Transmission Products
Offering system integration for grid solutions

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Transmission Products
Market leader in innovation

Key information

- Worldwide #2 position
- ~13,300 employees
- 30 factory locations in 14 countries
- Transmission Products has the competence of building all product and system elements of HV substations
  - a trusted and reliable partner
  - comprehensive portfolio
  - driving technology innovations
  - highest quality standards
Transmission Products
Major backbone of the Energy Value Chain

Our functionality offer

Transmission products & systems for:
- Efficient power transformation
- Reliable protection
- Precise measurement
- Safe switching & operation
- Power quality
- Future built in connectivity & intelligence
- Improved grid resilience & sustainability

single source for products & systems from generation via transmission to distribution

Conventional power generation
Renewable power generation
Transmission Products & Systems
Industry & infrastructure
Distribution network

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TP comprising all products of HV substations including their electrical integration to systems

Air insulated substation

Gas insulated substation

Power quality

System

Product

Voltage Transformer

Current Transformer

Transformer

Insulators

Circuit Breaker

Disconnector

Bushing

GIS

Line Traps

Coils

Reactors

Phase Shifter

Sensors and connectivity; control, protection and automation; medium voltage; parameterization, system engineering; HV connection between AIS/GIS and transformers
Our portfolio – Reliable & sustainable for all applications (I/IV)

Gas-insulated switchgear

- Very reliable: Less than 25% of failures compared to GIS Cigre failure average
- Very compact
- For indoor and outdoor installation, also in environmentally sensitive areas
- Low operating costs with the first inspection required after 25 years of operation

8VM1 up to 72.5 kV  8VN1 up to 145 kV  8DN8 up to 170 kV  8DN9 up to 245 kV  8DQ1 up to 550 kV

Circuit Breaker

- Very reliable: Less than 10% of failures compared to Cigre failure average through self-compression interrupter unit and stored-energy spring mechanism
- Reliable product life time of up to 50 years
- Low installation and maintenance costs
- Market leader with >100 years of operational experience

8VM1  8VN1  8DN8  8DN9  8DQ1

Live Tank Circuit Breaker from 72.5 kV up to 1200 kV
Dead Tank Circuit Breaker from 72.5 kV up to 1200 kV
Disconnecting Circuit Breaker for 145 kV and 420 kV
Dead Tank Compact for 145 kV and 245 kV
Our portfolio – Reliable & sustainable for all applications (II/IV)

**Disconnector & Earthing Switches**

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Voltage Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>3DN3</td>
<td>(Pantograph)</td>
<td>up to 550 kV</td>
</tr>
<tr>
<td>3DN1</td>
<td>(Center break)</td>
<td>up to 550 kV</td>
</tr>
<tr>
<td>3DN2</td>
<td>(Double side break)</td>
<td>up to 1200 kV</td>
</tr>
<tr>
<td>3DN4</td>
<td>(Vertical break)</td>
<td>up to 550 kV</td>
</tr>
<tr>
<td></td>
<td>Earthing switches</td>
<td></td>
</tr>
</tbody>
</table>

- Delivery of pre-assembled and pre-adjusted disconnector & earthing switch poles and main components
- Easy erection and final adjustment according to the operating instructions
- No special tools necessary
- Dry-lubricated contact systems

**Surge Arrestors & Long rod insulators**

<table>
<thead>
<tr>
<th>Type</th>
<th>Voltage Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV station arresters</td>
<td>up to 1200 kV</td>
</tr>
<tr>
<td>MV arresters</td>
<td>up to 72.5 kV</td>
</tr>
<tr>
<td>Line surge arresters</td>
<td>up to 800 kV</td>
</tr>
<tr>
<td>Arresters for railway</td>
<td>up to 45 kV</td>
</tr>
<tr>
<td>Long rod insulators</td>
<td></td>
</tr>
</tbody>
</table>

- One of the leading manufacturers with 90 years of operational experience in standard and special applications
- Superior sealing system that reliably prevents moisture ingress to ensure the highest possible degree of overvoltage protection and decades of trouble-free service
Our portfolio – Reliable & sustainable for all applications (III/IV)

Instrument Transformers

- Complete product portfolio for AIS & GIS applications in all technologies
- Excellent insulating stress control using fine graded bushings, increasing safety & reliability
- We meet and exceed our customers’ specifications and some of the industry’s most rigorous standards, with designs available in compliance to ANSI/IEEE, IEC and other major standards

Coils

- Highest mechanical and short-circuit strength
- Low noise levels are maintained throughout the life of the reactor
- Weatherproof construction, with minimum maintenance requirements
- Product lifetime of 30 years and more
- Designs available in compliance with ANSI/IEEE, IEC and other major standards.

