voltages up to $\pm 800\text{kV}$ DC and have been developed in both liquid filled and dry type designs. The liquid filled reactors can be customized with many of the options available for power transformers.

Single phase shunt reactors are available in voltage ratings ranging from 35kV to 1000kV with MVAR ratings of 20, 30, 40, 50, 60, 70, 100, 140, 240, and 320 MVAR. Three phase shunt reactors are available in voltage ratings from 35 to 400kV, with MVA ratings of 20, 30, 40, 50, 60, 80, and 100 MVAR. Single phase shunt reactors are available with AC control of the shunt reactance or with a tertiary winding to supply power in the 150 to 250kVA range for installations in remote locations where local power is not available.

Rectifier Transformers

Transformers for use in industrial applications must be designed to withstand severe and extreme operating and environmental conditions. Huge currents need to be supplied to arc and smelting furnaces for aluminum, zinc, and chlorine processing. They must operate through cyclic loads, high thermal stress, and over voltage and current conditions caused by short circuits in the furnace.

XD|GE delivers advanced and ruggedized rectifier transformers that meet customers unique operating and environmental requirements.

Delivering these advanced and ruggedized transformers is a unique niche for XD|GE. Rectifier transformers can be supplied with ratings ranging from 35kV to 220kV, and up to 140MVA, some of the largest in the world.

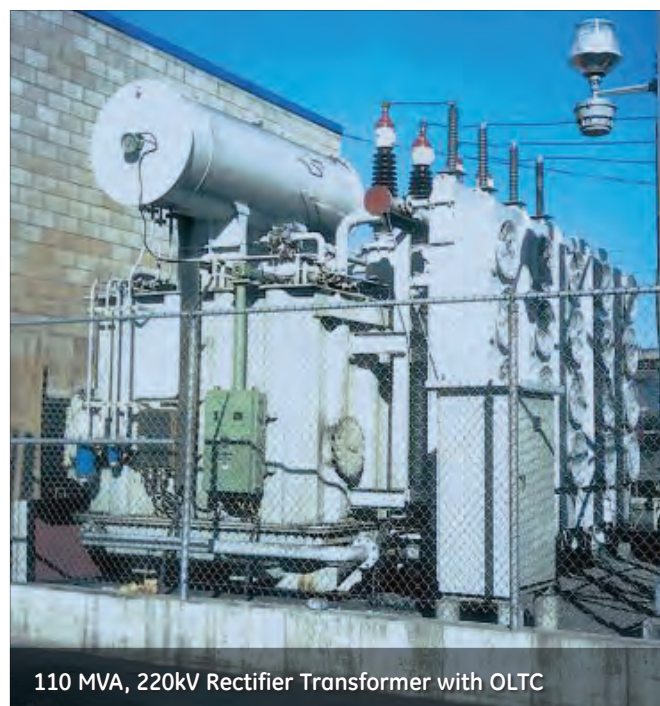
Various transformer configurations are available, including:

- On-load or off-load tap changers
- Three phase bridge-type rectifier
- Double Delta-star three phase, five-leg rectifier transformer
- Cooling options including ONAN, ONAF, OFWF, OFAF, ODAF

Key Characteristics

The chart below is an overview of the characteristics for a sampling of large rectifier transformer:

Type	Capacity (MVA)	DC Voltage (V)	DC Current (A)	Number of Pulses
74MVA/110kV	74	700	2x45000	12
134.05MVA/330kV	134	1230	2x46000	12
70.5MVA/220kV	71	880	2x34000	12
106.26MVA/220kV	106	1220	2x37000	12
140MVA/220kV	140	1350	2x44000	12
136.2MVA/330kV	136	1300	2x44000	12



HVDC Converter and Arc Furnace Transformers

HVDC Converter Transformers

XD|GE has designed the HVDC converter transformer to the maximum $\pm 800\text{kV}$ voltage level and has produced a large number of these transformers. These have been developed to support projects from $\pm 50\text{kV}$ HVDC back-to-back converter stations up to $\pm 800\text{kV}$ HVDC transmission projects.

