AND9517/D

NGTB03N60R2DT4G Application Note for Refrigerator Examination of Optimized Circuit

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APPLICATION NOTE

1. Overview

RC-IGBT is the abbreviation of Reverse Conducting Insulated Gate Bipolar Transistor, which is a type of IGBT with built-in FWD on the same chip.
Like inverter circuit, when both IGBT and FWD are needed, 1chip can reduce the package size; thermal balance can also be obtained.

This paper shows RC-IGBT's typical type NGTB03N60R2DT4G characteristics matching by peripheral constants optimization with an inverter demo-board.

2. IGBT Inverter Demo-board

Inverter operation board is board that supports various controls such as vector control, 180 degree scalar control, sensor/sensor-less and so on.

We used NCP5304 for gate driver, induction motor with 180 degree open loop for evaluating the characteristics of NGTB03N60R2DT4G.
(Fig.1)

For the inverter operation board, please refer to Photo.1.

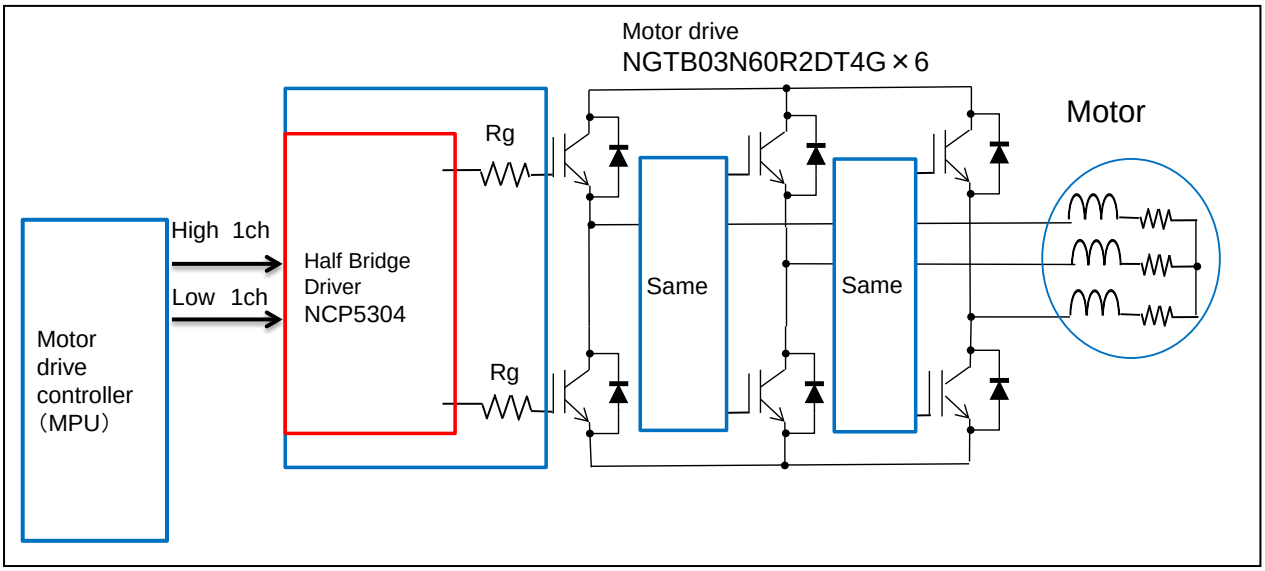


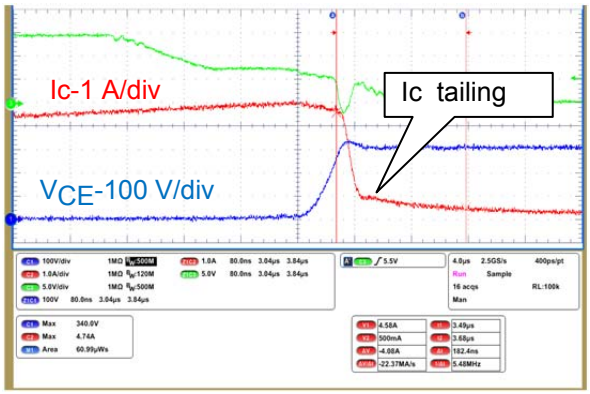
Fig.1 Block diagram of demo board

3. Evaluation result of the optimized driving conditions

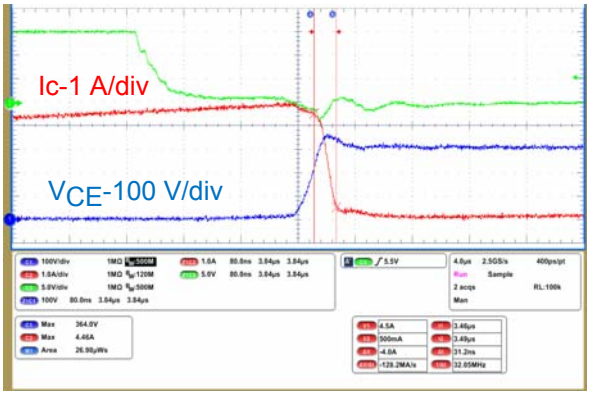
3-1) FS2 Process and SW Loss Reduction

