# GFM

## $SF_6$ Gas-insulated Metal-Enclosed Switchgear

### 72.5/145kV,…3150A,…40kA

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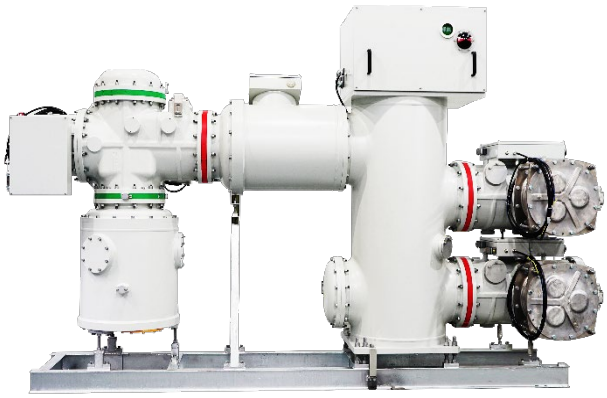
# Contents

# Overview



## Overview

GFM $SF_6$ gas insulated metal-enclosed switchgear (GIS) consists of the circuit breaker, disconnector, earthing switch, current and voltage transformers, lighting arrester, connection bus, etc., and is filled with $SF_6$ gas with excellent arc extinguishing and insulation performance as the interphase and ground insulation. It has many advantages, such as less land occupation, unaffected operation by external environment, simple maintenance, long service life, high cost-effectiveness in the whole life cycle, and is favored by users.

## Technical Features

- Technologies from BW and Voith Turbo, Germany and Plansee, Switzerland;
- $SF_6$ gas insulation;
- Rated voltage: 72.5 kV, 126kV and 145kV;
- Three-phase box, compact structure, high integration and small floor area;
- Self-energized arc extinguishing, with high breaking ability and small operating power;
- Mechanical interlocking to ensure the correct and reliable sequence operation;
- Able to break the small current and large current;
- Low ablation rate and high electrical wear resistance of contact;
- The whole-process automatic production line for arcing contact to ensure the consistency and reliability;
- Flexible integrated structure applicable to various wiring and layout modes;
- Modular spring operation mechanism for quick maintenance and replacement;
- Aluminum alloy shell, light in weight and good in antirust performance, suitable for various harsh conditions;
- Efficient sealing, and low leakage rate;

# Working Conditions & Qualifications

## References and Standards

- IEC 62271-1 High-voltage switchgear and controlgear – Part 1:Common specification
- IEC 62271-203 Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV
- GB/T 11022 Common specifications for high-voltage switchgear and controlgear standards
- GB 7674 Gas-insulated metal-enclosed switchgear for rated voltages of 72.5kV and above
- DL / T593 Common specifications for high-voltage switchgear and controlgear standards
- DL / T617 Specification for gas-insulated metal-enclosed switchgear

## Environment and Operating Conditions

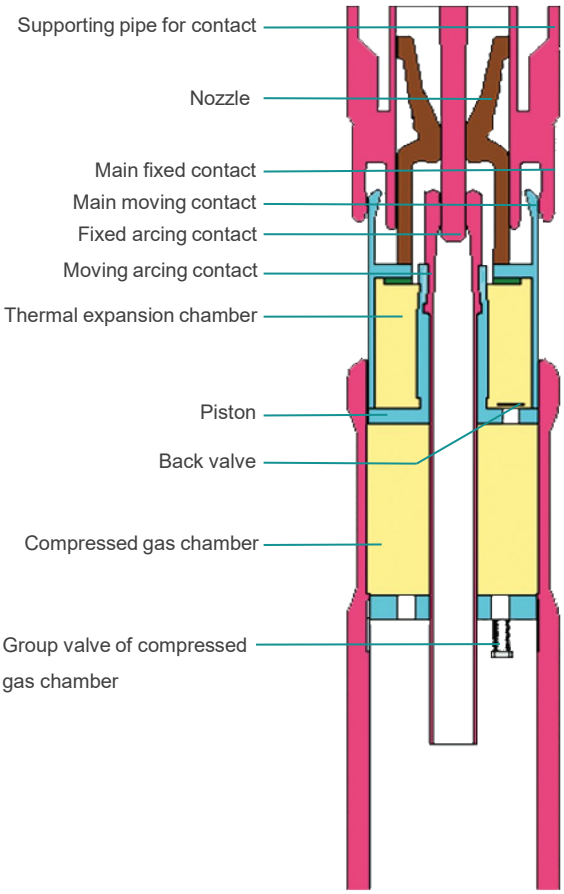
- Ambient temperature: -25℃~50℃
- Altitude: ≤1000m
- It can be applied for normally outdoors with condensation and rain
- Pollution level: Grade III
- Anti-seismic strength: horizontal acceleration ≤ 0.5g and vertical acceleration ≤ 0.25g
- Maximum wind speed resistance: 35m/s
- Sunlight resistance intensity: ≤1000W/$m^2$
- Icing thickness: ≤20mm

## Field of Application

- Distribution network
- Petrochemical industry
- Ferrous metallurgy
- Airports
- Rail transit
- Data center

