Test Methods for Evaluating SCSOA of IGBT

I. Purpose

SCSOA, "Short Circuit Safe Operating Area", is a fundamental item of IGBT's performance to be considered in designing application systems of IGBT. This document presents test methods for evaluating the SCSOA.

II. Types of short circuit

In the International Standard IEC 60747-9, two types of load short circuit are mentioned for evaluating SCSOA of IGBT. The first one is a case where the IGBT is switched on under an existing load short circuit. The second one is a case where the IGBT is already in on-state, and then a load short circuit occurs. In other words, the second one simulates break-down or false turn-on of the complementary IGBT under the power running operation of inverter. The major application field of inverter is a motor drive. Therefore, a regenerative operation should be also considered. In this document, the third type for the generative operation is referred to, and the above-mentioned three types are defined as Type 1, 2 and 3 respectively.

III. Test Circuit

A half-bridge circuit, shown in Fig.1, is generally utilized for evaluating the characteristics of IGBTs. The circuit is effective in estimating IGBT's SCSOA also, and composed of series connected two IGBTs and diodes, a power supply (PS), inductive load (L) and total stray inductance (L_S), where DUT means "Device Under Test".

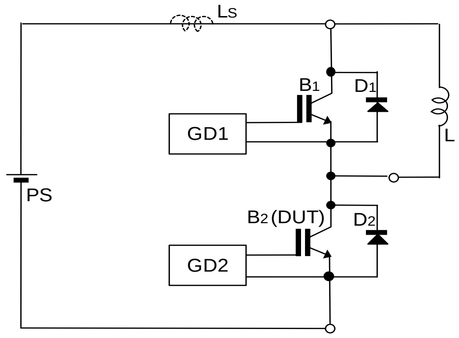

Fig.1 Half-bridge circuit.

IV. Test Methods

A) Type 1

Type 1 is a case where the DUT is turned on under an existing load short circuit. This test mode can be realized by operating the half-bridge circuit under the gate voltage pattern of Fig.2 (a). The existing load short circuit is simulated by keeping upper-side IGBT B_1 in on-state, where the value of gate voltage V_{GE1} is adequately set, higher than 15V (18V for example), in order to make the collector saturation current I_{Csat} of B_1 larger than the I_{Csat} of B_2 (DUT). Under on-state of B_1, B_2 is turned on and off in accordance with gate voltage pattern V_{GE2} of Fig.2 (a). Then, a short circuit current I_S flows as shown in Fig.3, where a collector current $I_C = I_S$. Fig.2 (b) shows the waveform of collector current I_C.

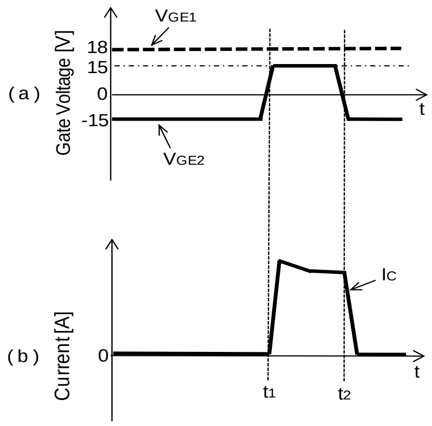

Fig.2 Waveforms for Type 1.

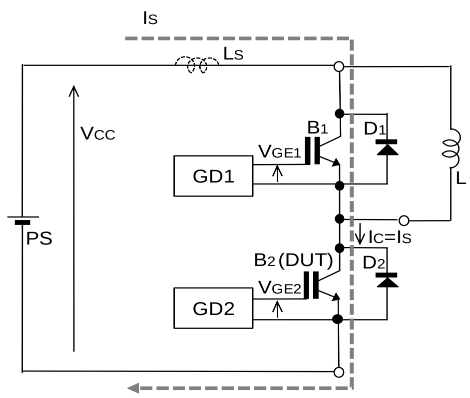

Fig.3 Current flow in short circuit of Type 1.

B) Type 2

Type 2 is intended to simulate a case where an on-state of the DUT is kept under power running operation of an inverter, and then short circuit of L occurs. This case also means break-down or false turn-on of the complementary IGBT (B1) under power running operation of an inverter. The case is realized by applying the gate voltage pattern of Fig.4 (a) to the circuit of Fig.1. In accordance with the pattern, during the first period, t=0 to t_1, load current I_L flows as shown in Fig.5, and the complementary IGBT becomes on-state at t_1. Then a short circuit current I_S flows as shown in Fig.6, where a collector current $I_C = I_S + I_L$. Fig.4 (b) shows the waveform of collector current I_C.

