Transform(ers) – Our Future
Siemens AG Österreich – Transformers Weiz
Innovation topics

- Alternative Liquids
- Low Noise
- Bullet Resistant
- Direct Current Compensation
- Geomagnetically Induced Currents
- Tank Rupture Safe
- Short Circuit Capability
- Low Partial Discharge

Product Overview
Alternative Insulation Fluids separate Siemens Weiz from competition

- Dielectric property comparison of various liquids
- Technology (investigations of liquid / board properties)
- Production implementation
- Synthetic / natural ester up to 420 kV / 575 MVA
- Main topics: Dielectric charging tendency, breakdown and partial discharge behavior of alternative liquids

Cooperation: Institute of high voltage engineering – Graz / Austria
Low Noise Transformers and Reactors for special customer applications

- Dynamic models for winding resonance and core resonance optimization
- Innovative clamping design for low noise emission

- Noise reduction measures
  - Vibration isolation: up to 5 dB
  - Customized sound panels: up to 15 dB
  - Sound enclosure: up to 30 dB

- Outstanding expertise in on site measurements including customer consulting regarding noise
- Retrofit solutions for reducing the noise level of existing units on site

Ultra low noise 1200 MVA transformer with 54,8 dB(A) under full load
Retrofit of combined sound & bullet resistant panels with a noise reduction of 20dB(A)
Bullet Resistant Transformers to support customer’s critical asset protection concepts

Bullet resistance for new or retrofit transformers

- Both new and retrofit bullet resistant units manufactured to UL 752 Level 10*
- All components protected - except the bushings (which are replaced with interchangeable resin impregnated paper bushings)
- Noise reduction measures are incorporated into the structure
- Designs optimized for cooling efficiency
- No additional on-site foundations required

*highest American bullet resistant class

Bullet resistant units designed, manufactured and delivered – new and retrofit. Combining sound reduction (-20dB) and bullet resistance (UL752 Class 10*).
Direct Current Compensation (DCC) can eliminate or reduce negative effects caused by (small) DC

- (Small) DC in transformers causes
  - increased noise levels
  - increased reactive power consumption
  - Increased no load losses
- Transformers at low rated induction levels (e.g. low loss / low noise transformers) are even more sensitive to DC exposure

Worldwide unique method to compensate DC effects
GIC-safe power transformers survive solar storms

- Detailed DC withstand capability studies of the transformer behavior during a solar storm
- Special test arrangements in laboratories can be used to verify the GIC strength
- GIC risk evaluation
- Knowledge modules in order to monitor critical transformer hotspots

Designed to withstand GIC events from solar storm and sunspots
Tank Rupture prevention to secure fire safety on site

- Real tests on transformers with arc energies ≤ 50MJ
- Dynamic FEM simulation and verification of real tests
- Improvement of static formula for practical use
- Optimized tank design to withstand internal arcs
- Controlled deformation of the tank

Tank rupture-safe power transformers – safety first
Short circuit strength to ensure reliability throughout lifetime

- Provide common design criteria to design and manufacture short circuit proof transformers
- Global center of competence for short circuit design support
- Perform short circuit tests on mock-ups and real units
- Investigate dynamic winding oscillation behavior during short circuit
  - 440 MVA / 420kV GSU Tx - SC tested
  - 450 MVA / 315 kV Auto Tx - SC tested
  - 6 MVAr Short Circuit Limiting Reactor - SC tested

Withstanding short-circuits – without compromises
PD – Partial Discharge Technology to secure lifetime reliability

- Optimized dielectric design through the use of 3D FEM modeling
- Stable processing with advanced drying technology
- Proven results on a range of transformers manufactured for our clients
- Pilot work and model studies

Low Partial Discharge – high reliability
Product overview

- Pretact®-Concept
- Phase shifters
- Variable shunt reactors
- Transformers for urban applications
Pretact® – React in advance
Keeping grids resilient - at all times

The Siemens resilience concept, named Pretact®, for resilient grids comprises of a three-pillar-plan to enable our customers to prevent failures, protect their equipment and react in cases of emergency and any other kind of bypasses.