Current Transformers (Oil & Gas)
Voltage Transformers (Ind.: Oil & Gas; Cap.)
Combined Transformers (Oil & Gas)
Instrument Transformers for GIS

Air Core Dry Type Reactors
Line Traps
Arc Suppression Coils
Variable Shunt Reactors
Our portfolio – Reliable & sustainable for all applications (IV/IV)

Transformers and Reactors

- Full portfolio tailored to meet specific customer needs
- Designed to maximize grid availability
  - Extreme high reliability ("excellent" mean time between failure rates)
  - Comprehensive Pretact® and Ester solutions
- Long-lifecycle solutions with maximum efficiency
- Connectivity & optimized operation by Sensformer® technology

Bushings

- HSP & Trench, two world market leaders in high-voltage bushing technology share their knowledge in terms of development, design and production of AC & DC bushings
- Highest quality and customized solutions
- Technologies have been successfully in service for more than 65 years

- Power Transformers 1)
  - up to 1200 kV
- HVDC Transformers
  - up to 1100 kV
- Reactors
- Phase Shifting Transformers
- Transformers for Industry

- Transformer Bushings
  - 24 - 1200 kV
- Wall Bushings
  - 24 - 1000 kV
- GIS Bushings
  - 73 - 550 kV
- Generator Bushings
  - up to 50,000A

1) Including Generator step-up transformers and System-interconnecting transformers
Global factory network for highest performance & customer intimacy

- Toronto, CA
- Jackson, US
- Guanajuato, MX
- Querétaro, MX
- Cairo Mont., IT
- Troisdorf, DE
- Berlin, DE
- Dresden, DE
- Bamberg, DE
- Nuremberg, DE
- Troisdorf, DE
- Leonding, AT
- Linz, AT
- Weiz, AT
- Voronesh, RU
- Shenyang, CN
- Jinan, CN
- Cairo Mont., IT
- Trento, IT
- Saint-Louis, FR
- Cairo Mont., IT
- Pravets, BG
- Zagreb, HR
- Kalwa, IN
- Aurangabad, IN
- Hyderabad, IN
- Jakarta, ID
- (in set up)
- Wuhan, CN
- Wuxi, CN
- Shanghai, CN
- Hangzhou, CN
- Guangzhou, CN
- Jakarta, ID
- (in set up)

• Clear global product responsibility in Lead Factories for highest performance of entire factory network
### Key innovations for high-tech performance and sustainability

#### Sensformer® – Born Connected
- Sensformer® enables our customers to get digitalized and optimize its operations

#### Grid Resilience – Pretact®
- Mobile Resilience Units for easy and fast replacement / bypassing

#### Ester – alternative fluid for transformers
- Fully biodegradable insulation fluid produced from renewable sources

#### Blue Clean Air / Vacuum portfolio (SF₆ free)
- "Blue" portfolio combines high-tech performance, easy operation, maintenance and sustainable
- No CO₂e emissions

#### UHV equipment <=1200 kV (AC) / 1100kV (DC)
- State-of-the-art technology for efficient longest distance transmission

#### Low power instrument transformer
- Compact combined eCT/eVT solution suitable for wide range of applications

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Transmission Products
Reference: Gas Insulated Switchgear and Transformers for groundbreaking Megaproject in Egypt

Power Transformers
- 86 Power Transformers delivered in total, therein step-up transformers and auto transformers with ratings from 165 to 485 MVA
- Utilizing factory network to meet tight delivery schedule

Gas-insulated switchgear
- Six 500 kV gas-insulated substations and six 220 kV gas-insulated substations to enable a reliable and resilient energy delivery
- Provision of training and employment

Key facts
- Customer: Egypt government
- Local partners: El Sewedy Electric and Orascom Construction
- Siemens gas successfully managed to connect 14.4 gigawatts to the Egyptian national grid
- Ordering year: 2015
Reference: Product supply for world’s first 1100 kV UHVDC transmission line

**HVDC Transformers**
- Design and manufacturing of 4 different transformer types
- World’s first 1100 kV UHVDC transformer
- Utilizing factory network to develop & produce 28 units

**Bushings**
- First bushing worldwide for ±1100 kV UHVDC transmission in RIP dry technology

**Key project facts**
- UHVDC transmission line from Changji to Guquan in China
- Operator: State Grid Corporation of China (SGCC)
- Distance of 3,284 kilometers with a transmission capacity of twelve gigawatts
- Ordering Year: 2016
Reference: World’s first SF6-free high-voltage switchgear with clean air insulation

Circuit Breakers
• Installation of two SF$_6$-free 3AV1 Blue circuit breakers
• Vacuum interrupter technology
• Clean air insulation

Instrument transformers
• Six SVAA voltage and current transformers with clean air insulation

Key information
- Customer: Netze BW GmbH, Germany
- Modernization of a 110 kV substation in Nördlingen
- Operation requires no SF$_6$ insulating gas anymore
- Ordering year: 2017
Transmission Products – benefiting from experience and innovation power

Total cost of ownership
- Short delivery and commissioning times
- Highest overall value through predictable revenue stream and lowest costs of operation driven by energy efficient solutions

Reliable & resilient
- Lowest failure rates
- Long product life times
- Over 100 years of operational experience
- Global Resilience concept to Protect, Prevent and React

Leading in innovation
- State-of-the-art technology
- UHV equipment up to 1200 kV (AC) and 1100 kV (DC)
- Several world first solutions

Cost efficient

Connectable & intelligent
- Digitalized products to optimize operations
- Secure data transmission
- Data storage on cloud solutions