## Technical Parameters

| GFM 72.5/126/145 | | | | |
|---|---|---|---|---|
| Technical parameters | | | Rated value | |
| Rated voltage (kV) | | | 72.5 / 126 / 145 | |
| Rated current (A) | | | 2000~3150 | |
| Rated frequency (Hz) | | | 50 | |
| Power frequency withstand voltage, 1min (kV) | To ground and between phases | | 230 / 275 | |
| | across the open swiching | | 230+73 / 315 | |
| Lightning impulse withstand voltage (kV) | To ground and between phases | | 550 / 650 | |
| | across the open swiching | | 550+103 / 750 | |
| Rated short-term withstand current/rated short-circuit duration (kA/s) | | | 40/4 | |
| Rated peak withstand current (kA) | | | 100 | |
| Coefficient of the first disconnecting pole | | | 1.5/1.3 | |
| Quantity of contact solutions | | | 1 | |
| Closing time (at rated voltage of control loop) (ms) | | | 70±10 | |
| Opening time (at rated voltage of control loop) (ms) | | | 30±3 | |
| Standard operating sequence | | | O-0.3s-CO-180s-CO | |
| Mechanical life (times) | | | 10000 | |
| Breaking frequency of rated short-circuit current (Cycles) | | | 20 | |
| Three phase asynchronous (ms) | | Opening | ≤2 | |
| | | Closing | ≤2 | |
| Rated $SF_6$ pressure (measured pressure at 20℃) | Circuit breaker chamber | MPa | 0.6/Relative pressure | 0.7/Absolute pressure |
| | Other chambers | | 0.5/Relative pressure | 0.6/Absolute pressure |
| Main circuit resistance per phase (μ Ω) | | | ≤80 | |
| $SF_6$ locking/warning/rated inflation pressure (measured pressure at 20℃) (MPa) | | | Relative pressure0.5/0.55/0.6 | |
| | | | Absolute pressure0.6/0.65/0.7 | |
| $SF_6$ moisture content (ppm) | | | ≤150 | |
| Power frequency withstand voltage of auxiliary circuit (kV) | | | 2 | |
| Operating mechanism | | | Operating mechanism of spring | |




Schematic Diagram of Self-energized Arc Extinguishing Chamber

## Circuit Breaker Module and Its Interruption Principle

With the latest generation of $SF_6$ high voltage circuit breaker self-energized arc extinguishing technology in the world, and the unique arc extinguishing chamber structure, GFM $SF_6$ gas insulated metal-enclosed switchgear is able to break the small and large currents and has the characteristics of high breaking reliability, small operating power required by the mechanism and low contact ablation rate.

### Interruption for small current of circuit breaker

- When the main moving contact and the main fixed contact are just separated, the fixed arcing contact and the moving arcing contact are still closed and the current is transferred to the arcing contact system;
- When the moving arcing contact and fixed arcing contact are separated, the arc is generated and heats the surrounding $SF_6$;
- As the breaking current is small, the energy of arc is not enough to heat $SF_6$ in the expansion chamber to reach the required arc extinguishing pressure;
- Thermal expansion chamber continues to move down and compress SF6 in the thermal expansion chamber and compressed gas chamber to achieve the arc extinguishing pressure;
- Moving arcing contact continues to move downward, and the high-pressure $SF_6$ in the thermal expansion chamber and compressed gas chamber forms a high-speed airflow at the nozzle, which extinguishes the arc when the current crosses zero;

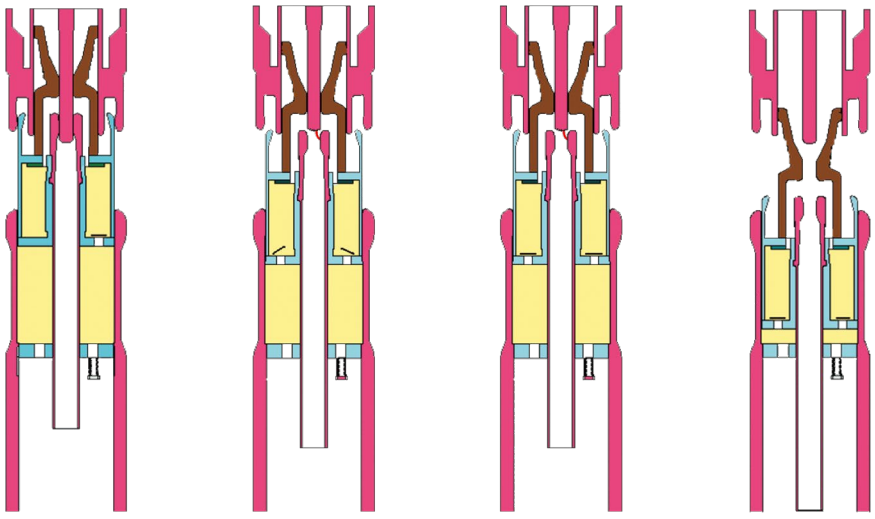
## Interruption of Circuit Breaker Short-Circuit Current

• When the short circuit current is cut off, the moving and fixed arcing contacts are separated and arc is generated;

• Short circuit current arc has large energy, which rapidly heats $SF_6$ around the arc, makes the air pressure in the thermal expansion chamber high enough and closes the back valve between the thermal expansion chamber compressed gas chamber;

