Short-Circuit Generator Set for AICHI ELECTRIC CO., LTD.

Noriyuki Koshizuka

Keywords Short-circuit generator, Static excitation system, Medium-voltage inverter

Abstract

A short-circuit generator system is used to supply heavy currents and large power for the testing of circuit breakers, switchgears, insulators, and transformers by driving a generator with a motor.

We recently received an order for a 330MVA (3Hz) short-circuit generator system for the High Power Laboratory of AICHI ELECTRIC CO., LTD., and supplied the system on full-turn-key contact. Major products we supply are a short-circuit generator system (motor and generator), reactors, medium-voltage inverters, control panels, monitoring systems, closing switches, circuit breakers, test sequencer, and measuring devices.

1 Preface

We supplied a short-circuit generator system to AICHI ELECTRIC CO., LTD. Our scope of supply includes the main part of the short-circuit generator system and a control panel. Others include a closing switch, a test sequencer to control a closing switch and closing phase, and measuring devices for currents and voltages. This paper introduces the items mainly supplied.

2 Short-Circuit Generator

2.1 Motor-Generator Set

The ratings of the short-circuit generator and the motor to drive this generator are as specified below.

(1) Synchronous generator

330/275MVA (3Hz) – 60/50Hz – 2P – 3600/3000min^{-1} – 13200/11000V (Y)/7620/6350N (Δ)

(2) Induction motor

1120/933kW – 6600/5500V – 60/50Hz – 2P – 3600/3000min^{-1}

Fig. 1 shows an equipment layout drawing. For the generator, a 2-pole machine has been adopted because of its high revolving speed and large inertial energy. For the excitation system of the generator, a static excitation system with high responsiveness is adopted. Generator windings can be changed over between y-connection and Δ-connection with the aid of an external disconnecting switch. For the y-connection at 60Hz, the rated voltage is 13,200V. At 50Hz, the rated voltage is 11,000V. For the Δ-connection, the rated voltage is 7620V at 60Hz and 6350V at 50Hz, respectively. The system capacity is designed to carry a short-circuit current of more than 20kA for the Δ-connection at 60Hz.

The adopted driving motor is a squirrel-cage rotor type induction motor. A medium-voltage inverter system is adopted for start-up operation and speed control. Bearings for the generator and the driving motor are of the plain sleeve bearing type. The lubricating system provides a lubricating oil from a forced lubricating oil supply unit at the time of start-up and stoppage. While the system is operated at the rated revolving speed, however, a pump directly connected with the motor-generator shaft feeds a lubricating oil to bearings for saving energy.

2.2 Control Unit

Fig. 2 shows the switchgears and Fig. 3 shows the single-line connection diagram of this short-circuit generator system.

(1) Medium-voltage inverter

The medium-voltage inverter consists of three panels. The basic function is specified to control the speed at 3600min^{-1} at 60Hz and 3000min^{-1} at 50Hz. Its main feature is that the inrush current is small at the time of start-up. In addition, restarting is possible even in the middle of a stopping sequence.

