Measuring Method of Stray Inductance for Inverter Circuit

In evaluating the characteristics of IGBTs, stray inductance of the test circuit is a major factor to be considered. This document presents the measurement method of the stray inductance (inclusive of the module's own internal inductance). In evaluation of IGBT, one phase circuit of inverter, as shown in Fig. 1, is generally utilized. The circuit is basically a half–bridge topology, composed of two series connected IGBT modules, a power supply (PS) and an inductive load (L), where the total stray inductance of the main circuit is symbolized as Ls.

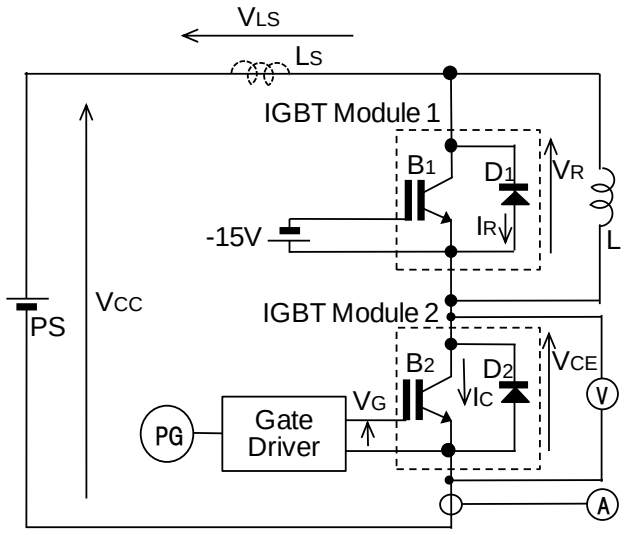

Fig.1. One phase circuit of inverter

The operational timing pattern of the circuit for measuring Ls is given in Fig.2 (a). The voltage and current waveforms of the pattern are shown in Fig.2 (b) and (c) respectively. In accordance with the pattern, IGBT B_2, i.e. Module 2, is operated. From t = 0 to t_1 the state of B_2 is ON and current I_C flows through load L and IGBT B_2, as shown in Fig.3. In this case, the load current I_L which flows through inductive load L has the same value as the collector current I_C of B_2 where I_C increases with time.

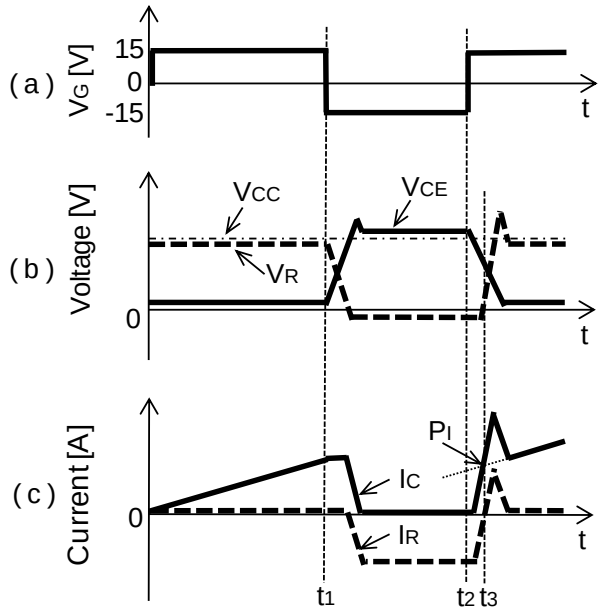

Fig.2. Operation pattern for measuring Ls

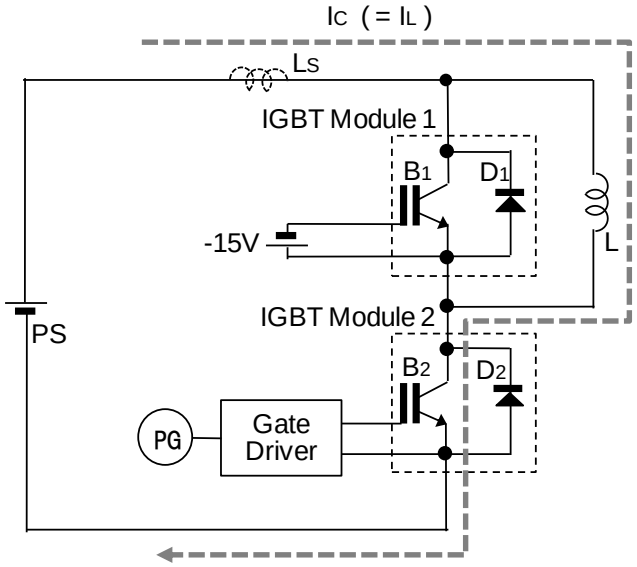

Fig.3. Current flow in the ON-state of B_2

After t_1, B_2 shifts to OFF-state through a transient period. During the OFF-state of B_2, the current I_C is blocked but the load current I_L is maintained as a circulating current through diode D_1 as shown in Fig.4. After t_2, B_2 turns ON during a transient period.

