PERFORMANCE EVALUATIONS OF ADVANCED GENERATION IGBTS AND MCT IN SINGLE-ENDED RESONANT INVERTER

N. Ishimaru, A. Fujita, I. Hirota, H. Yamashita
and H. Omori
Matsushita Electric Industrial Co., Ltd., Osaka ,Japan
2-8-8,Hinode-Tyou, Toyonaka, Osaka, Japan
Phone +81-6-332-8769 Fax +81-332-7940

Tetsuo Nakamizo, S.Shirakawa and Mutsuo.Nakaoka
The Graduate School of Engineering and Science,
Yamaguchi University
2557 Tokiwa-dai Ube Yamaguchi, 755-8611, Japan
Phone +81-836-35-9946 Fax +81-836-9449

1.INTRODUCTION

In recent years, a cost-effective voltage-source type single-ended resonant-load inverter using MOS gate power switching devices and its related resonant inverter topologies have been commonly used for induction-heated cooking appliances because of relatively-lowered switching losses, simple circuit topology, low cost, compactness and low harmonic current in utility AC side.

This paper present some comparative performance evaluations of IGBTs as sample devices in each generation and MOS controlled Thyristor(MCT) incorporated into the voltage-source type single-ended load resonant inverter for induction-heating rice cookers used for consumer power electronic applications, in which the output power can be regulated on the basis of Frequency Modulation Scheme.

2.SINGLE-ENDED RESONANT INVERTER

Figure 1 shows a typical circuit configuration of voltage-source type single-ended quasi-resonant inverter used for performance evaluations which can operate under a principle of a zero voltage soft-switching and pulse frequency modulation scheme. The input AC power source voltage supplied to this inverter fed cooking appliance is linked at 100Vrms and in this case, the input power of this appliance becomes 1200W. The latest IGBTs are used in a voltage-source type single-ended resonant inverter with its high peak current, high peak voltage capabilities under high frequency switching . The conduction losses of IBGTs incorporated into this inverter and their turn-off switching losses can be estimated by analyzing the operating voltage and current waveforms obtained from the voltage-source type single-ended quasi-resonant inverter. The broken curves shown in Figure 2 denote the regions to achieve total losses which are estimated on the basis of operating voltage and current waveforms of IGBTs used in this inverter. The allowable handling voltage and current ratings of IGBTs used for performance evaluations are 900V/65A.

3.IGBTs AND MCT

The comparison between fall time(ft) vs. saturation-voltage(Vce(sat)) characteristic for each generations IGBT under a condition of the same chip size are illustrated in Figure 2. For the purpose of the conduction losses reduction, the optimum miniaturization of unit cell is proceeded as shown in Figure 3 in order to develop low Vce(sat) of IGBTs. As a result, the total losses of IGBT incorporated into the inverter are to be lowered as shown in Figure 2.

4.CONPARATIVE PERFORMANCE EVALUATION

Figure 4 provides the conduction and switching losses vs. junction temperature characteristics developed for the 3rd and 4th generation IGBTs. The conduction loss of the 4th generation IGBT has negative temperature coefficient relating to Ic-Vce(sat) characteristics displayed in Figure 5. According to the junction temperature rise of the IGBT, Ic-Vce(sat) curve of the 3rd generation IGBT does not change too much. However, it is proved that Vce(sat) of the 4th generation IGBT is considerably reduced. The 4th generation IGBT has a newly-designed trench-type structure which forms deep narrow ditches at the chip surface and allocates MOS-FETs at their sides as shown in Figure 6. Therefore, there is no junction resistance with positive temperature coefficient and its Vce(sat) is reduced. Consequently, it is proved that the 4th generation IGBT has a fine loss-temperature characteristics as compared with the previously developed IGBTs.

In Figure 7, it is clear that MCT can be further reduced its conduction loss as compared with advanced IGBTs. This reduction is brought in accordance with its Ic-Vce(sat) characteristics that provide about a half of Vce(sat) for IGBTs demonstrated in Figure 8.

5.CONCLUSIONS

Comparative performance evaluations of each generation IGBTs including next generation IGBTs in each developed stage and MCT produced by Harris Co. Ltd. have been presented from a practical point of view for simple voltage-source type single-ended load resonant inverter operating at zero voltage soft switching mode which is widely applied for the induction-heated cooking appliances. These data proved that the loss-temperature characteristics of the 4^{th} generation IGBT was more improved because of its promising trench-type structure. It was clarified from an experimental point of view that MCT incorporated in this inverter could be further reduced with respect to the conduction loss.