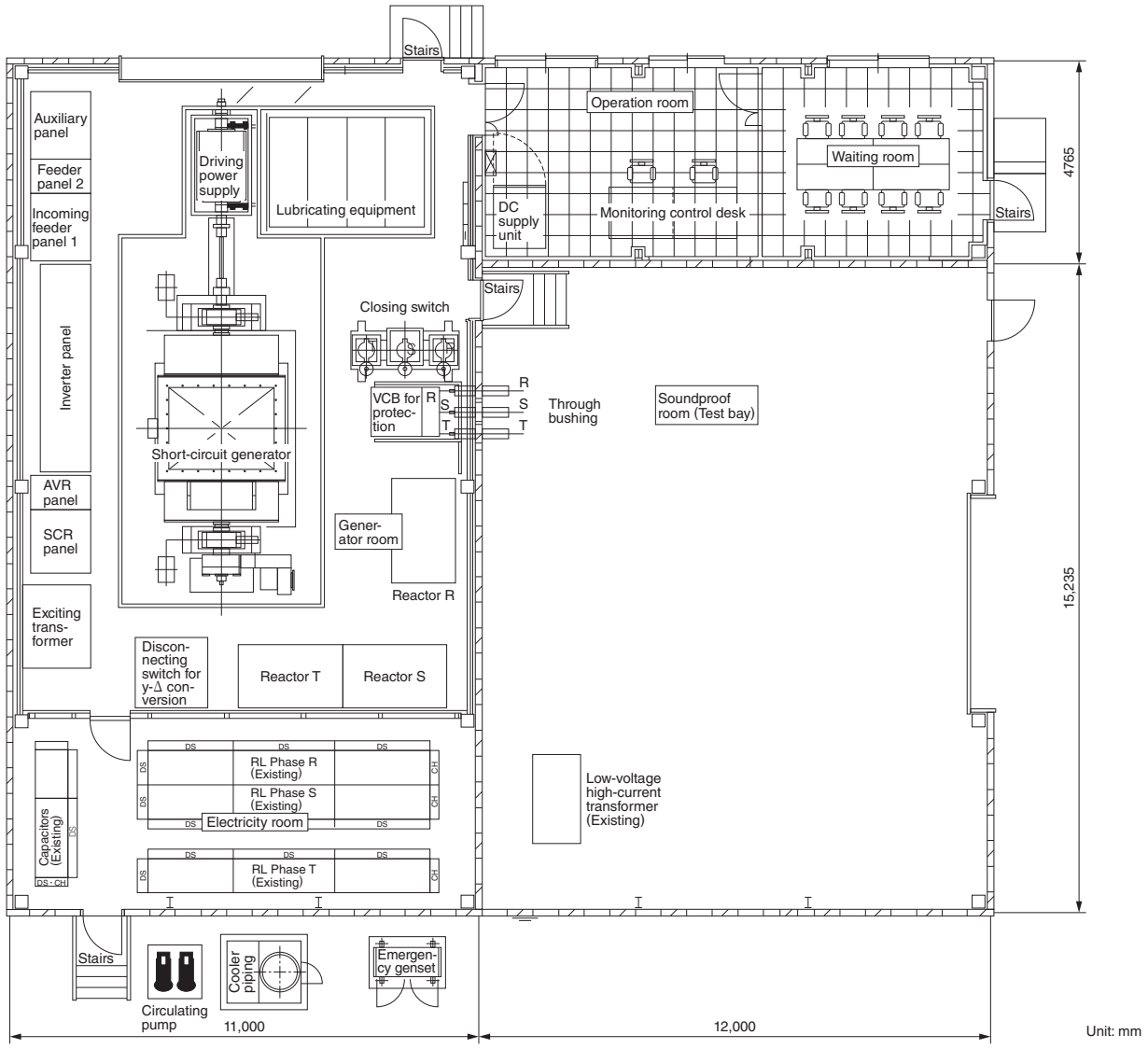

Fig. 1 Equipment Layout Drawing

Major products are neatly organized. In so doing, we factored the reduction of the overall footprint in the generator room.

Fig. 2 Switchgears

The switchgears are allocated in the line beside the short-circuit generator.

(2) AVR panel

The AVR control range is 0 to 110%. Using a touch panel mounted on the panel surface, the generator voltage can be regulated. Thyristors for rectifying field currents have enough capacity to carry 4000A in a short time.

(3) Monitoring and operation panel

Fig. 4 shows the control room where a touch panel is installed. Using this touch panel, various operations are possible at the monitoring and operation desk in this room, from the operation and stop of the auxiliary machines, to the run-stop of the main machine set and startup operation for short-circuit testing. Since indicator lamps and graphic panels are installed, it is possible to look over the full view of the testing system.