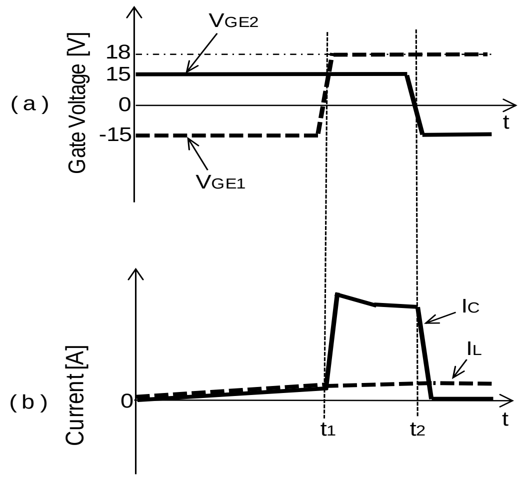

Fig.4 Waveforms for Type 2.

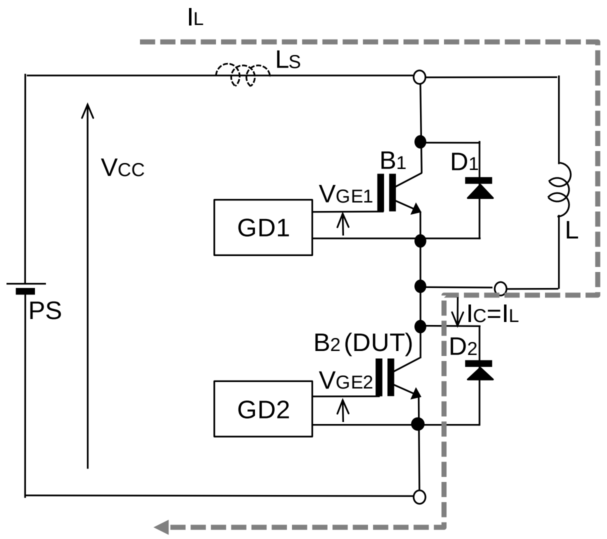

Fig.5 Load current flow in Type 2.

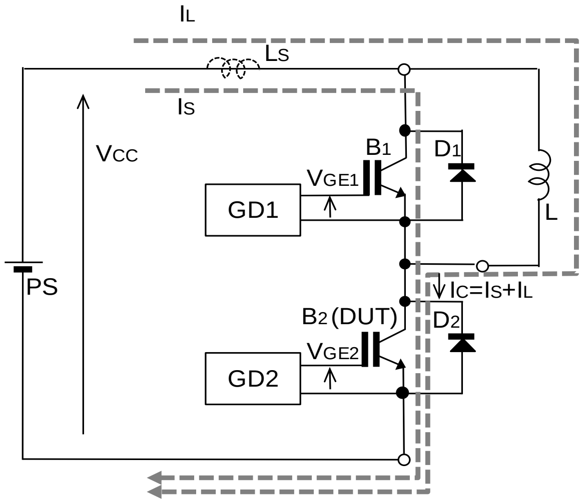

Fig.6 Current flow in short circuit of Type 2.

C) Type 3

Type 3 is intended to simulate a case where an on-state of the DUT is kept under regenerative operation of an inverter, then break-down or false turn-on of the complementary IGBT (B1) occurs. In this document, the case is realized by applying the gate voltage pattern of Fig.8 (a) to the circuit of Fig.7, where connection points of inductive load L is changed from upper-side to lower-side. In accordance with the pattern, during the first period, t=0 to t_1, load current I_L flows as shown in Fig.9 and increases. During t_1 to t_3, I_L is kept as a circulating current through diode D_2 shown in Fig.10. B_2 (DUT) turns on at t_2, and the complementary IGBT becomes on-state at t_3. Then a short circuit current I_S flows as shown in Fig.11, where a collector current $I_C = I_S - I_L$. Fig.8 (b) shows waveform of collector current I_C.

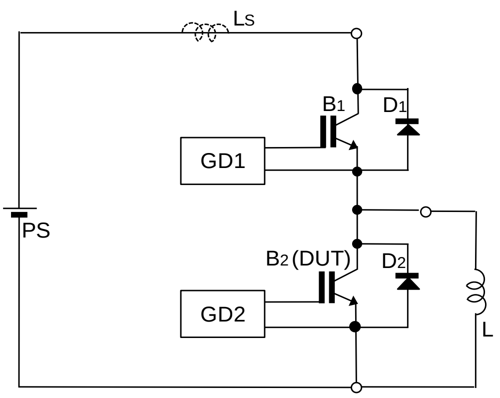

Fig.7 Modified circuit for Type 3.

