HIS – Highly Integrated Switchgear up to 550 kV, 63 kA, 5000 A
Type 8DQ1

Answers for energy.

SIEMENS
HIS – Highly Integrated Switchgear – Solves Space Problems

No more losing sleep over space restrictions: HIS, the gas-insulated switchgear for indoor and outdoor use requires less than half the space of comparable air-insulated switchgear.

The 8DQ1-type HIS is a compact switchgear solution for rated voltages of up to 550 kV. It is used mainly for cost-efficient renewal or expansion of air-insulated outdoor and indoor substations, particularly if the operator wants to carry out modifications while the switchgear is in service. New construction projects, high site prices and increasingly complex approval procedures make space prime factor in costing. With the HIS solution, the circuit-breakers, instrument transformers, disconnecting and earthing switches are accommodated in pressure-gas-tight enclosures with a minimum of five independent gas compartments, which makes the switchgear extremely compact.

Thus, you can meet the growing demands on your switchgear within the scope of the existing site.
HIS – Highly Integrated Switchgear – is the Cost-Effective Alternative

Cost-effective and versatile
With HIS, it is possible to implement all commonly-used substation configurations by using compact, standardized modules. Thus, for example, one air-insulated (conventional) bay can be replaced with two HIS bays – with space to spare! Low operating costs, minimal maintenance requirements and a long service-life of the system additionally help to reduce life-cycle costs. With the units preassembled and tested at the factory the switchgear is easily set up. In addition, HIS will readily fit your existing control and protection concept – whether it is conventional, digital or process-bus based. This allows flexibly and cost-effectively integrating HIS in your substation.

Low investment cost
State-of-the-art CAE and IT tools for order and execution management in combination with highly efficient manufacturing processes make for short planning and delivery times. The switchgear is delivered to the site in preassembled units that have already been tested. This significantly reduces the time between the award of the contract and handing over the complete switchgear to the client. In addition, HIS requires only half the floor space of air-insulated switchgear. Due to the small, compact bay structure, only few foundations are necessary. Civil works activities are reduced to a minimum, so that even in mountainous, rocky terrain, construction presents no problems. To a large extent, the work required for expanding existing outdoor switchgear can be performed during operation. Isolating sub-sections of the equipment for short periods of time is all it takes. This minimizes switchgear outage time, which, in turn, helps keep investment costs down and ensure speedy commissioning.

Safe, reliable operation
The enclosed design protects operating personnel from contact with live parts. Integrated disconnecting and earthing switches on the busbar and outgoing feeder sides permit risk-free isolation and earthing of switchgear sections. All operations are remote controlled. Outgoing feeder earthing switches can also be supplied in the make-proof high-speed version. This avoids releasing conductor connections to establish isolating sections as well as the use of mobile earth rods. Rupture diaphragms with defined discharge directions prevent unacceptably high pressure rises in the enclosures. Bay construction on a single level makes for a straightforward switchgear layout. In addition to operator safety, the HIS solution provides excellent protection against vandalism. Thus, you can ensure maximum safety for your personnel and your switchgear as well as reliable operation.

Environmentally compatible
The environment also benefits from your HIS. The oil-free operating mechanism and the highly effective sealing of the enclosure prevent environmental pollution. The long service-life of HIS and its reduced space requirements additionally conserve resources. This means that you are protecting the environment for the future.

Robust and low maintenance
The high quality of the switchgear is a result of comprehensive quality management. The enclosures are corrosion-resistant aluminum castings and the motor-operated mechanisms are self-lubricating. The switchgear has no contact systems or operating linkages exposed to air, which protects it from external influences, even under corrosive environmental conditions.
It is also aseismic and impervious to wind. This means that you can rely on your switchgear at all times – at an extremely low operating cost.