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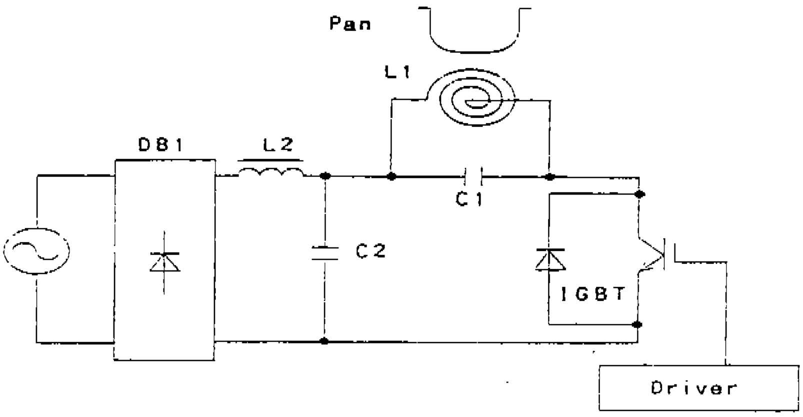


Fig. 1. Quasi-resonant ZVS-PFM inverter with a single active switch (IGBT/MCT).

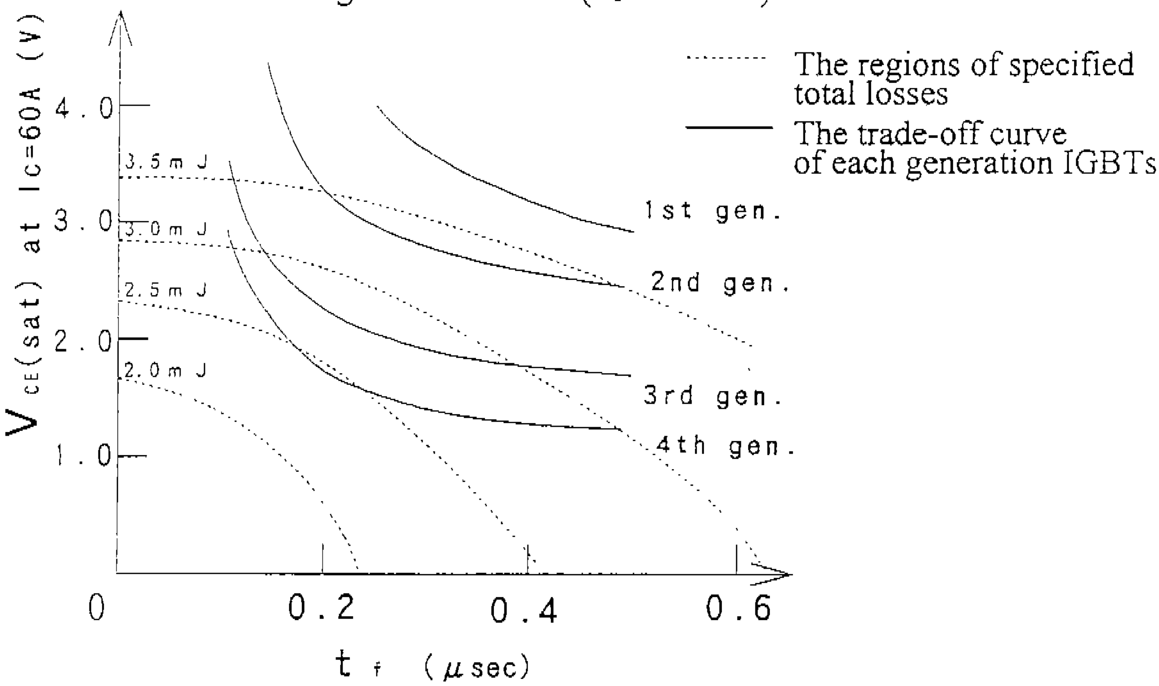


Fig.2. Comparison between tf-V_{CE}(sat) characteristics for each generation IGBT.