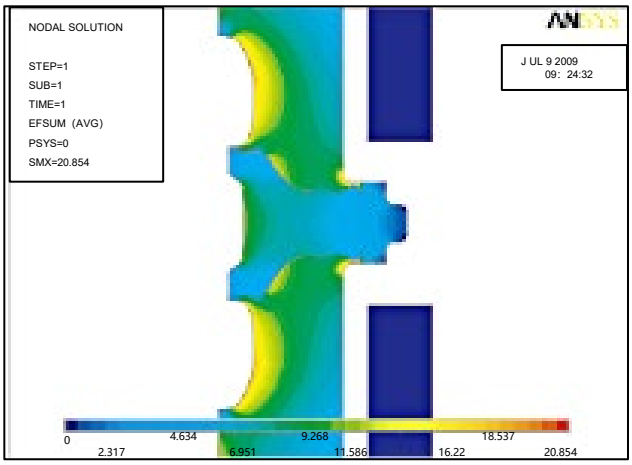
• The thermal expansion chamber continues to move downward so that the pressure of $SF_6$ in the compressed gas chamber is too high, and the valve group is automatically opened to release the pressure;

• When the arc extinguishing nozzle is separated from the fixed arcing contact, the high-pressure $SF_6$ in the thermal expansion chamber forms a high-speed airflow at the nozzle, and the arc can be extinguished reliably when the current crosses zero;



A. Closing B. Breaking of working current C. Breaking of short-circuit current D. Opening

Schematic Diagram of Arc Extinguishing Principle of Self-energized Arc Extinguishing Chamber




Analysis of Electric Field Distribution of Disk Insulator

Disk Insulator

## Disk Insulator

• The shape is analyzed with electric field calculation software to design the optimal shape of disk insulator;

• The insulator is manufactured with epoxy resin and aluminum oxide filler;

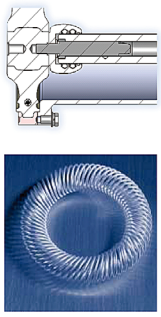
• With the vacuum casting process, the pressure resistance completely complies with the design requirements, which has been verified by type test;

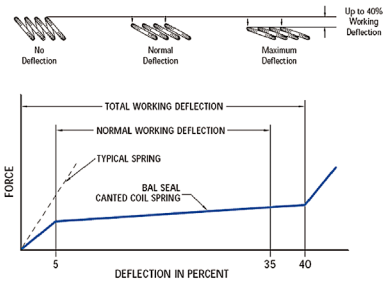
• The disk insulator is installed between adjacent different air pressure compartments or between adjacent spaced bus-type three-position switch modules;

• The insulator may support the main circuit conductor, withstand the different gas pressures from adjacent compartments, and reduce the interaction between adjacent modules;

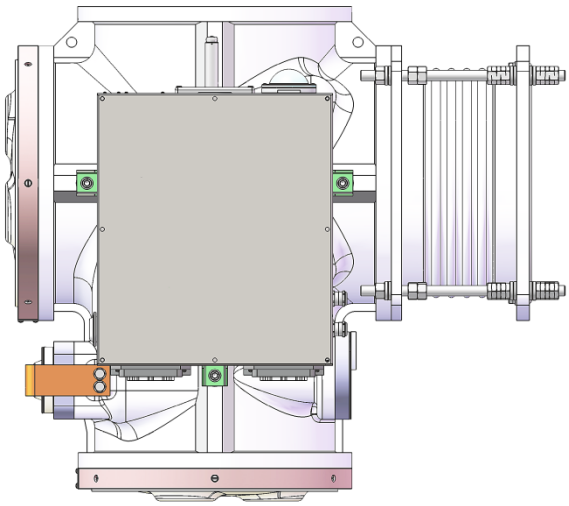
• The design of outer ring made of metal aluminum alloy makes the adjacent module shells equipotentially connected, and can balance the mechanical stress caused by uneven fastening of insulators and reduce the risk of insulator fragmentation;

• Double sealing design minimizes the influence on the internal operating conditions of the equipment caused by environmental factors;






Mechanical characteristics of spring



Schematic Diagram of Bus-type Three-Position Switch

## Contact Structure

• Spring contact fingers have excellent electrical and mechanical characteristics;

• Ensure the reliability of electrical connection and the portability of installation;

## Busbar moulde with three-position switching device

• It can realize three working conditions: operating condition (disconnector closed+ earthing switch opened), maintenance condition (disconnector opened+ earthing switch closed) and isolation condition (disconnector opened+ earthing switch opened);

• Three working conditions are driven by motors

• The operating mechanism is provided with an independent position indicator and an auxiliary switch to indicate the position of the disconnector and the earthing switch respectively;

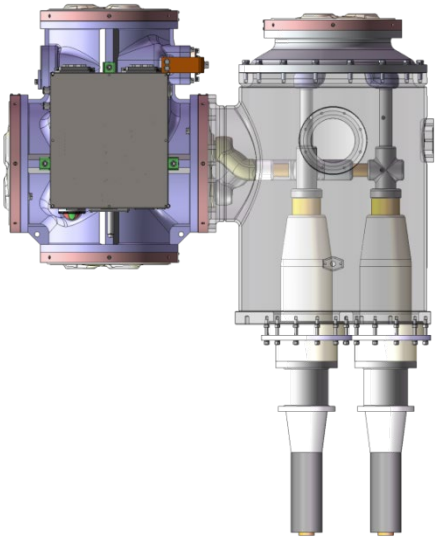
• The contact of auxiliary switch will only change when the main contact reaches the final position, so the position indicator can reliably indicate the actual position of main contact;

• The inner conductor of bus unit is connected in the sliding mode to avoid the disk insulator from the mechanical stress caused by the heating and expansion of bus;