Customer challenge

- Network outages due to maintenance or transformer failure
- It takes too much time to order a spare / replacement unit
Pretact® – React in advance
Keeping grids resilient – at all times

- A comprehensive concept to increase grid resilience & network availability
- To prevent, protect and react at the entire energy value chain (end to end)
- Modular feature & solution architecture
to meet almost all regional or application
needs, combining approved technologies
and latest innovations
- The right choice for emergencies, retrofit,
upgrades and new installations for your intermediate
or long-term solution to network stability challenges
- Ecofriendly transformers for highly populated
as well as rural areas

Save time & money while enjoying perfect peace
of mind in terms of grid resilience
Pretact® – Bypass transformers
Keeping grids resilient – at all times

- Installation time: within the shortest possible time instead of weeks
- Dimensions & weight to meet transportation limits
- Cost efficient solutions for planned and forced outages
- Applicable to all grid structures

Latest References
- ConEdison, New York, USA 2016
  3x100 MVA 335/136/69/13.8 kV, 1ph – plug-in bushing and connections
- ConEdison, New York, USA 2017
  Successful installation within 30 hours (within 3 days)
- WESTAR, Kansas, USA 2016
  3x133 MVA 345/230/138/115 kV, 1ph plug-in bushing and connections
Phase shifters
The most efficient device for load flow control

A phase shifter transformer is the most efficient way to control the active power flow in a line of a meshed grid. Load flow control is done, via manipulation of the phase angle between voltage at source side and load side. Even blocking or reversing the power flow is possible.

Customer challenge

- Transmission bottlenecks resulting in overloading of specific lines
- Unwanted power flow from adjacent grid operators through own network
- Unwanted physical power flows not covered by commercial contracts
- Difficulty to reconnect networks with large phase angles
Phase shifters
Grid stability – Flexibility – Maximized utilization of existing hardware

- Increased power capacity of grid, due to better utilization
- Cost efficient solution for power flow control
- Grid stability due to avoidance of overloading and additional possibility for voltage regulation
- Independence of adjacent grid operators and protection of own grid from unwanted loading
- Maximized commercial trading possibilities
- Reduction / Elimination of loop flows

Latest References

- **50Hertz, Germany**: 1200MVA / 410kV ±20°
- **City of Santa Clara, U.S.**: 420MVA / 230kV ±22°
- **Orlen Ochrona, Poland**: 75MVA / 33kV +28°/-18°
- **ConEd New York, USA**: 575 MVA, 345 kV ±40°, Ester design
Phase shifters
Siemens pushing the technical limits

Highest regulation range: Phase angle of $-80^\circ/ +31^\circ$

**Dual core / two tank phase shifter**

Technical Data:
- Power rating: 400 MVA
- Voltage: 230/230 kV
- Phase angle: $-80^\circ/ +31^\circ$
- Frequency: 60 Hz

*currently being manufactured*

**Single core / single tank phase shifter**

Technical Data:
- Power rating: 150 MVA
- Voltage: 138/138 kV
- Phase angle: $\pm 32.9^\circ$
- Frequency: 60 Hz

**Worlds first 525kV phase shifter**

**Dual core / two tank phase shifter**

Technical Data:
- Power rating: 650 MVA
- Voltage: 525/525 kV
- Phase angle: $\pm 24^\circ$
- Frequency: 60 Hz

*Tested fully assembled*

**Low noise levels, even without sound house**

**Dual core / two tank phase shifter**

Technical Data:
- Power rating: 575 MVA
- Voltage: 345/345 kV
- Phase angle: $\pm 40^\circ$
- Frequency: 60 Hz

**Sound pressure:** $< 60 \text{ dB(A)}$ \(^1\)

1) value achieved without sound house
Variable shunt reactors
Perfectly adapting to changing network conditions

Shunt reactors compensate capacitive reactive power from high voltage lines. While fixed shunt reactors are designed for defined system condition, variable shunt reactors allow continuous adjustment of the reactor power rating via tap changer to actual needs, dependent e.g. on current line loading or active network paths.

