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Conceptual design of the KSTAR Motor Generator

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ABSTRACT

The Korean Superconducting Tokamak Advanced Research (KSTAR) superconducting magnet power supply is composed of a Poloidal Field Magnet Power Supply (PF MPS) and a Toroidal Field Magnet Power Supply (TF MPS). When the PF MPS is operated, it requires a large amount of power instantaneously from the KSTAR electric power system. To achieve the KSTAR operational goal, with a long pulse scenario, a peak power of 200 MVA is required and the total power demand for the KSTAR system can exceed 200 MVA. The available grid power is only 100 MVA at the KSTAR site. Increasing the available grid power was uneconomical and inefficient which is why NFRI are installing a Motor Generator (MG).

National Fusion Research Institute (NFRI) has made a contract with Vitzrotech and Converteam to design, manufacture and install the MG. Converteam has designed the electromagnetic and mechanical specification of the MG and Variable Voltage Variable Frequency (VVVF) converter.

In this paper we discuss the conceptual design, including energy saving and electrical capacity of the MG system and the performance of the MG to satisfy the KSTAR 300 s operation scenario. In addition, the manufacturing and installation plan for the KSTAR MG is discussed.

1. Introduction

The Motor Generator (MG) is used to supplement the available power supply and to convert or supply stable power in the power station. There are two reasons for using an MG for the Korean Superconducting Tokamak Advanced Research (KSTAR).

Firstly, it is necessary to supply power to the Poloidal Field Magnet Power Supply. The superconducting magnet power system that supplies the KSTAR superconducting magnets with large currents of 20–25 kA is a pulsed power supply system that delivers a large amount of power momentarily [1,4]. Approximately 90% of the input is reactive power because the coils are superconducting and thus exhibit a low loss [2]. When the PF MPS is operated, up to 200 MVA can be required. At the moment, National Fusion Research Institute (NFRI) only has a 154 kV 100 MVA electricity supply available from the state supplier KEPCO. Thus it is necessary to provide more capacity to operate the PF MPS at its full rating.

Secondly, the PF MPS is controlled by 12 pulse thyristor converter power supplies to each coil with DC currents of up to 25 kA. A characteristic of the 12 pulse converter is that it generates 11th, 13th, 23th and 25th order harmonics of large magnitude. A Reactive Power Compensation (RPC) system is required to reduce the magnitude of these harmonics.

It is essential to install an MG to provide the reactive power to the PF MPS and to maintain the supply power stably when a voltage dip or interruption occurs on the main incoming power system. In this paper, the design of the MG required to operate the KSTAR PF MPS and the plans for its manufacturing and installation are discussed.

2. The KSTAR and MG power system

Fig. 1 shows the existing KSTAR power system without the MG. The KSTAR power system consists of 154 kV and 22.9 kV power systems. The 154 kV power system, which is supplied from a commercial grid of 100 MVA, provides power to equipment of large capacity including the PF MPS, Toroidal Field Magnet Power Supply (TF MPS), the helium refrigeration, heating devices, electron cyclotron heating (ECH), ion cyclotron heating (ICH), the cooling water facility and other auxiliary equipment.

The 22.9 kV system is also used to power the building services and other devices necessary for operation of the KSTAR system [3].

The augmented system comprising the MG, the VVVF for the control of the MG speed, power factor and excitation system, and cooling facilities is shown in Fig. 2. This system absorbs about

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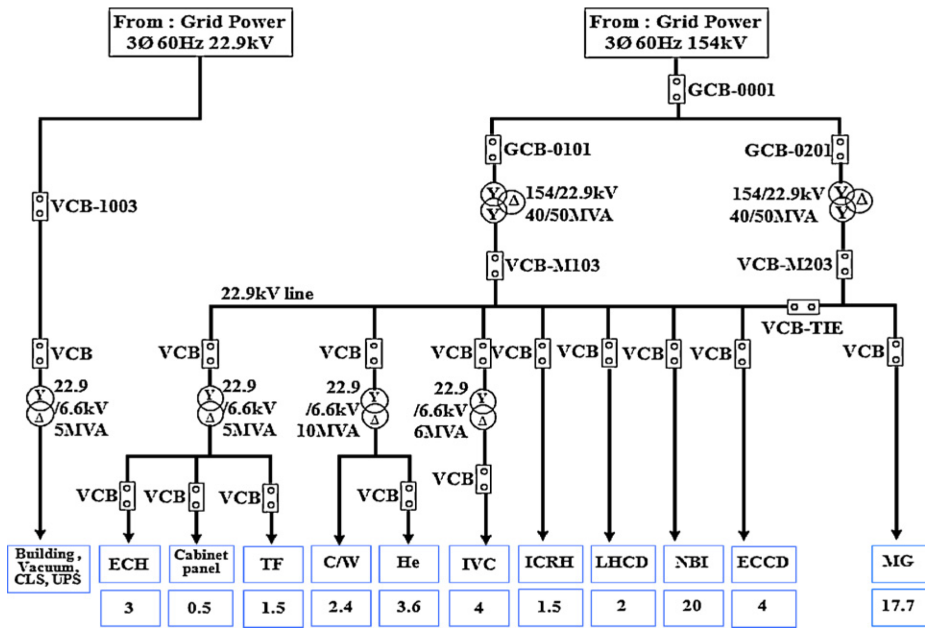