• The insulator is easy to install and disassemble for short-term application and long-term expansion;

• Bus-type three-position switch can be interlocked mechanically and electrically to avoid misoperation;

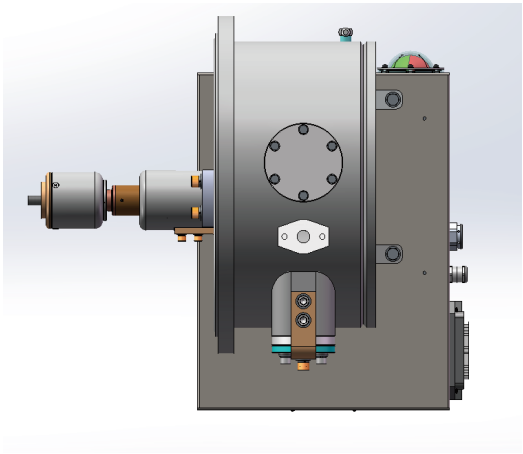
# Functional Units



Combined Structure Diagram of Feeder Type Three-position Switch Template and Cable Terminal Tube

## Outing feeder module with 3-position switching device

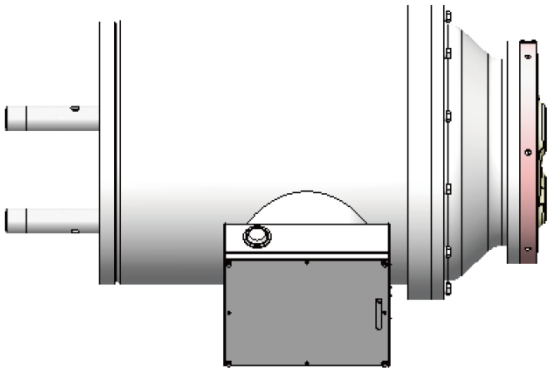
- Four flange faces
- Three-position switch is directly driven by the motor
- The following devices may be installed, such as the cable terminal tube, bushing module for overhead outgoing line, voltage transformer, lighting arrester, fast earthing switch, etc.
- The flange used to connect the voltage transformer can also be used as a high voltage test for substations or cables



High speed earthing switch

## High Speed Earthing Switch

- With electric spring operating mechanism, the contacts can be quickly closed;
- Short-circuit closing capability is suitable for feeder spacing;
- It is provided with the position indicator and auxiliary switch;
- Moving contact can be electrically isolated from the grounded shell after removal of the grounded copper bar;
- It can be electrically connected with the main loop conductor inside GIS from the outside, which is easy for on-site maintenance;



Current transformer

## Current Transformer Module

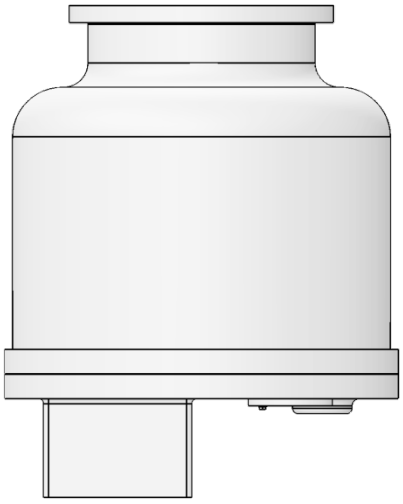
• In the same gas chamber as the circuit breaker;

• Primary coil is supported by aluminum shell, which has high load-bearing capacity;

• The ratio of current transformer, the number, accuracy and capacity of secondary measurement protection coils can be configured according to the design requirements of users;

• Secondary circuit is led out through air-tight sleeve, which can be used for measuring instruments and relay protection devices;

• It may be equipped with Rogowski coil CT, which is featured by the small size, light weight, no hysteresis and magnetic saturation interference, excellent transient response and high measurement accuracy;



Voltage transformer

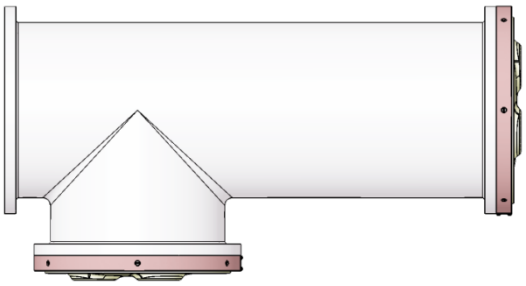
## Voltage Transformer and Lightning Arrester Modules

• Including capacitive divider or electromagnetic inductor;

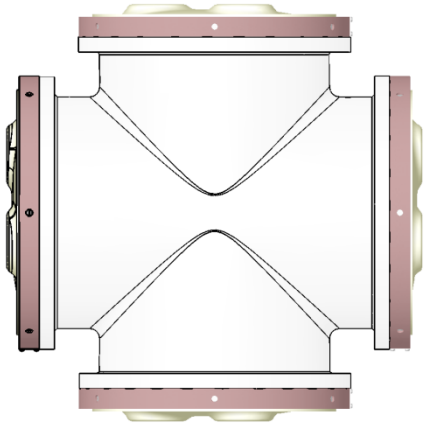
• With the voltage transformer with operable isolated fracture, the power frequency withstand voltage test may be conducted without the gas chamber opened;

• Secondary circuit is led out through air-tight sleeve, which can be used for measuring instruments and relay protection devices;