The creative solution
Based on GIS technology, HIS offers a creative solution for your switching functions as it is:
- Compact
- Low-cost and
- Modular for indoor as well as outdoor application
Efficiency
due to Modular Design

HIS switchgear is single-phase encapsulated in order to keep dielectric and dynamic stresses to a minimum. The switchgear is clearly laid out on a single level. Its enclosure is made of aluminum. As a result, the switchgear is corrosion-proof and exceptionally lightweight. State-of-the-art design methods and casting techniques permit optimum dielectric and mechanical construction of the enclosures. Sulfur hexafluoride (SF₆) is used as the insulating and arc-quenching gas. All modules are attached to one another with flanges. The gas-tightness of the flange joints is ensured by the Siemens O-ring sealing principle, proven over decades of service. Gas-tight bushings permit subdividing the bay into several distinct gas compartments. Each gas compartment is fitted with its own gas monitor, rupture disks and filter material. Static filters absorb moisture and decomposition products. In the improbable event of a fault, rupture disks prevent unacceptably high pressure buildup in the enclosures. When activated, diverter nozzles ensure discharge of the gas in a defined direction. The outdoor-proof enclosures and operating mechanisms are fitted with space heaters. Screws and nuts are corrosion-proof.
The modular system enables all conceivable customer requirements to be met with just a small number of components.
Circuit-breaker module

The central element of the gas-insulated switchgear is the circuit-breaker module with its two main components:
- Stored-energy spring mechanism and
- Interrupter unit

For air-insulated switchgear (AIS) and gas-insulated switchgear (GIS), the same interrupter units and operating mechanisms are used. The use of this platform concept in a wide range of applications has provided us with decades of comprehensive experience. The circuit-breaker is suitable for single-pole rapid auto-reclosure.

Stored-energy spring mechanism
The stored-energy spring operating mechanism provides the force for opening and closing the circuit-breaker. State-of-the-art production techniques allow using compact, corrosion-proof aluminum housings. Since the closing and opening springs are housed in the operating mechanism, the structure is compact and sturdy. This design results in a small number of moving parts. The use of roller bearings and the maintenance-free spring mechanism are a prerequisite for decades of reliable operation. Proven design principles, such as vibration-isolated latches and load-free isolation of the charging mechanism, are retained.

The advantages of the stored-energy spring mechanism:
- One principle for rated voltages from 72.5 up to 550 kV
- High reliability due to low operating energy
- Simple principle of operation
- Switching state controllable at all times
- Low-maintenance and economical with a long service-life
- Low environmental impact
Interrupter unit
The interrupter unit used in the circuit-breaker for arc-quenching operates according to the dynamic self-compression principle. This principle requires only low operating energy thus keeping the mechanical stresses on the whole circuit breaker to a minimum.

The current path
In the closed position, the operating current flows through the main contacts (2, 10). The arcing contacts (1, 7) are plugged in in parallel to the main contacts.

 Interruption of operating current
During the breaking operation, the main contact (10) opens and the current commutates to the arcing contacts (1, 7), which are still closed. This avoids erosion of the main contact. As the breaking operation continues, the arcing contact opens and an arc forms between the contacts (1) and (7). At the same time, the contact cylinder (10) compresses the SF₆ gas located in the compression volume (4). The compressed arc-quenching gas flows through the heating volume (11) into the contact gap and extinguishes the arc.

 Interruption of fault current
In case large short-circuit currents occur, the gas between the arcing contacts (1) and (7) is heated by the arc’s energy and is driven into the heating volume (11) with high pressure. When the current passes through zero, the gas flows back from the heating volume through the nozzle (9) and quenches the arc. The valve (3) of the contact cylinder (10) prevents the high-pressure gas from entering the heating volume. Thus, the arc quenching energy does not have to be supplied by the operating mechanism.
Disconnecting switches

Disconnecting switches assure a dielectrically safe gap between both contacts for secure isolation of system areas of different potential, e.g. busbar disconnecting switches isolating a whole feeder from the busbar. Cast-resin bushings keep the contact system in place and the pressurized gas serves as the isolating medium between live parts and the metal housing. The module is available with up to two earthing switches and the necessary connectors for different types of adjacent modules. Disconnecting switches can be built as separate gas compartments with their own monitoring or be combined with surrounding modules.

