Gas-insulated DC switchgear for up to ±550 kV, 5000 A

8DQ1 DC: Maximum performance at minimum space
8DQ1 DC – paving the way for the future of energy

The global energy landscape is increasingly characterized by decarbonization and decentralization, while the world’s power demand keeps growing. This development has numerous implications. One of them is the need for “power highways” to transmit large quantities of power from remote renewable energy sources such as offshore wind and hydropower straight to the load centers.

Pushing the boundaries of DC technology

Space hasn’t been much of an issue with traditional HVDC systems. In new applications, such as offshore wind farms or HVDC systems for the power supply of densely populated areas, however, space usually is at an absolute premium.

One of the most space-saving technologies in high-voltage power transmission is the use of gas-insulated switchgear (GIS) instead of air-insulated switchgear (AIS). That’s why Siemens has spared no effort to make the advantages of GIS available for HVDC transmission. Particular phenomena that are typical for gas-insulated DC switchgear and have impedied the use of GIS in DC systems so far were investigated thoroughly. Newly developed insulation technologies for DC finally made it possible to control these phenomena reliably. Thanks to this intensive research and development work, it has become possible to adapt the insulation system of Siemens’ proven 8DQ1 gas-insulated AC switchgear technology for the use with high-voltage DC applications of up to ±550 kV and currents of up to 5000 A.

Compact technology for future requirements

The new DC GIS greatly reduce the space requirements for HVDC switchyards: Technically equally powerful, reliable, and safe air-insulated switchgear, as have been used so far, require up to nine times more space. 8DQ1 DC switchgear perfectly complement other innovations from Siemens in the domain of HVDC, such as the voltage-sourced converters and the modular multi-level converter topology, which are used in the trendsetting HVDC PLUS systems. They are an important piece of key technology on the way to a more sustainable and diverse energy system and one of the core components of Siemens’ 2nd generation DC grid access solutions for offshore applications.

Save space and effort within the switchyard

DC GIS help you significantly reduce the size of HVDC transition and converter stations. In fact, the room volume for the switchyard can be reduced by up to 95 percent. And just like AC GIS, you can have the modular and extremely compact 8DQ1 DC switchgear installed in a container as well as underground to hide the switchyard from visibility and install the stations right in a load center.

If you decide for an outdoor switchyard, the robust design of DC GIS comes in extra handy: they usually don’t require a separate building or container, even under severe climatic conditions.

DC GIS benefits at a glance

- 95% Space savings of up to 95% compared with technically equivalent air-insulated switchgear. DC GIS require up to 95 percent less space.
- -30 °C to +50 °C Outstanding climatic resistance DC GIS operate safely and reliably onshore and offshore in the temperature range of -30 °C to +50 °C and even under severe conditions such as polluted and aggressive atmosphere.
- Containerized arrangements available DC GIS can be commissioned in prefabricated container modules to reduce environmental impact as well as local erection and commissioning efforts.
- Underground installation possible The encapsulated, compact, and modular DC GIS can be installed underground to prevent visibility and public access.
The new DC GIS provide you with the peace of mind you’re entitled to expect from Siemens GIS. The new switchgear type is based on Siemens’ tried and tested 8DQ1 550 kV AC GIS type series and a newly developed DC insulator. They are designed for all possible HVDC topologies.

Modular and flexible
With BDQ1 DC switchgear, you don’t have to worry about cookie-cutter solutions that don’t fit your needs precisely. There’s a comprehensive range of standardized modules that makes it possible to flexibly implement even complex arrangements and switchyard layouts – while requiring only the utmost minimum in interface-engineering for the connection of other equipment, such as control and protection devices.

Preassembled, containerized, standardized, and less visual impact
On demand, DC GIS can be delivered prefabricated and pretested in modular containers. This is especially practical whenever technical requirements such as extreme environmental conditions demand a housing, when the visual impact of a transmission system needs to be kept to a minimum, and when time is at a premium. The entire arrangement of the preassembled substation is tested at the manufacturer’s premises for the quickest possible commissioning and smooth, cost-effective interaction with civil works.

Layouts that are repeatedly needed, such as cable transition stations within an HVDC scheme, can be planned and provided as a standardized series, which brings costs further down.

Converter stations
1. Offshore
2. Onshore
Transition stations
1. From overhead line to cable
2. From overhead line to GIL
3. From GIS to cable
4. From cable to cable

The modules in detail

01 Disconnector and earthing switch
At the core of the BDQ1 DC switchgear is the disconnector. Together with the earthing switch, the disconnector ensures the safe insulation and earthing of deenergized circuits. An earthing switch can be placed on either side of the insulating gap for the safe operation of the disconnector in the absence of voltage under earthed conditions. The make-proof earthing switch also enables the safe discharge of system potential resulting from residual DC charges within the DC system.