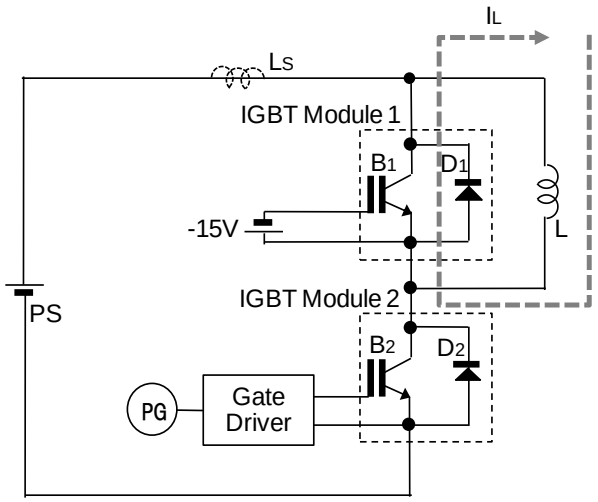

Fig.4. Current flow in the OFF-state of B_2

Just after t_1 and t_2, there appears transient state, where both I_C and I_L currents flow, as shown in Fig.5. The reverse current (I_R) of D_1 is the difference between I_C and I_L, that is to say $I_R=(I_C – I_L)$.

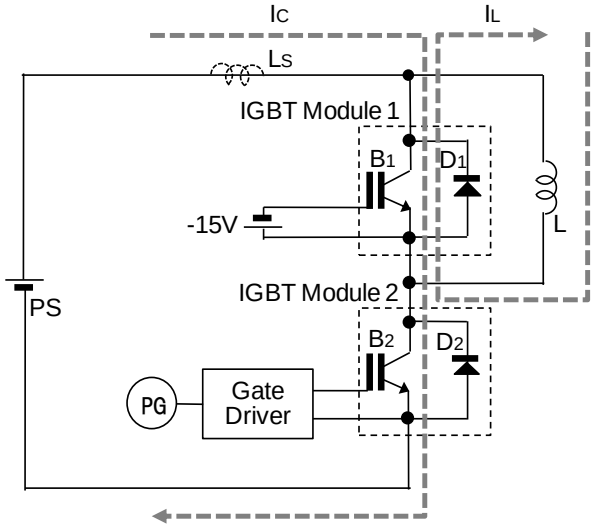

Fig.5. Current flow during transient period

Focusing on the transient period following t_2, I_C flows through D_1 and B_2 as shown in Fig.6. During this state, L_S is calculated by the following equation (1).

$$L_S = (V_{CC} - V_R - V_{CE}) \div \frac{dI_C}{dt} \quad \text{---------- (1)}$$

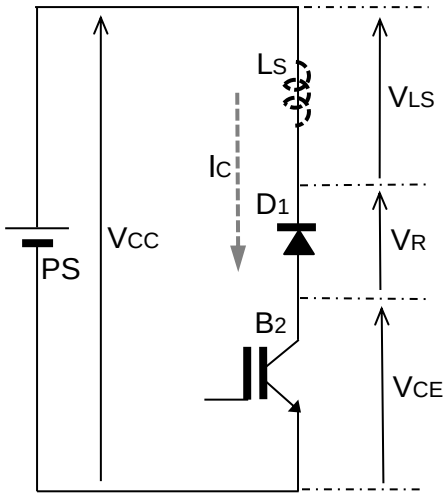

Fig.6. Simplified circuit for transient period

If V_{CE} and dI_C/dt are detected at a time point where V_R becomes zero, that is, $I_R = 0$, the following equation (2) can be derived from equation (1).

$$L_S = (V_{CC} - V_{CE}) \div \frac{dI_C}{dt} \quad \text{---------- (2)}$$

Therefore, L_S can be specified using the measured voltage V_{CE} and current I_C as arranged in Fig.1. The voltage meter must be connected to sense terminals of IGBT module in order to accurately measure the value of L_S including the internal inductance of the module. The time point symbolized as by t_3 in Fig.2 (c) can be detected through the intersection point P_I by checking the waveform of I_C.