Earthing switches

Earthing switches (e.g. work-in-progress earthing switches or busbar earthing switches) are used for properly connecting deenergized live parts of the high voltage system to the ground. On the outgoing side of the feeders a make-proof version (high-speed) is frequently used to eliminate risk to the GIS system, e.g. if the opposite side is not switched off properly. The insulated version is used for measuring purposes and for testing protection relays. In 8DQ1 switchgear, the earthing switches are of a pin-type design. They are preferably used in conjunction with disconnecting switches, but can also be supplied as separate modules with their own housing. With the pin-type earthing switch, the earthing pin at earth potential is pushed into the mating contact. Make-proof earthing switches are equipped with a stored-energy spring mechanism. The spring can be recharged either by a motor or manually in an emergency.

Common features of disconnecting and earthing switches

- The three poles of a bay are coupled mechanically
- All three poles are commonly operated by one motor mechanism
- Auxiliary switches and ON/OFF indicators are friction-locked
- Identical motor operating mechanisms are used for disconnecting and earthing switches
- Manual emergency operation is possible
- Enclosures can be fitted with inspection windows on request
Instrument Transformers

Both current and voltage transformers are used for measuring and protection purposes.

Current transformer
The current transformers used are of the single-phase inductive type. Current transformers are preferably located on both sides of the circuit-breaker. The high-voltage conductor forms the primary winding. The cores with the secondary windings are designed to comply with the requirements regarding accuracy class rating and performance. It is possible to change over to various transformation ratios via the current transformer’s secondary connections which are routed to a terminal box via a gas-tight bushing plate. The pressurized SF₆ gas in the module serves as the primary insulation.
The encapsulated design provides very high reliability in terms of EMC (electro-magnetic compatibility).

Voltage transformer
Each single-phase inductive voltage transformer is encapsulated in its own housing forming a separate gas-tight module. Each voltage transformer consists of the following main components:
- The primary winding
- One or more secondary windings (forming one coil)
- An iron core

The pressurized gas inside the enclosure combined with the film insulation provides insulation against high voltage. The high-voltage connection to the switchgear is established by means of the primary conductor, which is supported by a gas-tight bushing. The secondary connections are routed to the terminal box via a gas-tight bushing plate.

Surge arrester
If required, encapsulated surge arresters can be directly connected. Their purpose is to limit any overvoltages. Their active parts consist of metal-oxide resistors with a strongly non-linear current/voltage characteristic. The arrester is generally flange-jointed to the switchgear via a gas-tight bushing. In the tank of the arrester module, there is a manway opening through which the internal conductor can be inspected. At the bottom, there are connections for monitoring, arrester testing and an operation counter.
Termination modules

The termination modules connect the bays of the gas-insulated switchgear to the following:

- Overhead lines
- Transformer or reactor coils
- Cables

They thus function as the transition link between the SF₆ gas insulation within the enclosure to other insulating media. In the 8DQ1 range, various types of termination modules are available to suit different requirements, depending on the connections required.

Cable termination

This module acts as a link between the metal-enclosed gas-insulated switchgear and high-voltage cables. All customary types of high-voltage cables can be connected to the cable termination module without any problem. The manway opening also serves as a connecting flange for the high-voltage cable-testing system. For high-voltage testing, the primary conductor connection between the cable sealing end and the switchgear can be removed.

SF₆/air termination

The SF₆/air termination allows connecting the gas-insulated switchgear to air-insulated components or overhead lines. This termination is a combination of an angle-type module and an outdoor/SF₆ bushing. The length, shape-form and creepage distance of the outdoor/SF₆ bushing can be adapted to various requirements with respect to insulation coordination, minimum clearance or degree of pollution.

Splitting the connection points of the three phases to provide the necessary air clearance for conductor insulation must be taken into account when designing the substation.
Transformer tube-termination
The transformer tube-termination enables a direct tube connection from the GIS to an oil-insulated transformer or reactor. For this purpose, the transformer bushing must be oil-tight, gas-tight and pressure resistant. Temperature-related movements of the switchgear and the transformer as well as the settling of foundations are absorbed by expansion joints in the tube connection.

Extension and angular modules
These modules are used for the connections within a bay and for routing to the requested customer interface points. Their shape and number depends on the circuit and the layout of the bay.