02 Surge arrester
Encapsulated surge arresters ensure optimum protection from overvoltage surges directly at the equipment. Their active parts consist of metal oxide resistors with a strongly nonlinear current and voltage characteristic. Due to higher overvoltage surge requirements in DC systems, more than one surge arrester may be used.

03 Voltage and current measurement
Modules for measurement purposes carry up to three encapsulated measuring heads. Voltage measurements are performed by gas-insulated resistive-capacitive voltage dividers that map high voltage linearly over a frequency range from DC up to 30 kHz. They show excellent transient behavior up to 2 MHz, and their low power output is sufficient for modern protection and metering systems. Current detection relies on the Zero Flux current measurement principle that is already in use in air-insulated DC switchyards. It can be applied directly at the bushing terminals or within the GIS arrangement.

04 Interface modules
The interface modules enable the transition from the gas-insulated switchgear to other equipment. Gas-to-air bushings are available for the transition to an overhead line, cable termination follows IEC 62271-209. The conductor link within the module can be removed to separate the cable from the GIS for on-site cable testing. Another interface module is available for the transition to a gas-insulated line (GIL).

05 Passive modules
Several passive modules are available for flexible configuration. Further compensation modules provide sufficient options to deal with heat dilatation and make available access to the single modules within an arrangement for service and repair purposes.

Designed to suit your needs
The new DC GIS can simply be added to any technology room, such as the converter or reactor room.
Design considerations for DC GIS

Design criteria for DC GIS are different from those of AC GIS, as DC insulators are exposed to the phenomenon of field transition accompanied by charge accumulation at the insulator interfaces. On energization or polarity reversal, the electrostatic field, which is determined by the permittivities, is transformed into the electric flow field, which is determined by the conductivities. The resulting resistive field distribution strongly depends on the materials used and their temperature- and field-dependent conductivities.

Heat conduction, radiation, and gas convection caused by the current in the conductor lead to a temperature gradient during high load operation. The resulting temperature gradient within the insulator from the conductor toward the enclosure causes increased material conductivities in the warmer material close to the conductor. Accordingly, the electric field stress drifts toward the colder regions at the enclosure.

Investigations in consideration of the practical field strength have shown that additional charge carriers from voltage dependent sources may present besides natural ionization and have to be taken into account. Electric conduction must be perceived as the movement of different charge carrier species within the insulating material. The underlying physical processes are influenced by parameters such as nonlinear material properties dependent on temperature, humidity, and additional charges. Occurring effects that need to be considered comprise:

- thermal impact of operating current due to heat conduction, heat radiation, and gas convection
- changes in the net density of free electric charge due to ionization, recombination and attachment, charge injection, and partial discharges
- charge transport phenomena like drift, diffusion, surface conduction, and charge accumulation

In view of these physical characteristics, safe DC field distribution requires the selection of proper materials plus reliable electric field control.

The reliability of the 8DQ1 DC switchgear under various load cycles and under electrical as well as thermal stress has been proven in type tests according to applicable IEC standards for equivalent AC technology and the CIGRÉ recommendations for the testing of gas-insulated HVDC systems.

Gas-insulated switchgear for DC

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<thead>
<tr>
<th>Technical Data</th>
<th>8DQ1 DC</th>
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<tbody>
<tr>
<td>Un nominal DC voltage</td>
<td>±320 kV</td>
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<tr>
<td>Urdc rated continuous DC voltage (max. continuous operating voltage)</td>
<td>±336 kV</td>
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<tr>
<td>Uli rated lightning impulse withstand voltage (1.2 / 50 μs) - superimposed with DC - across the open isolating distance</td>
<td>±1175 kV LI</td>
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<tr>
<td></td>
<td>±336 kV DC &amp; ±1175 kV LI</td>
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<tr>
<td></td>
<td>±960 kV SI</td>
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<tr>
<td></td>
<td>±336 kV DC &amp; ±950 kV SI</td>
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<tr>
<td></td>
<td>±336 kV DC &amp; ±1950 kV SI</td>
</tr>
<tr>
<td>Us rated switching impulse withstand voltage (250 / 2500 μs) - superimposed with DC - across the open isolating distance</td>
<td>±950 kV SI</td>
</tr>
<tr>
<td></td>
<td>±336 kV DC &amp; ±950 kV SI</td>
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<tr>
<td>Ik rated short-time withstand current (AC)</td>
<td>50 kA (1 s)</td>
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<tr>
<td>Ambient temperature range</td>
<td>(-30…+50) ºC</td>
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Due to standardized modules, this typical arrangement of DC GIS can be adapted to suit your needs.