Development of SiC Diode Applied Inverter

Background

Improvement of efficiency and compactness of inverter is essential for enhancing power electronics appliances utilized widely in the consumer, transportation and industry sectors. SiC is expected as a promising semiconductor device to realize such an improvement. To advance the practical use of the SiC device applied inverter, considering the situation that SiC switching devices such as the SiC MOS-FET will not be commercialized in the near future, a hybrid inverter consisting of Si switching device and SiC diode is evaluated as a prior object for development. It is important to verify the performance and to clarify the design guideline of the hybrid inverter.

Objectives

The purpose of this study is to verify the effect of SiC diode application on the inverter performance in terms of efficiency and compactness, and to summarize a design guideline to improve efficiency and compactness of the hybrid inverter;

Principal Results

1. Verification of the performance of a SiC diode applied hybrid inverter

A prototype hybrid inverter of 3.3kW (Fig. 1) was manufactured to verify the efficiency improvement through SiC diode application. The prototype inverter is for the PV system power conditioner which is selected as a development object through a prior evaluation regarding cost-effectiveness of SiC diode application. As a result of the performance test, 15% loss reduction is achieved when compared to the commercially available highest efficiency Si inverter. The maximum efficiency of the hybrid inverter reached 96.4% (Fig. 2). In addition, 14% volume reduction can be achieved by reducing the volume of reactors through harmonics reduction with high switching frequency.

2. Design guideline and marginal performance of hybrid inverter

Based on the test result concerning the prototype hybrid inverter, parameter analyses were performed using a simulation program CRIEPI has developed. The results obtained were as follows;

(1) Design guideline: The principal parameters when discussing the optimal design considering inverter efficiency and volume are switching frequency and inductance both for the DC/DC converter part and the inverter bridge part. To optimize those design parameters, it is required to define a performance index incorporating efficiency (loss) and volume of an inverter. A set of parameters to maximize the performance index should be identified through parameter analyses considering operational restrictions such as current intermittent in the DC/DC converter part and output harmonics *1 in the inverter bridge part.

(2) Marginal Performance: A performance index *2 considering the effect of loss reduction and volume reduction equivalently is defined. As a result of parameter analysis to maximize the performance index, it is clarified the marginal performance reaches 18% loss reduction and 15% volume reduction by changing the DC/DC converter switching frequency of the prototype inverter from 72kHz to 36kHz.

Future Developments

A SiC inverter that achieves significant loss and volume reduction will be developed.

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Reference

N. Okada, et al., 2008, “Development of Inverter Simulation Program (Part 2) – Verification of Analysis Accuracy Based on Actual Measurement –”, CRIEPI Report R07016 (in Japanese)

M. Takasaki, et al., 2009, “Design Guideline and Marginal Performance of a SiC Diode Applied Inverter”, CRIEPI Report R08027 (in Japanese)

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*1 : Grid interconnection guideline says harmonic current should not exceed 3% for every individual component and 5% for total distortion.

*2 : The performance index is defined as [reference loss]/[calculated loss]+[reference volume]/[calculated volume]. Reference loss and volume are determined using the prototype inverter result. Calculated volume is derived based on the prototype inverter result. It is estimated using the assumption that the reactor volume is propotional to the inductance value and the cooling fin volume is proportional to the loss.