Busbar module
The busbar modules of adjacent bays are connected with expansion joints that absorb constructional tolerances and temperature-related movement of the system both longitudinally and transversely to the busbar. Axially guided sliding contacts between the conductors compensate for temperature-related changes in conductor length. A sectionalizer (to increase the availability of the switchgear) can be fitted without any additional measures.
Control and Monitoring
Reliable and Flexible Control and Protection System

Proven switchgear control
Robust electromechanical components are used to control and monitor circuit-breakers as well as other switchgear components. All elements necessary for the control and monitoring of circuit-breaker operating mechanisms are incorporated in the circuit-breaker control unit. The operating mechanisms are pre-tested at the factory to reduce commissioning time to a minimum and avoid errors on-site.

Gas monitoring
Gas-tight insulating partitions subdivide each switchgear bay into separate gas compartments (e.g. circuit-breakers with current transformers, disconnecting switches, voltage transformers, surge arrester and termination modules). The gas compartments are constantly monitored by density monitors providing alarm and blocking signals via contacts.

Reliable and flexible control and protection system
The local control system is easily accessible in the separately mounted control cubicle. As an option, the feeder protection can also be included in the same cubicle. The local control cubicle is normally placed near the switchgear, but installations in a separate control room is also customary. Screened control cables are used for the connections between the local control cubicle and the high-voltage equipment. Coded plug connectors are used to cut the cost of installation and minimize the risk of cabling errors. If requested, we can supply our high-voltage switchgear with any of the commonly available digital control and protection systems.

Standard interfaces in the local control system allow interfacing
- Conventional control systems with protective interlocking and control panels
- Digital control and protection systems with user-friendly bay controllers and station automation with PC workstations (HMI)
- Intelligent, fully networked digital control and protection systems with additional monitoring and remote diagnostics functions

Thanks to the extensive range of Siemens control and protection systems, we can offer you a multitude of custom concepts from a single source.
Transport
To facilitate easy transport and on-site installation, our switchgear assemblies are split into optimized shipping units with emphasis on ease-of-handling. Restrictions on transport dimensions usually do not allow transporting a whole bay in one unit. The means of transport, routes and on-site handling are taken into consideration in the process. All shipping units are mechanically and dielectrically tested before delivery. In the case of modules containing switching devices, all operating-mechanism attachments are preset at the factory prior to shipment. All flanges where the modules are to be joined to other equipment are protected and sealed with transport covers. All goods are packed according to means, duration and route of transport as well as in line with the conditions and duration of storage. Shipments within Europe are normally by road. Switchgear supplied to overseas countries is sealed in suitable shipping units with seaworthy packing taking into account any temporary storage that may be necessary.

Installation and erection
The delivery of the bays in just a few, easy-to-handle transport units reduces the time and effort needed for on-site installation. The control unit of the circuit-breaker and the gas monitoring unit of the bay are supplied factory-fitted on the supporting frame or as a separate standard cubicle. Detailed installation instructions and the use of relatively few special tools allow easy and rapid installation of the switchgear. It can even be effected by your own personnel with the help of an experienced supervisor from Siemens. Our training facilities are at your disposal.

Commissioning
After completion of the assembly work on site all switching devices and electrical circuits for controlling and monitoring are tested to ensure proper electrical and mechanical function of the whole system. All flanges are double-checked for tightness, especially those fitted on site. Commissioning work on the primary section ends with the high-voltage test to verify that all installation work, including the work done inside the enclosure, has been done correctly. All tests are performed in accordance with IEC standards and the results are documented in the final test reports.

Operation and maintenance
Our SF₆-insulated switchgear installations are designed and manufactured to provide an optimum balance of design, manufacturing, operation and maintenance. Due to the tightly-sealed enclosure, a minimum of maintenance is needed and the GIS-system can even be regarded as maintenance-free under normal operating conditions. Subject to environmental conditions visual inspections are recommended. A visual inspection is carried out bay by bay without any need for outages or the opening of gas compartments. A major inspection is not recommended before 25 years of operation.
Typical Bay Arrangements

The modular system not only allows all customary circuit arrangements but also individual solutions for specific building dimensions, system extensions and much more.