Customer challenge
- Volatile line loading e.g. from renewables or demand cycles resulting in voltage fluctuation
- Future network changes – e.g. grid extensions, switch from overhead lines to cable
- Voltage stability and grid efficiency
Variable shunt reactors
a profitable investment

- Cost efficient solution for flexible reactive power
- Profitable due to reduced reactive power purchase
- Increased grid efficiency
- Reduced reactive power loading
- Reduced network losses
- Better network voltage control
- Independence of adjacent grid operators
- Cheap spare concept if variable shunt reactor is combined with the Pretact® concept

Latest References
- Amprion, Germany: 50-250 MVAr
- Energienet, Denmark: 60-120 MVAr
- North East Utilities, U.S.: 75-150 MVAr
- Statnett, Norway: 90-200 MVAr, 420 kV
Variable shunt reactors  
Siemens pushing the technical limits

Highest regulation range of 80%

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<th>Three phase variable shunt reactor</th>
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<td><strong>Technical Data:</strong></td>
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<tr>
<td><strong>Power rating:</strong> 50-250 MVAr</td>
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<tr>
<td><strong>Voltage:</strong> 400 (420) kV</td>
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<td><strong>Frequency:</strong> 50 Hz</td>
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Highest voltage levels 765kV with lowest losses

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<th>Single phase shunt reactor</th>
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<td><strong>Technical Data:</strong></td>
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<tr>
<td><strong>Power rating:</strong> 100 MVAr</td>
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<tr>
<td><strong>Voltage:</strong> 765 kV</td>
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<tr>
<td><strong>Frequency:</strong> 50 Hz</td>
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<td><strong>Losses:</strong> 146 kW</td>
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Lowest noise levels, even without sound house

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<td><strong>Technical Data:</strong></td>
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<tr>
<td><strong>Power rating:</strong> 60 MVAr</td>
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<tr>
<td><strong>Voltage:</strong> 33 (36) kV</td>
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<tr>
<td><strong>Frequency:</strong> 50 Hz</td>
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<td><strong>Sound pressure</strong>(^1): 58.8 dB(A) (without sound house)</td>
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Whisper reactors with sound house

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<td><strong>Technical Data:</strong></td>
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<td><strong>Power rating:</strong> 57-23 MVAr</td>
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<tr>
<td><strong>Voltage:</strong> 123 kV</td>
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<tr>
<td><strong>Frequency:</strong> 50 Hz</td>
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<tr>
<td><strong>Sound pressure:</strong> 43 dB(A) (sound house)</td>
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\(^1\) Sound pressure measured with Intensity method at 0.3 m distance in test field, w/o DC & w/o harmonics
Transformers for urban applications for the challenges of megacities and urban regions

Customer projects in urban areas need to deal with several challenges:

- Requirements to comply with strict regulations on:
  - Environmental safety
  - Noise emission
  - Maximum reliability and safety in operation
  - Maximum usage of applied resources
  - Economic value add
  - High performance and low losses
Transformers for urban applications for the challenges of megacities and urban regions

**Alternative insulation liquids - Esters**
- Renewable, eco-friendly and fully biodegradable
- Safe & reliable in operation
- High acceptance in urban areas and mega cities

**Low noise**
- Noise emission compliance becomes more and more important in urban regions
- Siemens low noise transformers comply with the strictest noise performance requirements

**Waste heat usage**
- Waste heat usage maximizes utilization of resources and energy
- Allows for greater flexibility in site configuration and smaller space requirements

**Latest References**
- ConEd, New York, USA, 2019: 575MVA 345kV, ±40°
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