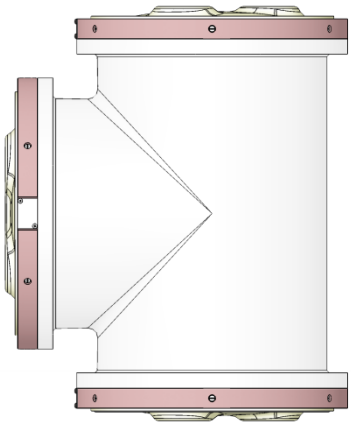
• Optional lighting arrester module is provided to limit the overvoltage, and lightning arrester is made of valve plate and gap-free zinc oxide;



Schematic Diagram of Straight Bent Tube



Schematic Diagram of  Four-way Bus



Schematic Diagram of Three-way Bus

## Commonly Used Connection Modules

• Various connection modules can better meet the needs of various substation layouts;

• Straight bent tube module and bus straight tube modules of various lengths;

• Three-way bus expansion module to expand the connection surface;

• Four-way bus expansion module to extend the connection surface;

## $SF_6$ Gas System

• Circuit breaker and current transformer are co-located in the same gas chamber where the rated pressure of $SF_6$ is 0.6 MPa (relative pressure) /0.7 MPa (absolute pressure) at the ambient temperature of 20 ℃;

• Rated pressure of $SF_6$ in other gas chambers at ambient temperature of 20 ℃ is 0.5 MPa (relative pressure)/0.6 MPa (absolute pressure);

• gas chambers of Circuit breaker and current transformer are isolated from other ones by disk insulator;

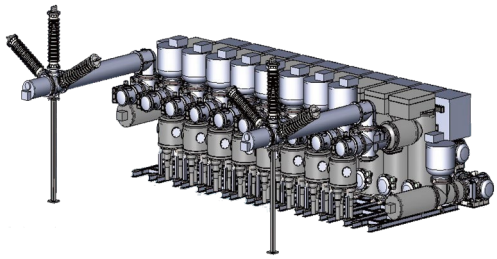
• Each independent gas chamber is equipped with a gas density relay with temperature compensation for monitoring the pressure (density) and a corresponding self-sealing inflatable joint;

• Adsorbent is provided in the gas chamber to absorb the moisture in $SF_6$ and the decomposition products of $SF_6$ under the action of electric arc;

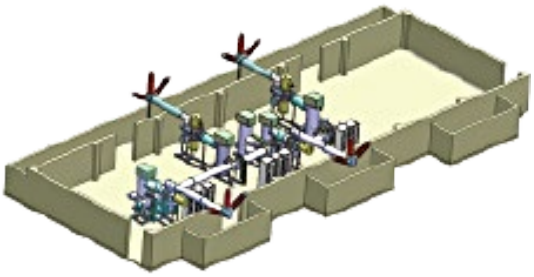
• Each gas chamber is equipped with an explosion-proof membrane device;

• Gas guide nozzle on the explosion-proof membrane ensures that when the explosion-proof membrane is opened, the gas is ejected in the direction far away from the operators to ensure the safety of personnel;

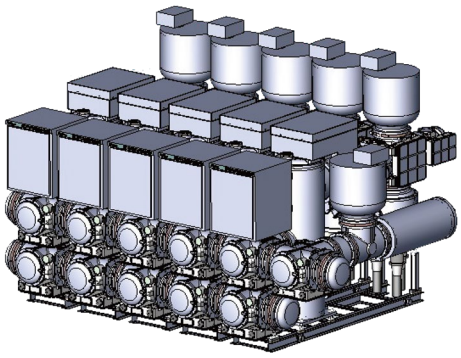
# Main Connection Mode



Overhead incoming for double bus



Overhead incoming and outgoing for the segmented wiring of single bus



Incoming and outgoing of double bus cable

The design and layout of substation can fully consider various conditions and factors, such as main wiring, incoming and cable direction, switch room size of substation, reserved space for expansion, quick maintenance and troubleshooting, etc.

- Linear transformer group
- Single bus
- Double bus
- Segmented wiring of single bus
- Segmented wiring of double bus
- Bridged wiring
- Ring bus wiring

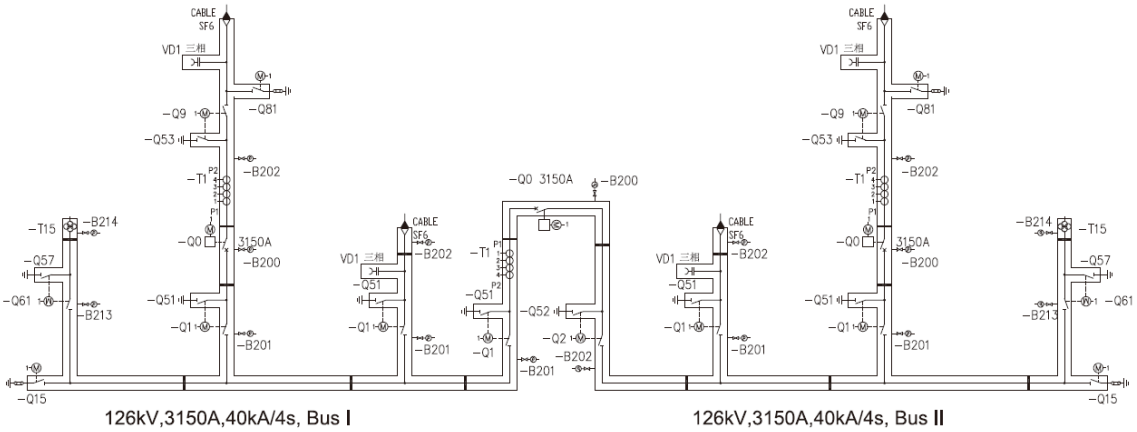
# Main Connection Mode

## Bay arrangement of inner bridge

• Advantages: less high-voltage circuit breakers are required, and only three circuit breakers are required in 4 circuits, and the cost is low;