**In/out arrangement**

**Double busbar arrangement**

**Bus coupler arrangement**
Comparison AIS – HIS: Diameter 1 1/2 CB arrangement

<table>
<thead>
<tr>
<th>AIS</th>
<th>HIS modules</th>
<th>HIS compact</th>
</tr>
</thead>
<tbody>
<tr>
<td>143000</td>
<td>89000</td>
<td>73000</td>
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</table>

Comparison AIS – HIS: Ring busbar arrangement

<table>
<thead>
<tr>
<th>AIS</th>
<th>HIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 %</td>
<td>30 %</td>
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</tbody>
</table>

Comparison area
Comparison 1 1/2 CB arrangement – Ring arrangement

AIS 1 1/2 CB arrangement (9CB):
- High redundancy
- High reliability
- High availability
- Low failure costs

HIS ring arrangement (6+1 CB):
- Low redundancy
- Higher reliability
- Higher availability
- Lower failure costs

HIS modules – segregated phases
HIS compact

HIS modules (6CB)
A consistent quality management system supported by our employees makes sure that we produce high-quality gas-insulated switchgear. The system was certified in 1983 in accordance with CSA Z299 and again in 1989 according to DIN EN ISO 9001. The quality management system is process-oriented and subject to continuous improvement. Certification according to DIN EN ISO 9001:2000 was passed with flying colors in 2003.

As early as 1994 the environmental protection system according to DIN EN ISO 14001 was implemented as an addition to the existing quality management system and successfully certified. One of the fundamental milestones in developing testing competence was the certification of the test labs according to ISO/IEC 17025 (previously EN 45001) in 1992. From that point on, they have been considered independent.

The quality management and environmental protection systems cover every single process in our products’ life-cycles, from marketing to after-sales service. Regular management reviews and internal audits of all processes based on the consistent documentation of all processes relevant to quality and environmental protection ensure that the system is efficient and up-to-date at all times and that appropriate measures are taken to continuously improve it. The quality of our switchgear consequently meets even the highest requirements. In addition to consistent quality management and environmental protection, the special “clean” areas set up in the production workshops are an important contribution towards the high quality of our gas-insulated switchgear. Comprehensive manufacturing inspections and routine testing of individual components, sub-assemblies and modules all ensure reliable operation of the overall product. Mechanical routine and high-voltage tests of the complete bay or complete shipping units verify that the manufactured quality complies with the standards. Suitable packing provides for the switchgear’s safe arrival at its destination.

Technical Data

<table>
<thead>
<tr>
<th>Switchgear Type</th>
<th>8DQ1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>550 kV</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>50/60 Hz</td>
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<td>Rated power frequency withstand voltage (1 min)</td>
<td>740 kV</td>
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<tr>
<td>Rated lightning impulse withstand voltage (1.2/50 μs)</td>
<td>1550 kV</td>
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<tr>
<td>Rated switching impulse withstand voltage (250/2500 μs)</td>
<td>1250 kV</td>
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<tr>
<td>Rated normal current busbar</td>
<td>up to 5000 A</td>
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<tr>
<td>Rated normal current feeder</td>
<td>up to 5000 A</td>
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<tr>
<td>Rated short-breaking current</td>
<td>up to 63 kA</td>
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<tr>
<td>Rated peak withstand current</td>
<td>up to 170 kA</td>
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<tr>
<td>Rated short-time withstand current</td>
<td>up to 63 kA</td>
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<tr>
<td>Leakage rate per year and gas compartment</td>
<td>≤ 0.5 %</td>
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<tr>
<td>Height, depth</td>
<td>See typical bay arrangements</td>
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<tr>
<td>Driving mechanism of circuit-breaker</td>
<td>Stored-energy spring</td>
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<tr>
<td>Rated operating sequence</td>
<td>O−0.3 s−CO−3 min−CO CO−15 s−CO</td>
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<td>Rated supply voltage</td>
<td>60−250 V DC</td>
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<tr>
<td>Expected lifetime</td>
<td>&gt; 50 years</td>
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<tr>
<td>Ambient temperature range</td>
<td>−30 °C up to +55 °C</td>
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<td>Standards</td>
<td>IEC/IEEE</td>
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Other data on request
For further Information

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- Gas-insulated switchgear up to 550 kV
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