Low-loss Compact Inverter Applied Equipment

Background and Objective

Innovation in power electronics technology can play an important role in realizing a low-carbon society through promoting energy saving, electrification of energy usage, and the introduction of renewable energy sources. As a core of the innovation, the development of electric equipment and apparatus which utilize SiC semiconductor devices (SiC devices) can achieve high efficiency, small size and high control performance. For the wide practical use of such high performance equipment, it is important to initiate practical development of SiC devices with placing a high priority on the application where the largest benefit can be gained through their use.

In this project, aiming at the practical use of electric equipment with SiC devices, we develop an SiC device applied equipment after selecting an appropriate application. To establish the simulation and control technologies of power electronics circuit with SiC devices is another objective of this project.

Main results

We chose a pole-mount STATCOM[*1] (Table 1) for distribution systems as an object for practical development of SiC device applied equipment. STATCOM is indispensable when introducing large amount of PV generation into the distribution system, and the application of SiC devices brings a substantial advantage in achieving high efficiency and space saving. Development has been implemented under the cooperative research with Toshiba Corporation.

In 2009 FY, technical feasibility of a pole-mount STATCOM has been demonstrated through a conceptual design study and the applicability of SiC-JFET[*2] devices commercially available has been verified.

1. Optimal circuit configuration for a pole-mount STATCOM

A transformerless configuration is required to achieve compactness and light weight. We first chose several alternatives for the circuit configuration. Through a comparison of the required number of semiconductor devices, total volume of elements, efficiency and simplicity of manufacturing, we finally selected the Y-connection Modular Multilevel Converter (MMC)[*3] (Fig. 1) as the optimal circuit configuration for a pole-mount STATCOM [R09010].

2. Structural design of a pole-mount STATCOM

The practicability of installation on a distribution pole has been examined through a structural design of a STATCOM with the Y-connection MMC topology based on the electrical design results such as filter parameters and efficiency (Fig. 2). External dimensions and weight can be estimated as W0.8m×D0.5m×H1.5m and 500kg (ac filter 300kg, inverter 200kg) respectively.

3. Evaluation of applicability of SiC-JFET device

The applicability of a newly commercialized SiC-JFET device[*4] was verified by obtaining the following experimental results on its characteristics. 1) characteristic on-resistance is low as 2.8 $m\Omega cm^2$, 2) turn-on loss and turn-off loss decrease to 1/6 and 1/8 respectively compared to the same rating Si-IGBT, 3) stable inverter operation can be achieved in an all SiC configuration combined with an SiC Schottky barrier diode.

These results on the characteristics of the SiC-JFET device prove that the device is applicable to a demonstration equipment of a pole-mount STATCOM.

Table 1 Design specification of a pole-mount STATCOM

As this equipment is embedded into a distribution network, the design specification is decided considering the reduction of harmonics and audible noise as well.

Rated capacity	100 kVA
Rated voltage	6600 V
Harmonics	Total current distortion factor < 2.5%
DC voltage deviation	< ±5%
Equivalent switching frequency	20 kHz

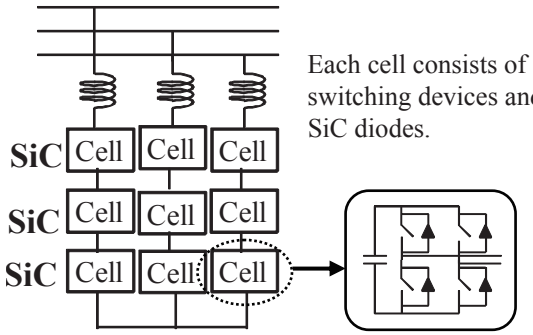
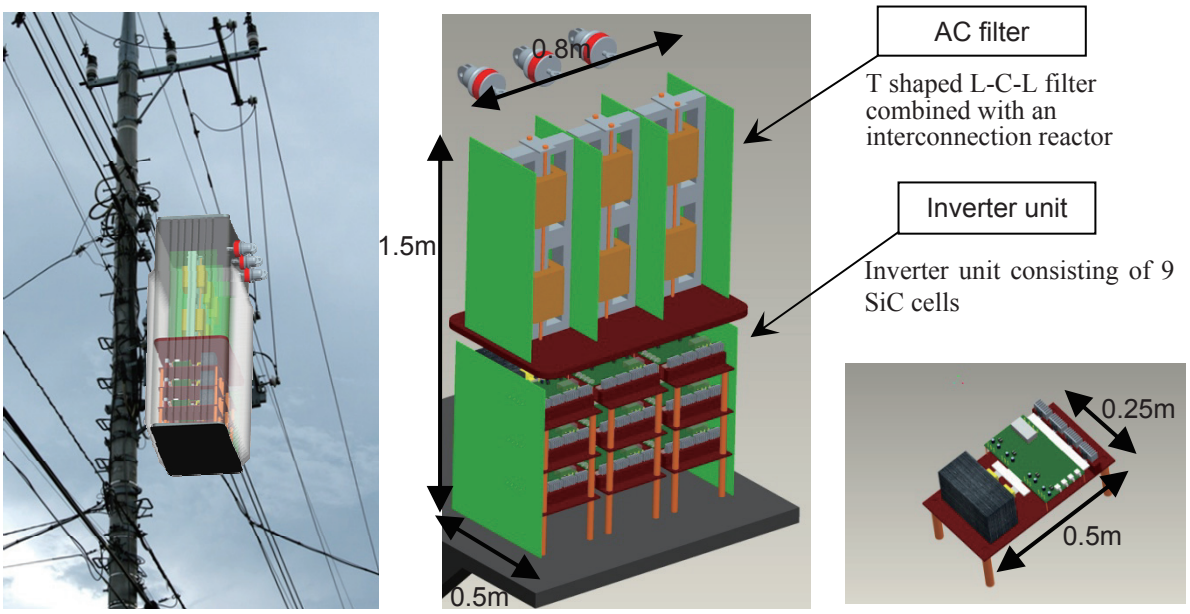


Fig. 1 STATCOM configuration with the Y-connection MMC topology

As a result of performance comparison between circuit configurations available, we decided the Y-connection MMC is optimal for a compact STATCOM.



(a) STATCOM mounted on a distribution pole **(b) Inner structure** **(c) SiC cell**

Fig. 2 Illustration of a 6.6kV-100kVA pole-mount STATCOM

The practicability of a pole-mount STATCOM was demonstrated through the structural design.

*1: STATCOM (STATic synchronous COMpensator): Reactive power compensation equipment using Voltage Source Converter
*2: Among SiC switching devices, SiC-JFET and SiC-MOSFET are now under intensive development. At present, SiC-JFET is the most promising device close to commercialization.
*3: An inverter configured with the series connection of multiple cells or modules (Fig. 1).
*4: Normally off type device. Rated voltage: 1200V, rated current: 30A.