Fig. 1. The power distribution of the KSTAR.

17.7 MVA from the 154 kV system. The MG system is able to provide the power and energy (200 MVA, 1.6 GJ) required by the PF MPS to operate at full rating. In the event of a supply system power failure the MG system can act as a generator by extracting stored rotational energy to supply emergency power to the systems necessary for a controlled shutdown i.e. cooling water circulation, cooling fans and dynamic braking cooling fans.

3. Pulse duty of the MG

The MG is designed to provide a maximum power of 200 MVA at the rated voltage of 22.9 kV. For the 300 s operation scenario, the pulse duty is as shown in Fig. 3 and the peak reactive power is limited to 160 MVA. This pulse duty can be repeated every hour.

The electrical demand by the PF MPS is not only almost all reactive but also the 12 pulse PF MPS creates harmonic currents and the MG acts as low impedance to them. Fig. 4 shows the harmonic current spectrum from the PF MPS at the 22.9 kV line on the basis of an I_{THD} equal to 11.1%. These harmonic currents create additional heating and are most prominent in the stator windings and damper cage due to the ac/dc resistance ratio of the harmonics. The MG has been designed to accommodate these harmonics together with the heating effects of eddy currents due to the harmonics in other relevant steel components, connections, and terminals in order to ensure all MG components remain within their thermal design limits.

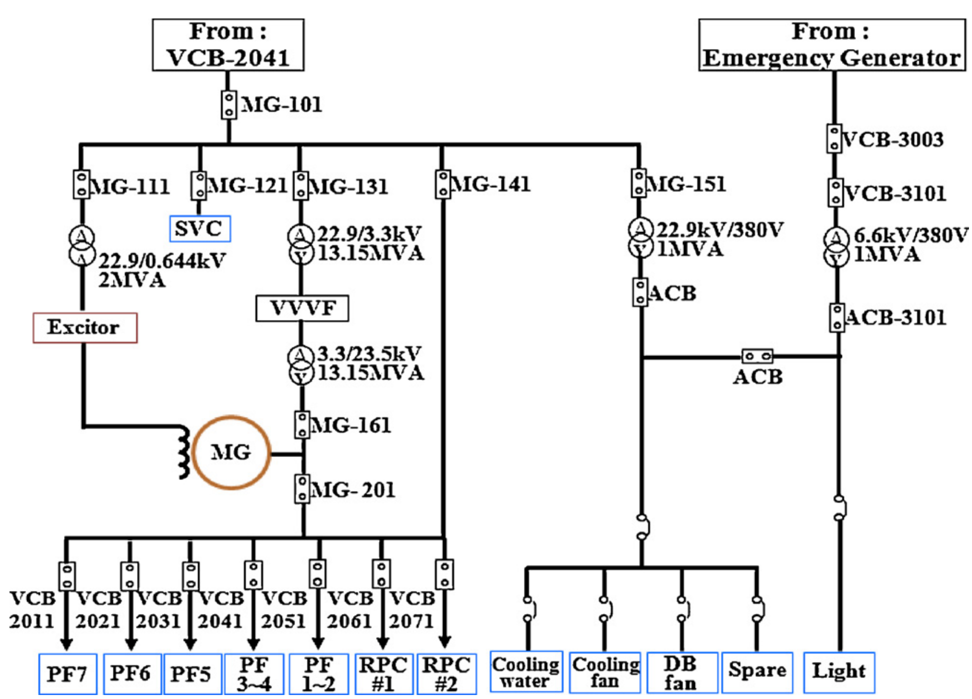

Fig. 2. Power distribution diagram of MG.