Sustainable
- High efficiency products
- Minimal SF₆ volume and best in class leakage rate
- Blue products with no greenhouse gas impact
- Ester technology

Comprehensive & global
- Global footprint operated as factory network
- Most comprehensive portfolio for all high voltage applications
- Single source opportunity
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Customer benefits of the blue portfolio

- **High reliability**
  due to the hermetically tight vacuum interrupter, eliminating any influence caused by decomposition products

- **High performance**
  Perfect for frequent switching applications: Higher number of short-circuit interruptions throughout life-time of the vacuum circuit-breaker

- **Perfect for low temperature**
  No liquefaction of switching medium

- **No maintenance**
  Maintenance free due to sealed for life technology; no spare part costs

- **No CO₂e emissions**
  Switching media (vacuum) with GWP=0;
  no CO₂e emissions during operation, maintenance or recycling
Ester technology - Benefits of alternative insulation fluids for Power Transformers *)

Higher fire safety
- Higher flash and fire point
- Fire point above 300°C
- K class rating (IEC 61100 / 61039)
- Lower gas conversion factor
- Tank rupture prevention

Lifetime extension
- Slower decrease in the degree of polymerization
- High capability to take water from cellulose
- Dielectric strength unaffected by water
- Higher temperature limits

Smaller Footprint
- Eliminate rocks, grating, and support steel
- Change containment size
- Shorter bus duct length

Cost savings (example)

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost/Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings from design difference</td>
<td>$ 655,494</td>
</tr>
<tr>
<td>Bio-oil transformer extra costs</td>
<td>– $ 275,450</td>
</tr>
<tr>
<td>Total savings</td>
<td>$ 390,044</td>
</tr>
</tbody>
</table>

OPEX savings
- Lower savings annual insurance premiums
- Lower losses during operation due to shorter bus duct length

*) up to 420kV in operation – higher values on request
Pretact® – Increase grid resilience at any time
Minimizing unplanned outage and blackout risks

Risk factors for safe power supply

- Operational issues
  - Network failure
  - Aging fleet
  - Load balancing
  - Incorrect operations

- Natural disasters
  - Storms
  - Flooding
  - Fire
  - Earthquakes
  - Geomagnetic storms

- Other forced outages
  - Vandalism
  - Cyber attacks

Common protection

<table>
<thead>
<tr>
<th>PREVENT</th>
<th>PROTECT</th>
<th>REACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>operational issues</td>
<td>against natural disasters and forced outages</td>
<td>to emergencies and temporary outages</td>
</tr>
</tbody>
</table>

Benefits:

- Maximize energy availability at reasonable efforts vs. blackout impacts
- Increased personal safety in combination with ecofriendly design (e.g. ester filled, clean air)
- Minimized outage risk from months to a minimum e.g.
  - 300 MVA transformer-bank exchange in 30 hours (within three working days)
  - Mobile GIS
- Optimized outage management costs
- Outage recovery plan definable
Pretact® – Increase Grid Resilience at any time
Modular feature architecture to protect, prevent and react

**PROTECT**
against natural disasters
and forced outages

- Bullet resistance, composite insulators and bushings
- Protection equipment like surge arresters and coils
- DC compensation, GIC- and tank rapture safe transformers

**PREVENT**
operational issues

- Alternative Fluids, Blue products: vacuum switching and clean air technology
- Monitoring, Life Time Management, Service concepts
- Reliable products, state of the art design tools

**REACT**
to emergencies and temporary outages

- Mobile Plug & Play concepts for transformers, reactors, Power VT, RIS and RIP bushings
- DCB, Hybrid insulated switchgear / Deadtank CB, Mobile GIS
- Spare product concepts at customer sites for AIS, GIS equipment

**GENERAL**
Financing

**Abbreviations:**
- DC: Direct Current
- GIC: Geomagnetically Induced Currents
- RIS: Resin Impregnated Synthetic
- RIP: Resin Impregnated Paper
- DCB: Disconnecting Circuit Breaker
- GIS: Gas-insulated Switchgear
- AIS: Air-insulated Switchgear
- VT: Voltage Transformer
- Transmission Products
Pretact® – Reference
REACT Transformers for emergencies and scheduled maintenance

Multiple Rating units

Flexible EPR cable connection

Single phase units with optimized geometry

Plug In Bushings (HV & LV)

Sensformer® Cloud connection

Alternative Insulation fluid (e.g. Ester)

Optimized for transportation

Cable Plug In connections Neutral / LV
Sensformer® – Born Connected
Future is in managing and learning from the data

- Sensformer® equipped to provide following direct measurements per default:
  - Oil Level Alarm
  - Top Oil Temperature
  - LV Winding Current
  - GPS Location
  - Local weather information

- Secure data transmission through GSM or Ethernet with state-of-the-art cyber security measures
- Data storage on cloud solution with graphic interface tool for data analysis
- Software applications for further value creation and operational enhancement
Sensformer® App…
Stay on-grid even when you're off-site

- Secure mobile connectivity
- Instant overview of asset status with real-time data
- Enhanced asset life cycle management
- Key KPIs at a glance
- Optional push messages in case of alarms
Thanks for your attention!