• Disadvantages: the reliability of power supply is not as good as that of single bus and segmented wiring of single bus;

• Scope of application: generally end-user power stations; no special line protection device is required for the incoming line of power supply, and the line is protected by the upstream power station;

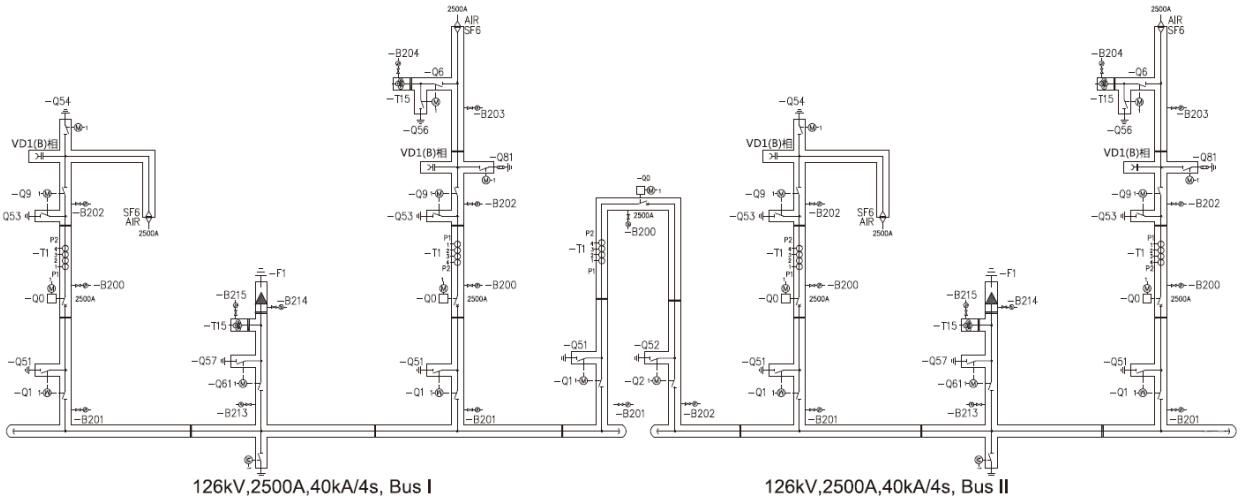



## Bay Arrangement of Single bus with busbar section

• Advantages: Two buses are connected by a segmented circuit breaker, and the incoming lines are standby for each other; when one section of bus fails, it will not affect the normal operation of another section of bus;

• Disadvantages: When a section of bus fails or is overhauled, all lines involved in the section of bus shall be shut down;

• Scope of application: scheme with less circuits and generally 2 incoming lines (standby for each other, and two sections always running in parallel) and 2-4 outgoing lines;