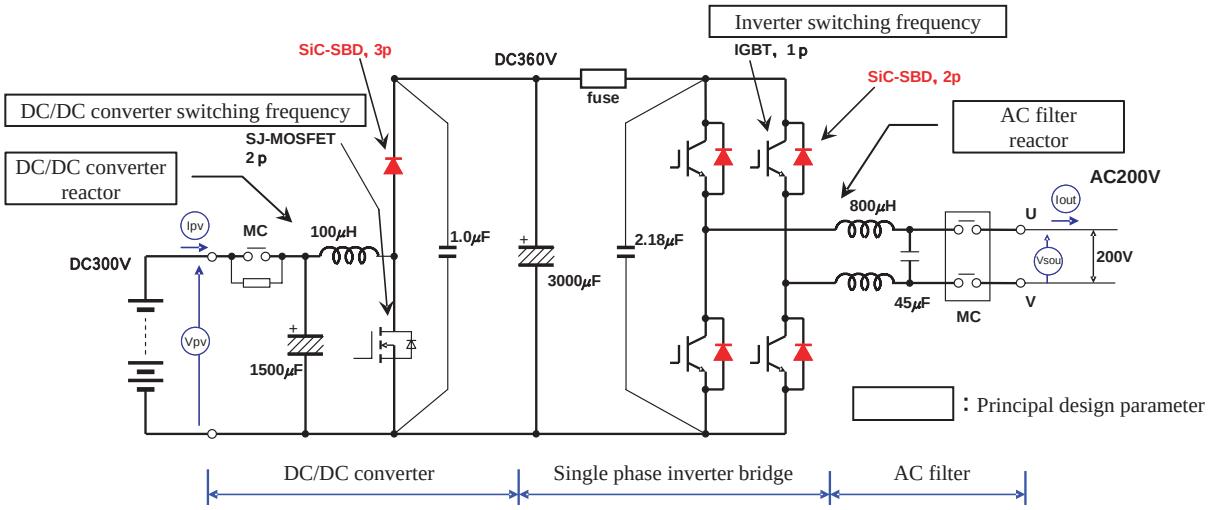


Fig.1 Prototype SiC diode applied inverter (3.3kW)

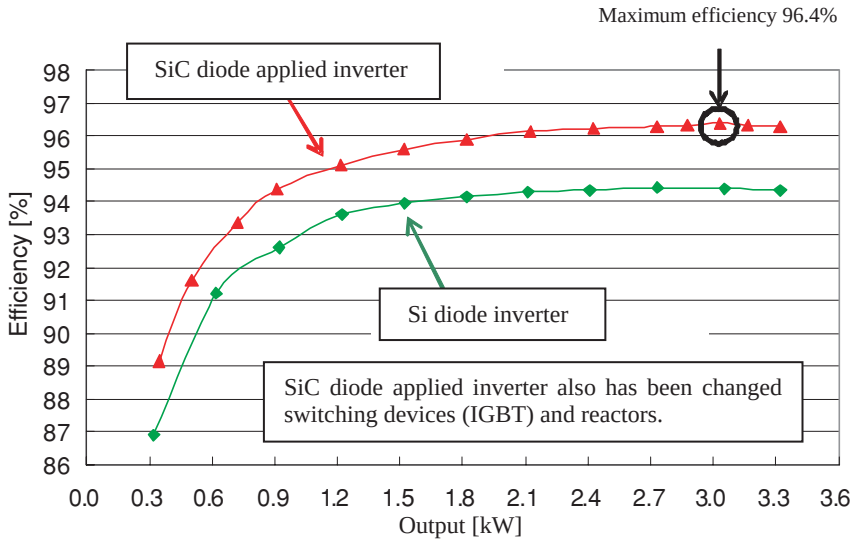
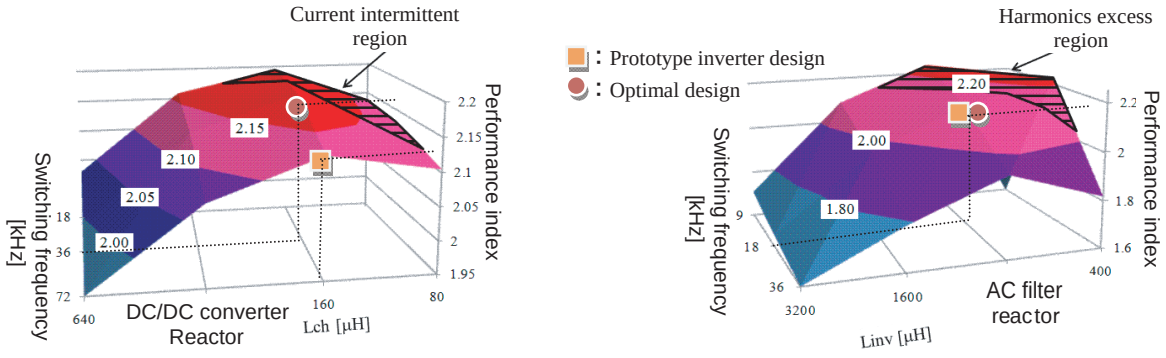


Fig.2 Efficiency measurement result



(a) DC/DC converter parameter design (b) Single phase inverter parameter design

Fig.3 Optimal design of the hybrid inverter parameter considering efficiency and volume