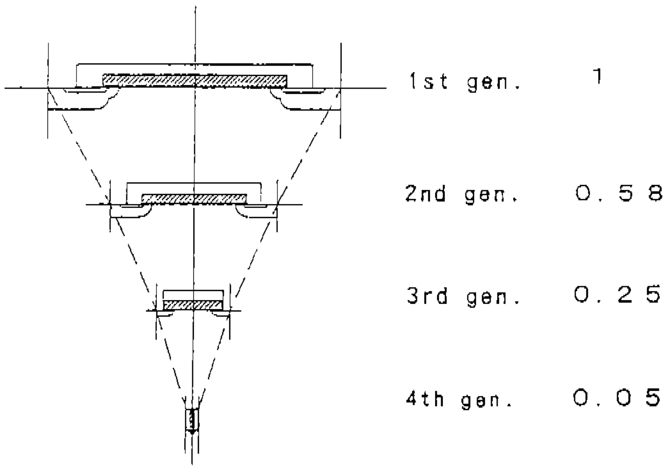


Fig.3. Sectional view of unit cell and ratio of each cell size.

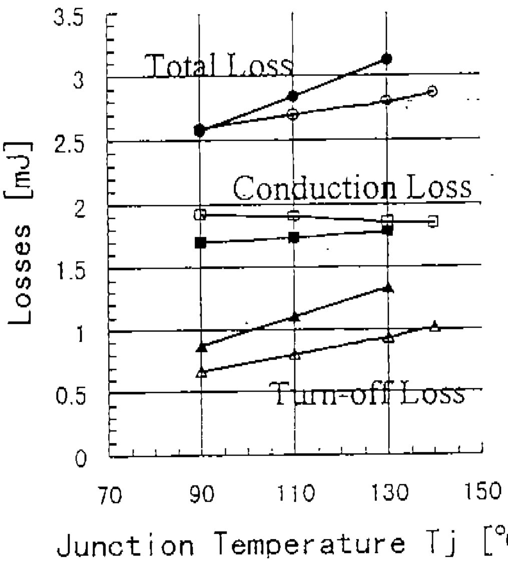


Fig.4. Losses vs. junction temperature characteristics in the 3rd(black marker) and the 4th generation IGBT(white marker).

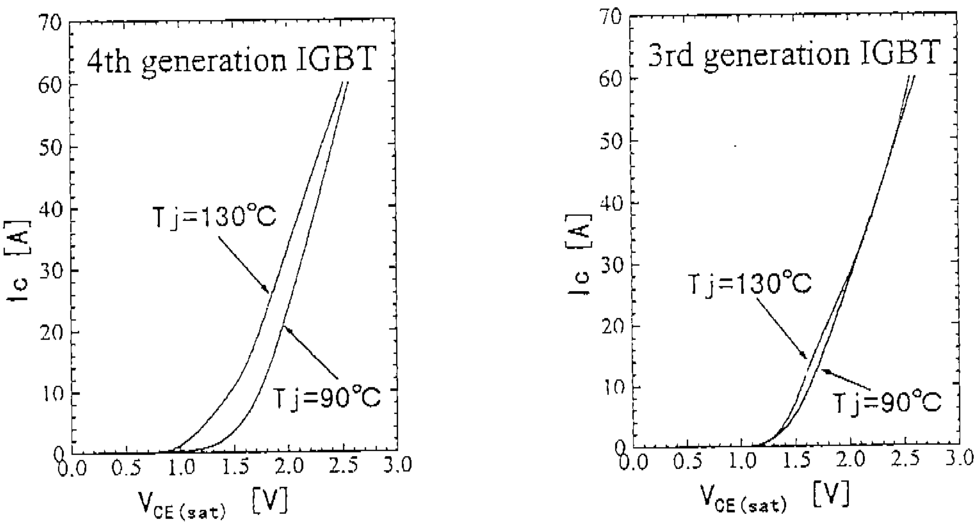
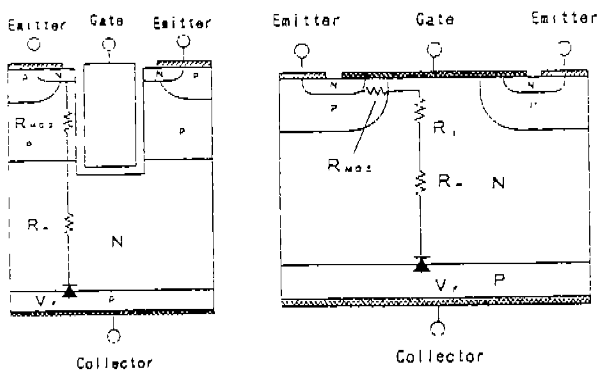


Fig.5. I_C vs. V_{CE}(sat) characteristics in the 3rd or the 4th generation IGBT.



4th generation IGBT 3rd generation IGBT

Fig.6. Two types of IGBT structures.