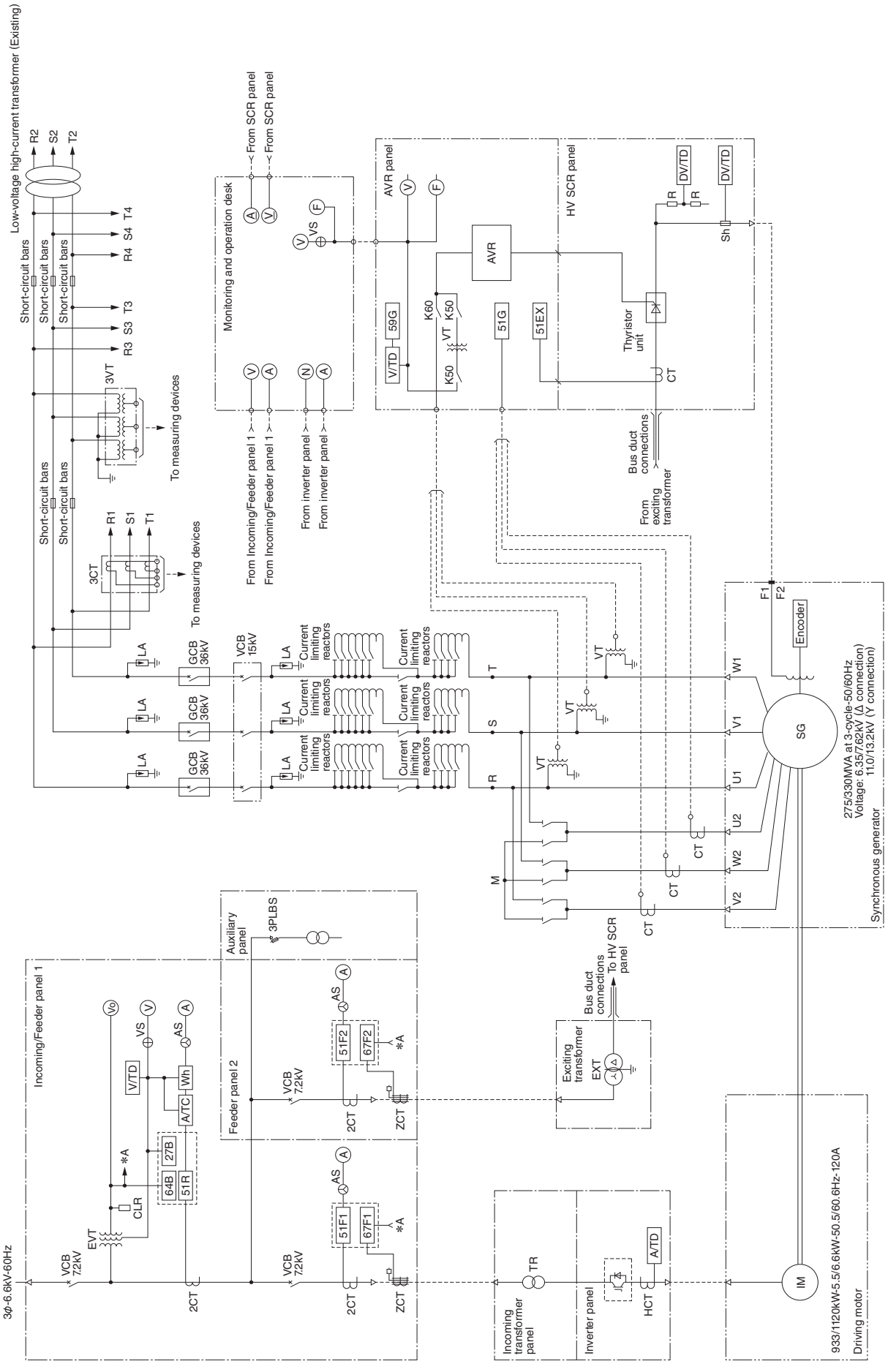

Fig. 3 **Single-Line Connection Diagram**

A single-line connection diagram is shown.

Fig. 4 Control Room

The control room is shown. Various operations can be carried out from here.

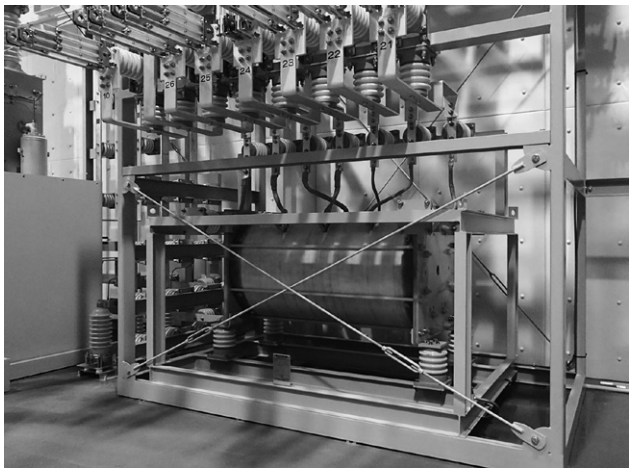

Fig. 5 Reactors

An external view of reactors is shown.