In case of conventional IGBT (NPT-IGBT) compared with MOSFET, what is called “tailing current” flows at the time of IC cutoff, so switching loss at the time of IC cutoff becomes larger than that of MOSFET. (WP.1)

But in case of NGTB03B60R2DT4G that adopts FS2 process and supports high speed switching, this tailing loss can be greatly reduced. (WP.2)



WP.1 NPT-IGBT Ic = 5 A, tf = 102 ns



WP.2 FS2-IGBT Ic = 5 A, tf = 31.2 ns

3-2) Selection of Optimized Rg

In order to drive IGBT optimally, gate resistance Rg becomes critical. The smaller Rg is, the faster the gate charge will be. But the noise will be an issue. Furthermore, as stated in 3-1), in case of a general IGBT, IC cutoff loss is large. So Rg in the gate drive circuit can be made into 2 paths (Fig2-1) to reduce the Rg of the path in gate OFF direction.

However, in case of NGTB03N60R2DT4G, this loss is small. So Rg can be one (see Fig.2-2), which enables parts count reduction. When changing this value (see Fig.3), VIN(DC) = 240 V,under the condition of motor current = 1 A, when taking **Rg = 33 Ω, the lowest operation temperature Tc can be obtained. This is the optimized value.** WP.3 shows the operation waveform of NGTB03N60R2DT4G.

