A Study on a High-Power Inverter Employing Four Parallel General-Purpose SiC Discrete Devices

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Introduction

With the advancement of electrification, there's an increasing demand for higher power density in power converters. In response, silicon carbide (SiC) power modules have become widespread. However, these modules involve complex internal wiring and thermal design, which inherently lead to higher costs. As an alternative, there's growing interest in constructing high-power inverters using general-purpose discrete devices. Nonetheless, the increased thermal resistance, loop inductance, and overall system volume are recognized as critical design challenges [1]. While modularizing discrete devices can reduce loop inductance and thermal resistance; it often makes the design and implementation more complex [2]. Furthermore, specific discussions regarding overall system volume and cost are often lacking. This study aims to achieve comparable performance to that of power modules in terms of thermal resistance and inverter volume by connecting general-purpose SiC discrete devices in parallel, thereby reducing the mass production cost.

Inverter structural design

An inverter utilizing parallel-connected discrete devices was developed, achieving a volume comparable to that of an inverter designed with a power module. When connecting devices in parallel, current imbalance can arise due to parasitic inductance between them. While it's possible to implement countermeasures using active gate drivers or by adding passive components, both approaches increase component count and cost. By optimizing the layout, a structure is adopted to match the gate loop inductance. In addition, the gate resistance of each device can be individually adjusted to suppress current imbalance. Furthermore, any increase in loop inductance is addressed by strategically placing decoupling capacitors.

Effective thermal design is also crucial. Power modules typically feature an adequate internal thermal design, resulting in low thermal resistance. To achieve sufficient heat dissipation with discrete devices, a structure utilizing an additional metal block was employed. Thermal analysis of this configuration revealed a temperature rise difference of only 2-5°C compared to power modules, demonstrating comparable performance.

Summary

A three-phase inverter that replaces the power module with discrete devices was developed, while maintaining comparable volume and performance. This approach achieved an approximate 35% cost reduction in mass production.

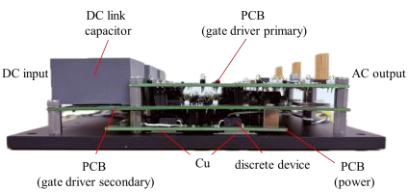

Fig. 1. proposed 3-phase inverter

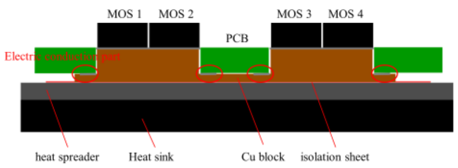

Fig. 2. Cooling structure for power devices using copper blocks

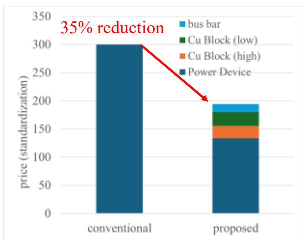

Fig. 6. Cost comparison

References

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