XD|GE has a large manufacturing base for complete HVDC equipment in China. Since the 1980s, the XD Group has been involved in all twenty three (23) completed and ongoing HVDC transmission engineering projects in China.

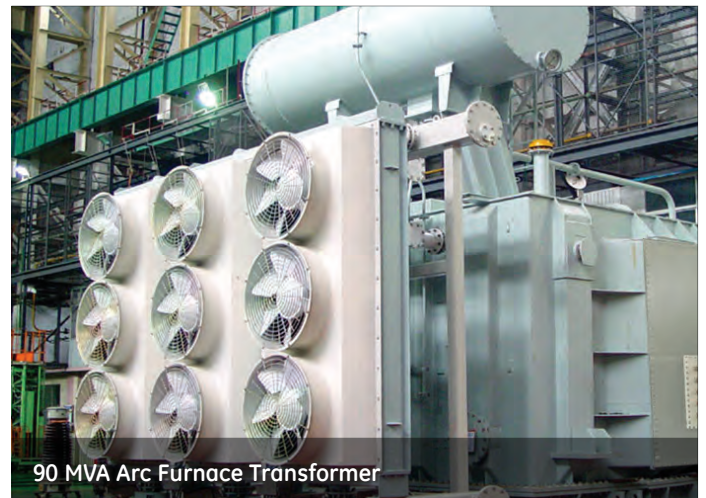
Manufacturing Scope for $\pm 50\text{kV}$ - $\pm 800\text{kV}$ Voltage Level:

- System research and design, DC system simulation
- Thyristor valves
- Converter transformer, smoothing reactors and filters
- Shunt capacitor, equalizing capacitor for thyristor valves



Arc Furnace Transformers

XD|GE has developed the technology to produce a range of arc furnace transformers including arc steel-smelting furnace transformers, ladle refined furnace transformers, and large ore arc furnace transformers. XD|GE arc furnace transformers are available in AC and DC supply, with capacities up to 200 MVA with 35kV single-core design, up to 160 MVA with series voltage regulation, and up to 100 MVA with a primary voltage of 110kV.



Railway Traction and Cast Coil Transformers

Railway Traction Transformers

The three phase/two phase impedance matching balance connection traction transformer for electrification of railways is suited for the operation condition of frequent short-circuits, short periods of severe overloads, and asymmetrical loading of the three phases.

This new type of traction transformer is greatly improved both in structure and performance.

XD|GE produces a variety of railway traction transformers including:

- Impedance matched balance traction transformers
- Traction transformers with Vv connection



Traction Transformer

Cast Coil Transformers

The cast coil transformer is a low-noise, low-loss, cast resin dry-type transformer. The high-voltage (HV) winding with copper conductors and the low-voltage (LV) winding with either copper conductors or copper sheet are wound and reinforced by glass-fiber and then cast with resin under vacuum.

Characteristics of Cast Coil Transformers:

- Windings have high mechanical strength and no partial discharge
- Epoxy resin and insulating materials used for windings are non-flammable, will not burn from an electric arc, and no toxic gases will be given off when the resin is burned
- Windings will not absorb moisture and a special anti-rust protective coating seals the core and frame.
- Operates under one-hundred percent relative humidity and other severe ambient conditions
- Ability to switch on the device without pre-drying or long periods of service interruptions
- Excellent short-circuit and lightning impulse strength
- Cooled naturally by air (AN) and forced air cooling (AF) provided as an option to improve overload capacity
- Smaller dimensions, less weight, and space saving
- Oil drainage pits and fire extinguishing devices not required for operation

Special Designs:

Though standard cast resin dry type transformers can meet the demands of most applications, special designs can be developed for single phase transformers, isolation transformers, rectifier transformers, grounding transformers and transformers with special tapping arrangements.