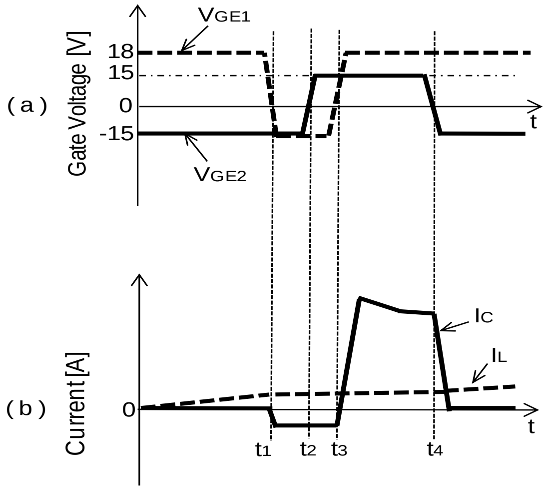

Fig.8 Waveforms for Type 3.

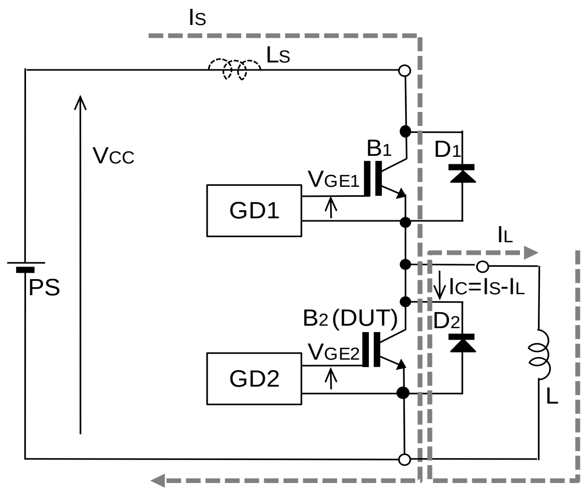

Fig.11 Current flow in short circuit of Type 3.

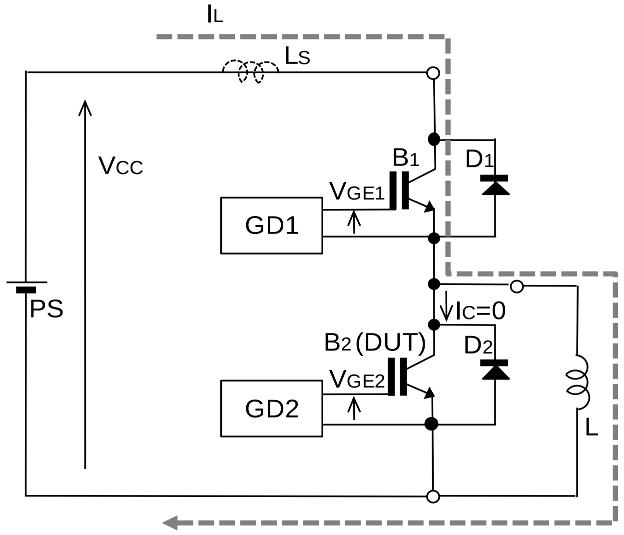

Fig.9 Load current flow in Type 3.

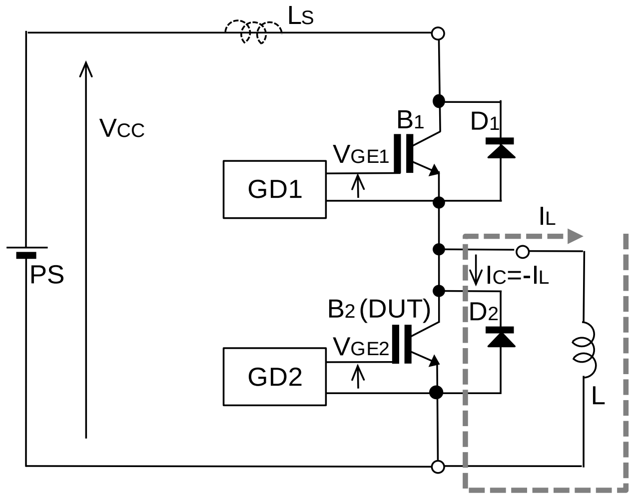

Fig.10 Circulating current of I_L in Type 3.