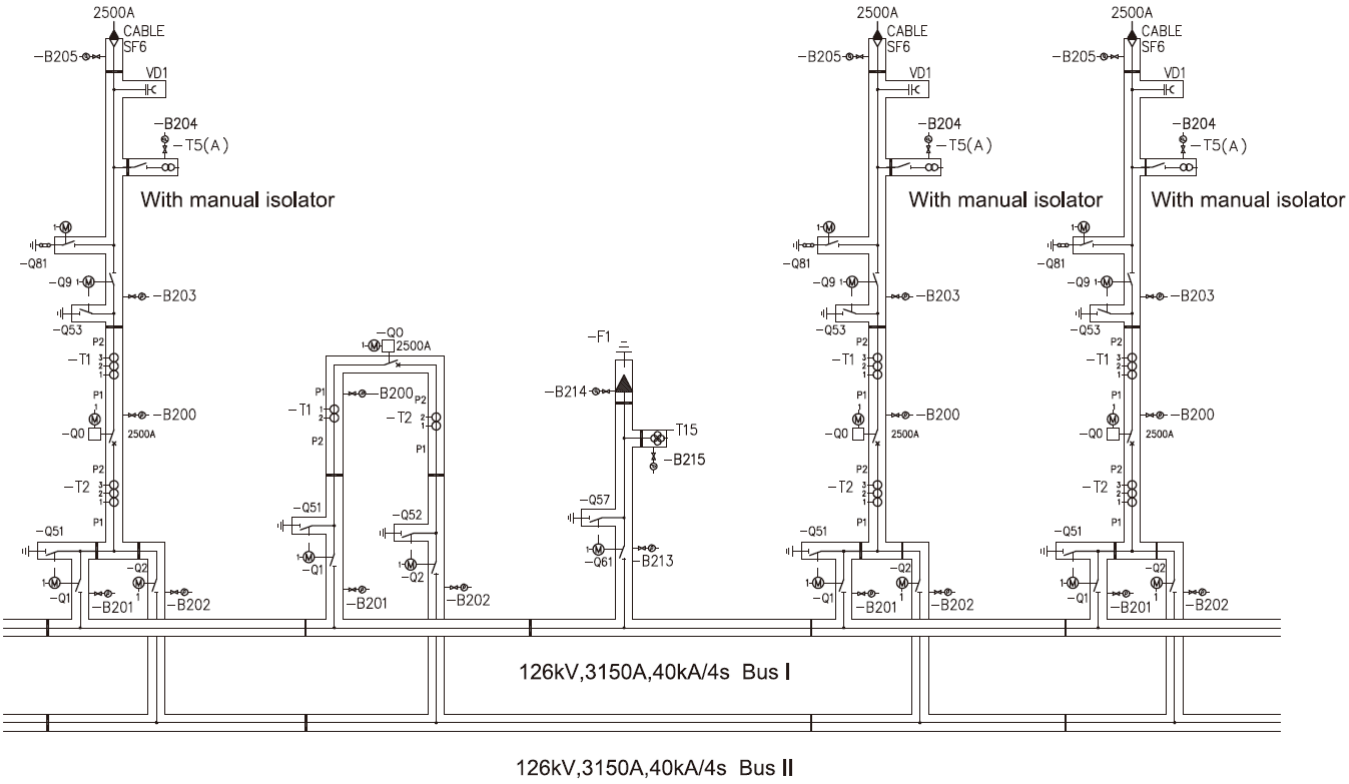
# Main Connection Mode

## Bay Arrangement of Double Bus

• Advantages: Two buses are standby for each other, and when one bus fails or is overhauled, another bus may be switched on, improving the power supply reliability and scheduling flexibility;

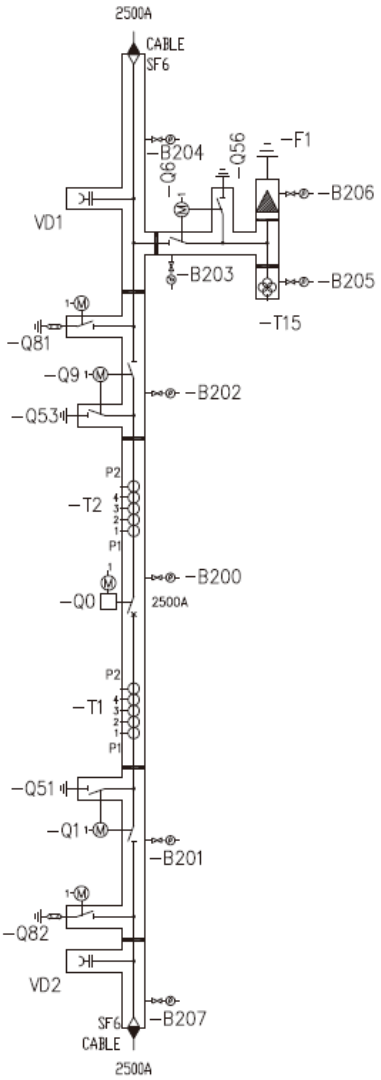
• Disadvantages: large number of equipment, high cost and complex protection scheme;

• Scope of application: Important core hub power station with high power supply demand; generally, 2 incoming lines and 2-6 outgoing lines;