Cast Coil vvvf Transformer



20 MVA, 35kV Cast Coil Transformer

Technical Specifications:

Voltage level	10-35kV
Power capacity	30-20000kVA
Type of voltage regulation	off-circuit or on-load
Tapping range	5%, 2 ±2.5% (or as requested)
Frequency	50Hz or 60Hz
Phases	Three phase
Connection symbol:	Y yno; D yn11 (or as requested)
Maximum temperature rise:	100°C
Cooling method	AN or AF

Innovative Facilities and Rigorous Quality Processes

XD|GE's technology portfolio is built in state-of-the-art manufacturing and testing facilities with robust quality processes which provide customers with products that meet the critical and demanding reliability and environmental challenges of transmission applications.

Manufacturing Excellence

XD|GE manages 4 state-of-the-art manufacturing facilities with capabilities to design a full range of transformers and shunt reactors with operating voltages up to 1100kV. Key highlights include:

- ISO® 9001 certified facilities
- Core type technology
- Annual manufacturing capacity of 200,000+ MVA
- 400 ton bridge crane, 400 ton air cushions
- 400 kW/9 m vapor phase drying ovens
- 150 ton stacking tables
- 40 ton vertical winding machines
- Isolated clean rooms for winding and assembling > 230kV
- Direct seaport access for transformers up to 800 tons

Exceptional Quality

A focus on quality is an ongoing strategic initiative for XD|GE and that is evidenced throughout the manufacturing environment. The quality process begins with an incoming inspection of all materials to ensure the best possible inputs before manufacturing begins.

Throughout the production and assembly process, there are multiple checkpoints, including both visual inspections as well as stopped flow.

Inspections are all performed to documented test plans. The production facilities follow strict non-conforming procedures to identify, control and avoid the use and delivery of non-conforming products. Each production facility has developed strict environmental standards, including controls of cleanliness, temperature and humidity. Controls are in place to monitor and manage to the established standards.

In addition, XD|GE has a dedicated measurement and inspection department with a certified full time inspector in each of its manufacturing sites.

The measurement and inspection department provides a secondary cross-inspection for all work in process, as well as finished products, ensuring a high level of quality is achieved throughout the manufacturing process. First Pass Yield and Cost of Quality data is maintained and analyzed, per product family, in order to drive continual product and process improvements and higher product reliability.

From raw materials acquisition and inspection to finished product, XD|GE's transformers and shunt reactors are designed to meet rigid quality processes so the installed product provides the highest level of reliability.

Advanced Test Facilities

XIHARI®, the Xi'an High Voltage Apparatus Research Institute, is an integral part of the XD|GE alliance. XIHARI has extensive testing capabilities at its facility sites, which include a: High Power Laboratory, High Voltage Laboratory, Artificial Climate Laboratory, EMC Laboratory, and an Operational Test Circuit for HVDC Thyristor Valves.

The testing facility for XD|GE transformers is currently the largest testing hall in Asia, measuring over 40,000 square feet and having a ceiling height of nearly 160 feet. It meets the requirements of ISO/IEC® 17025 and boasts some of the largest test equipment in the world, creating capacity to test transformers as large as 1100kV/1500MVA, 1100kV/360Mvar shunt reactors, ±800kV/380MVA converter transformers, and ±800kV/4500A smoothing reactors.

Dielectric tests can be performed for AC transformers and shunt reactors rated up to 1100kV AC and on HVDC converter transformers rated up to ±800kV DC. The transformer facilities also have impulse generators rated at 4800kV/720kJ, power frequency test transformers rated to 1800kV/2A, 4200kV lightning impulse chopping device, DC voltage generators, and high-voltage capacitors for thermal testing, impedance testing and load loss testing at maximum ratings.



Support and Service

Global Project Engineering Services

XD|GE is dedicated to helping its customers reach their system objectives and provides a suite of professional services to assist in the successful deployment and maintenance of XD|GE products and solutions. From design and implementation to post-sales support, a team of technical and business experts are available to help customers effectively use the capabilities and product domain knowledge that are available from XD|GE.

This support infrastructure covers the entire life cycle of the product. From the coordination of transportation logistics to the completion of site acceptance testing and warranty service, the highly qualified XD|GE team is available throughout the implementation.

