

Application note

Definition of Temperatures

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Definitions of Temperatures

Fig. 1 shows the basic structure of a power module and heat sink. Some temperatures of the thermal path, from die to coolant, should be defined for the thermal design of the power module. Herein are the definitions:

1. Junction temperature (T_j) and virtual junction temperature (T_{vj})

Junction temperature simply means the temperature in the pn-junction area of an IGBT or Diode die. It should be noted at an early stage, that the temperature is not uniform in the die. Furthermore, where multiple dies are mounted in a module, the temperature may differ from die to die. Therefore, the concept of a virtual junction temperature T_{vj} is introduced to define the thermal resistance or impedance junction to case ($R_{th(j-c)}$ or $Z_{th(j-c)}$). The virtual junction temperature does not precisely coincide with the junction temperature of each die due to the average value of the junction area of multiple dies, but it is useful for the estimation of a junction temperature. As the temperature is measured indirectly and does not have a precise value, it is appropriate to be termed a “Virtual junction temperature”. The measuring method of the temperature is presented in the international standard IEC 60747-9.

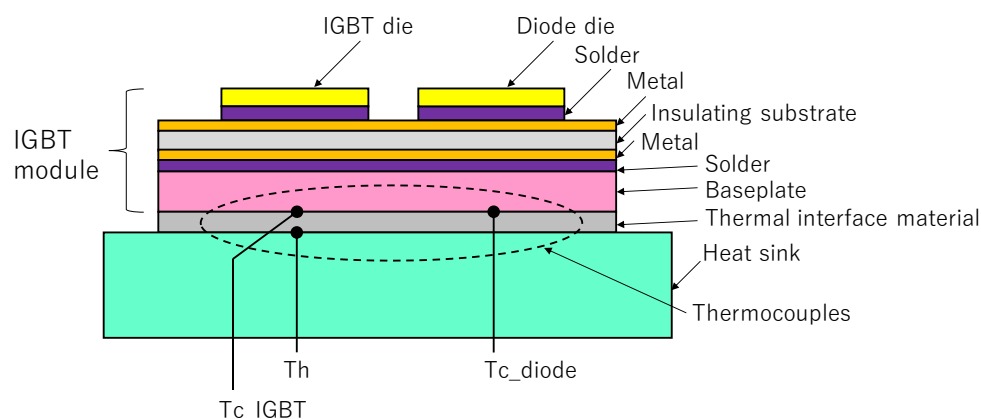


Fig. 1 Basic structure of power module and heat sink

2. Case temperature (T_c)

The case temperature, T_c , is defined as the surface temperature of a baseplate in an IGBT module. Hitachi measures temperatures beneath each die using thermocouples, and then defines the averaged value of each die as the case temperature. Fig. 1 shows the example of the temperature measurement at the baseplate surface underneath each die.

3. Heat sink temperature (T_h)

The heat sink temperature, T_h , is the surface temperature of a heat sink measured at fixed points on the surface where an IGBT module is mounted. Depending on the measuring position, the measured temperature has a certain deviation. As shown in Fig. 1, Hitachi defines the average surface temperature beneath multiple IGBT dies as the heat sink temperature.

4. Ambient temperature, T_a

The ambient temperature, T_a , is expressed according to the coolant medium. In the case of natural air cooling, T_a will be the natural environmental temperature in which the IGBT module is located. In the case of forced air cooling, the ambient temperature will be the temperature of air entering the heatsink. Where a sealed liquid or gas coolant system is adopted, the ambient temperature will be the temperature of the coolant before operation of the IGBT module commences. Typically, a sealed coolant system ambient temperature will be equivalent to the natural environmental temperature, unless pre-heating is adopted. The ambient temperature is often defined as the reference temperature that is unaffected by power dissipation etc.