On-line $V_{CE_{ON}}$ and $V_F$ Measurement

Preliminary I-V Characterization

Junction Temperature Estimation

Resistance Variation in an IGBT module

Experiments

Compensation of Effect of Internal Resistance

This paper proposes an accurate method to estimate the junction temperature using the on-state collector-emitter voltage and load current. By the proposed method, the estimation error which comes from the different temperatures of the interconnection materials in the module is compensated. Finally, it leads to satisfactory estimated results. The proposed method has been verified by means of an IR (Infra-Red) camera during power converter operations when the loading current is sinusoidal.

Junction Temperature Estimation

$T_{J\_est} = SF(I) \cdot (V_{CE_{M}} - V_{CE_{B}(I)}) + T_B$

$SF(I)$ : slope factor as a function of the current

$V_{CE_{M}}$ : measured on-state $V_{CE}$ in real time

$V_{CE_{B}}$ : base on-state $V_{CE}$ as a function of current

$T_B$ : base temperature corresponding to base on-state $V_{CE}$

Resistance Variation in an IGBT module

Temperature variation of resistance in the module under converter operation makes the estimation error

Compensation of Effect of Internal Resistance

$T_{J\_chip} - T_{Rint} = \alpha \cdot (T_{J\_est} - T_H)$

$V_{comp} = \alpha \cdot (T_{J\_est} - T_H) \cdot RVF \cdot I$

$T_{J\_comp} = SF(I) \cdot (V_{CE_{M}} - V_{CE_{B}(I)}) + V_{comp} + T_B$

$\alpha$ : scaling factor (0.85)

$T_{J\_est}$ : estimated $T_J$ (w/o compensation)

$T_H$ : heat-sink temperature

$I$ : load current

$RVF$ : 0.036 (mΩ/°C)

< Simplified temperatures in the IGBT module >

< Four-point probing method for resistances measurements in the module. >

< Resistances of high- and low-side IGBTs in the module as a function of temperature (a) module #1 (b) modules #2 >

$V_{CE_{ON}} = V_{CE_{chip}} + R_{int} \cdot I$

$RVF$ : 0.0234 mΩ/°C (High), 0.036 mΩ/°C (Low)

< Device Under Test; Transfer Molded Intelligent Power IGBT Module >

< Test Setup >

< Comparison of the junction temperature estimation at different operating conditions (a) IR camera (b) estimation. >

$V_{CE_{ON}}$, $V_F$, $T_H$ : estimated

< Comparison of the junction temperatures under the operating condition 1 >

< Junction temperature estimations under the operating conditions (a) 10 (b) 12 (c) 8 >

< Comparison of the junction temperature estimation at different operating conditions >

< Junction temperatures under the operating conditions (a) 10 (b) 12 (c) >

< Device Under Test; Transfer Molded Intelligent Power IGBT Module >

< Test Setup >

< Comparison of the junction temperatures under the operating condition 3 >

< Device Under Test; Transfer Molded Intelligent Power IGBT Module >

< Test Setup >

< Comparison of the junction temperatures under the operating condition 4 >

< Comparison of the junction temperature estimation at different operating conditions (a) IR camera (b) estimation. >

The estimation error which comes from the different temperatures of the interconnection materials in the module is compensated.

The feasibility of the proposed method has been verified by the experiments.