To ensure a high quality of service to meet the needs of each unique application, XD|GE has a global field service team of highly experienced and dedicated individuals. Coupled with a vast network of high voltage power equipment domain experts, XD|GE is able to support a broad range of applications in various environments.

Finally, XD|GE offers a 24x7 global support service to address and direct any customer application and field questions.

Specialized Installation and Commissioning

- Logistics management including coordination of ocean and inland transportation
- Installation services include receiving, rigging, unloading and labor (mechanical and electrical)
- Test commissioning
- Site acceptance testing

Post-Sales and Installation Support

- 24x7 global customer service
- Emergency response hotline
- Several customer support access points available to ensure timely support (telephone, e-mail, fax, or web)
- Global spare parts reserve
- A global network of maintenance and repair facilities



4800kV/720 kJ Impulse Voltage Generator & ±2000kV 30mA DC Voltage Generator

Primary Plus



Pre-Engineering Secondary Equipment

Primary Plus, XD|GE's supplemental offering to its primary equipment, is a pre-engineered, factory installed solution set that allows utilities to reduce the time and labor associated with substation construction and expansion. Primary Plus uses technologies and methodologies familiar to existing resources and skill sets.

- Digitized primary equipment for replacing labor-intensive, individually terminated copper wires
- Electrical transformer protection to monitor and react to fault conditions
- Transformer monitoring and diagnostics to predict problems and proactively manage performance
- Secure and ruggedized wireless devices, fiber optic multiplexers and Ethernet switches



Digitized Substation

Multilin™ HardFiber System

- Using the Multilin HardFiber system, XD|GE can deliver primary equipment with digital communications. The Multilin HardFiber system digitizes analog signals from primary assets utilizing IEC 61850 communications, reducing total life costs of protection and control through labor and resource optimization.
- This factory-installed solution reduces the amount of labor-intensive, individually terminated copper wire connections with pre-terminated copper and fiber optic cables with standard physical interfaces and open digital communications.

Key Benefits

- Saves up to 50% of Protection & Control labor costs
- Eliminates the majority of copper wiring to better utilize resources for the design, building, commissioning, and maintenance of power system protection and control
- Robust and simple architecture for deploying IEC 61850 process bus
- Improves employee safety by leaving potentially dangerous high-energy signals in the switchyard
- Reduces the chances for operational mistakes made during isolation and restoration after routine maintenance
- Built as an extension of the Multilin Universal Relay (UR) family of products, suitable for a wide array of protection applications
- Rugged, hardened, and secure switchyard interface enabling NERC/CIP compliance



Electrical Protection & Control

Advanced Relays for Substation Equipment

Primary Plus uses the Multilin T60 relay to monitor for fault conditions including winding and tank faults, core insulation failure, thermal overload, and overvoltage. While providing this protection, the T60 simultaneously captures all analog waveforms and digital signals via the transient recorder. In addition, the T60 records measured and calculated quantities via the data logger, documenting anomalies for necessary diagnostics.

Key Benefits

- Secure high-speed protection for transformers, compliant with IEEE® C37.91
- Improved security for transformer energization and inrush
- Integrated transformer thermal monitoring for asset management
- Sensitive ground fault protection provides low impedance differential protection
- Robust network security enables critical infrastructure protection
- Advanced automation capabilities for customized protection
- Advanced fault and disturbance recording, including internal relay operating signals





Monitoring & Diagnostics

Monitor & Proactively Manage Transformers

GE offers a wide range of solutions that monitor, manage, detect and diagnose transformer issues to optimize substation assets. Online monitoring of transformer oil with composite gas or multiple gas Dissolved Gas Analysis (DGA), allows asset owners to be notified of developing conditions that could lead to unscheduled outages. Our advanced prognostics, maintenance services, and proven modeling capture and analyze critical transformer data.

Key Benefits

- Minimizes costly unplanned outages and equipment failure by predicting faults up to 6 months in advance
- Optimize transformer output, maximizing assets
- Calculate transformer aging
- Remote 24x7 asset monitoring for online anomaly detection & trending
- Eliminate costly consumables and calibration gases with photo acoustic technology





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