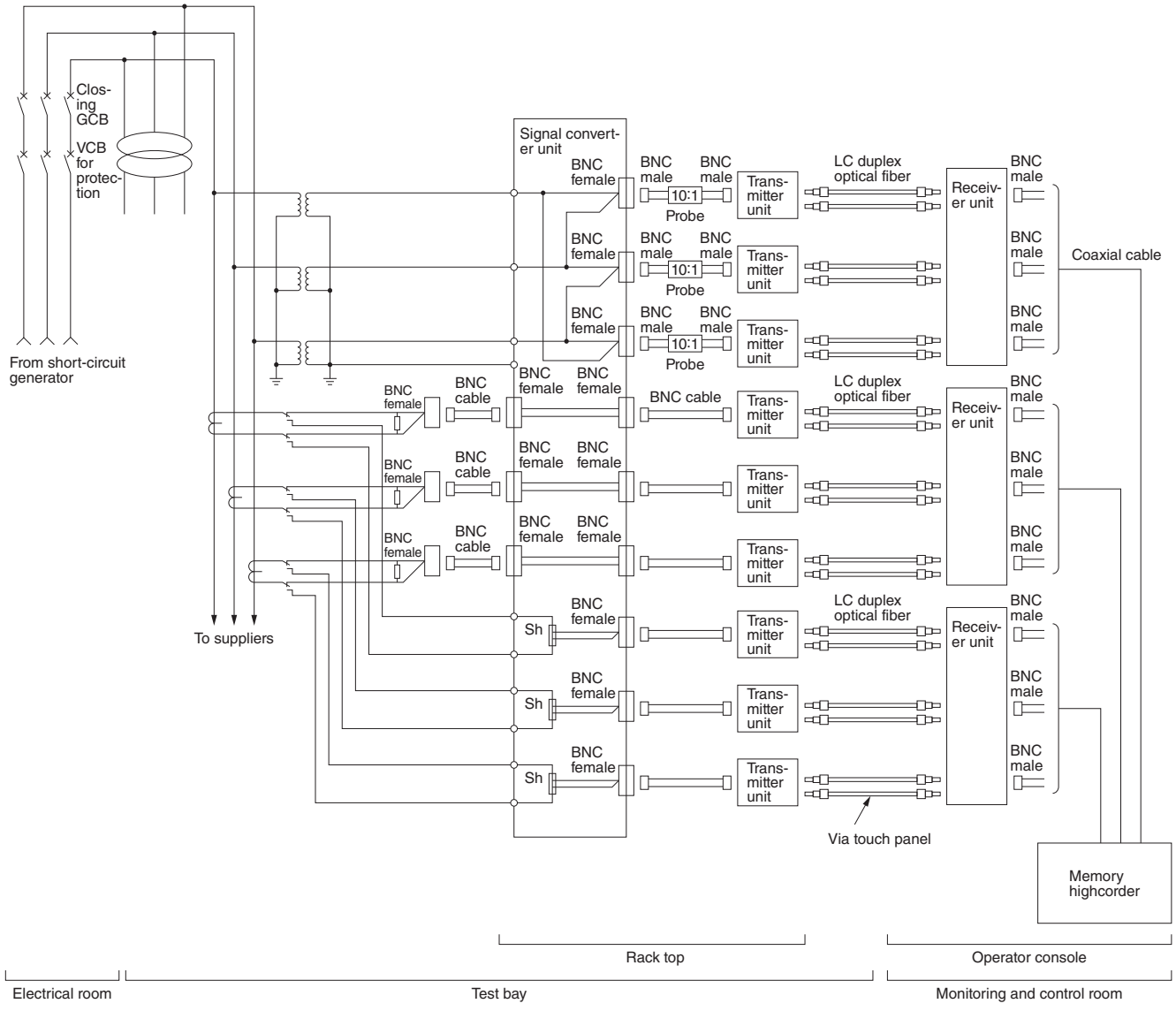

Fig. 6 Measuring System Diagram

A measuring system diagram is shown. Optical fiber cables are adopted for insulation.

(4) Others

In the event of a power outage for this testing system, the interruption of lubricant supply to bearings is a big concern. As such, an emergency generating system is used as a backup power for the auxiliary power supply. At the same time, a DC pump is installed. In this manner, this makes a redundant lubrication oil supply system which is intended to improve reliability.

3 Reactors

Fig. 5 shows a view of reactors. Two reactor sets with different capacities are allocated to each phase. Reactor 1 is served by seven combinations of changeover switches, and four combinations of changeover switches for Reactor 2. Twenty eight (28) combinations of current adjustment are, therefore, possible.

4 Closing Switch

In short-circuit testing, a closing-phase control function is required. The supplied test sequencer assures a high performance of adjustments to a testing condition of 1/10000s (0.1ms). Signals from the test sequencer are controlled through high-speed conversion performed by the Insulated Gate Bipolar Transistor (IGBT) switches. For the closing switch, a 36kV gas-insulated circuit breaker is adopted, which assures a closing accuracy of ±0.5ms.

5 Measuring Devices

Fig. 6 shows the measuring system diagram. The current transformers that measure short-circuit currents are installed in the test bay. These are special products rated 30,000/15A. They use the BNC connections where a 1Ω resistor generates a 15V voltage.

Optical fiber cables are used between the test bay (where equipment under test is placed) and the monitoring and control room (where the measuring devices are installed). This is an excellent measured data transmission method because the optical fiber cable can insulate the surge voltages caused by the switching of short-circuit currents or high voltages.

6 Postscript

A short-circuit generator system is an important facility for the performance verification of circuit breakers and switchgears. Customers who have short-circuit generator systems are limited in number and regular orders cannot be expected. We consider, however, our mission is to keep improving technology for our customers.

Lastly, we would like to express our gratitude to all project-related personnel for their helpful suggestions and guidance for the production and supply of this system.