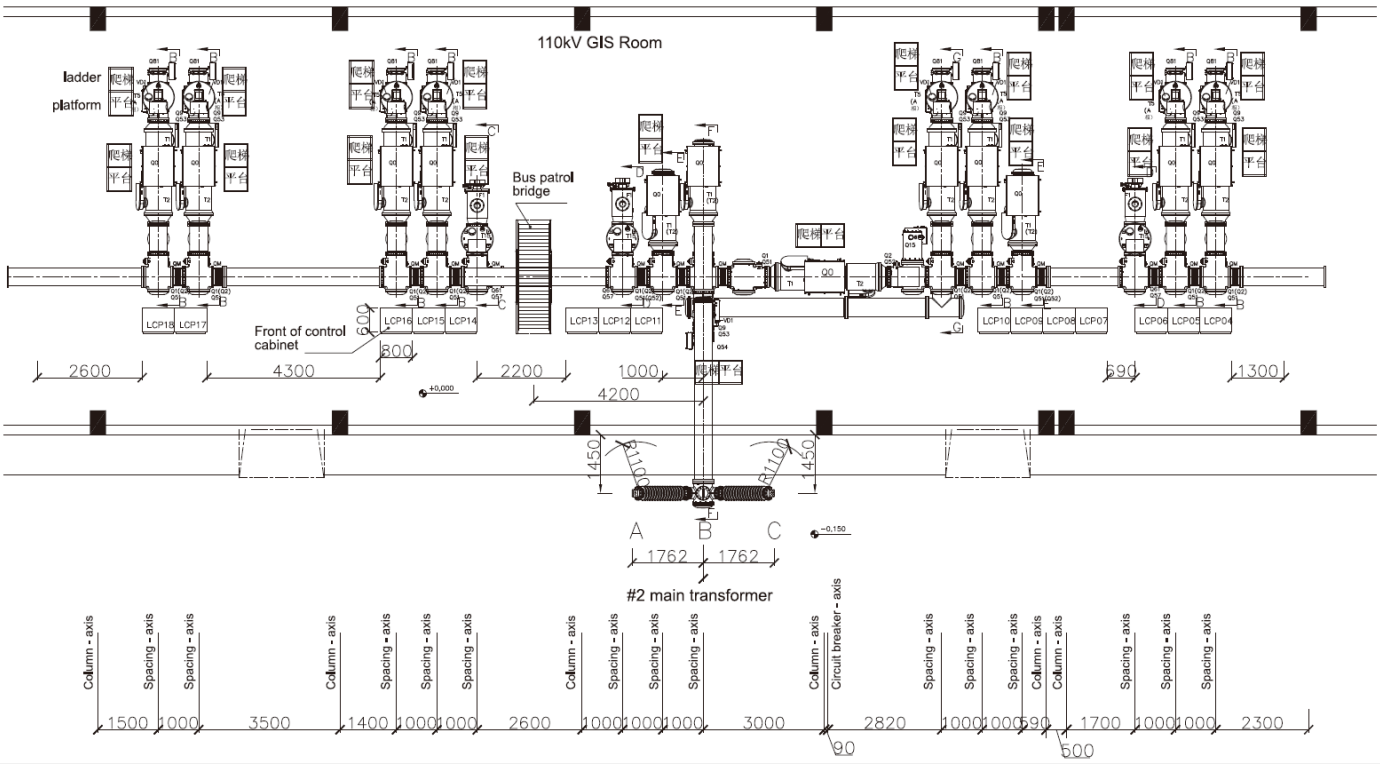
# Main Connection Mode

## Bay Arrangement of Line Transformer

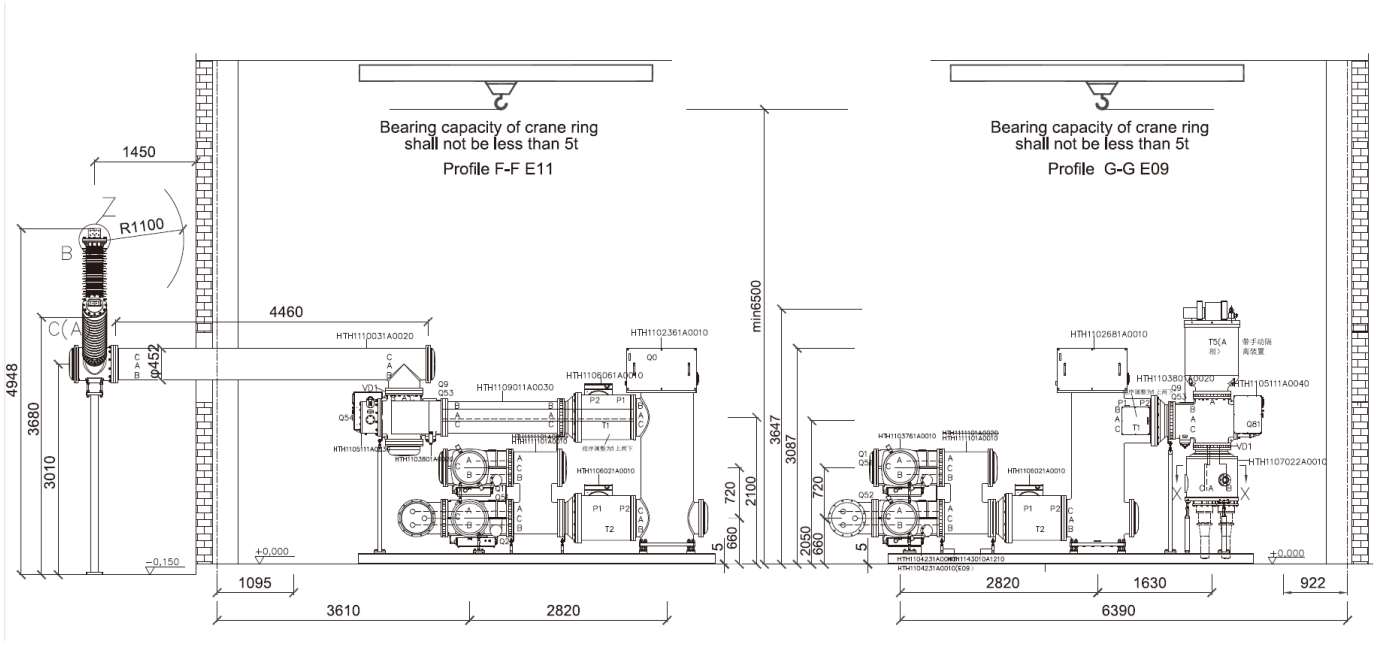



- Advantages: single bus, less equipment and low cost;
- Disadvantages: In case of failure or overhaul, the whole line shall be shut down;
- Scope of application: scheme of one incoming line and one outgoing line;

## Engineering Drawing



# Overall Dimensions



# Transportation, Installation and After-sales Services

## Transportation, Installation, Commissioning and Maintenance

- Compartment is filled with $SF_6$ or $N_2$ of transport pressure;
- Waterproof, moisture-proof and collision-proof packaging, transportation of full compartment and collision-prevention devices at each compartment;
- Equipment is transported by professional partners to ensure that the equipment is delivered to customers in good condition;
- The whole compartment is assembled and pre-tested in the plant with simple on-site splicing and minimal workload;

Under the guidance of experienced on-site installation engineers of Leistung Energie, installation and debugging are carried out according to the requirements of work instructions, and the equipment is installed quickly and effectively with low failure rate. The maintenance-free design can simplify the operating maintenance and reduce the cost after operation. Leistung Energie will give the training on the maintenance to the operation and maintenance personnel of substation to avoid worries.

Leistung Energie/GFM Catalog/202507/EN

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