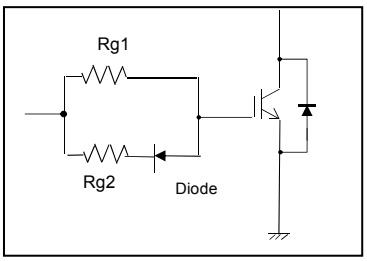


Fig.2-1 Dual Gate resistor

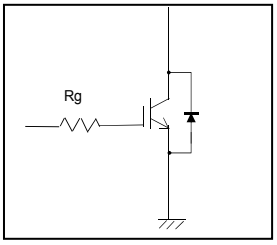


Fig. 2-2 Single Gate resistor

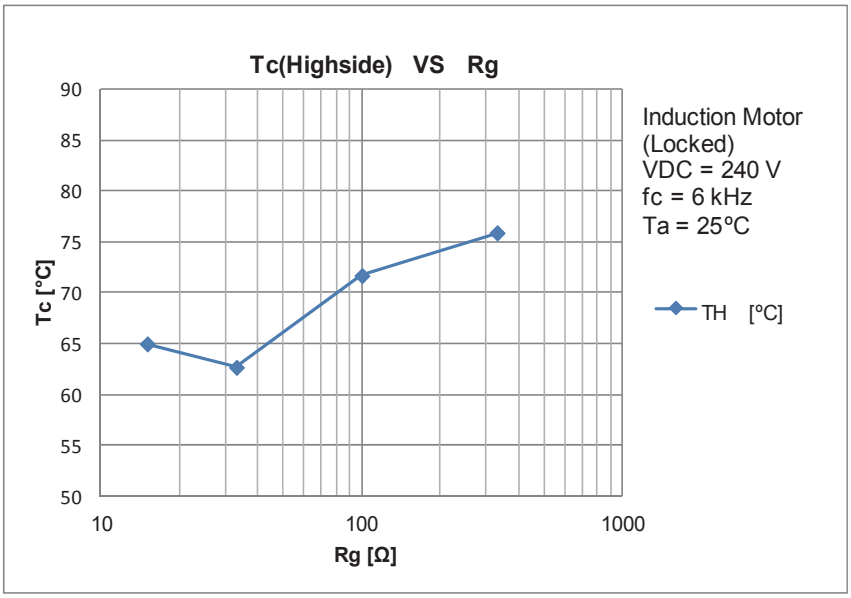


Fig.3 Test result of dependence between Tc and Rg

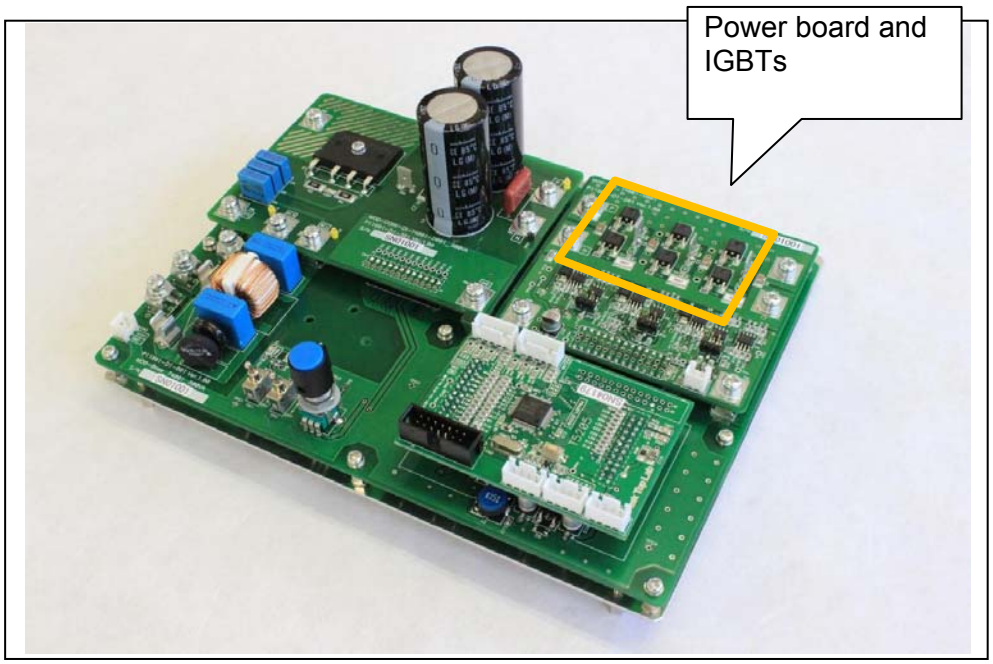
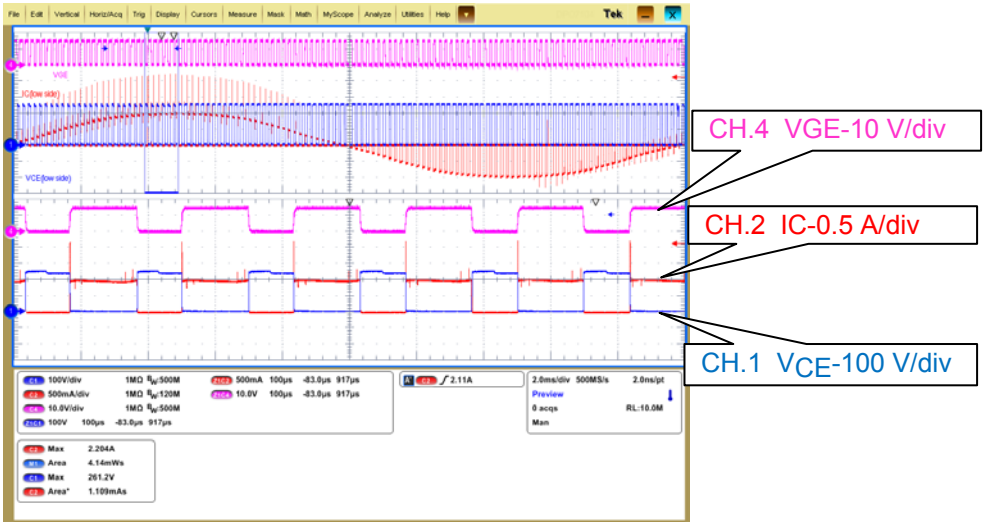


Photo.1 Inverter Demo board for testing IGBTs



WP.3 Driven wave form example of NGTB03N60DT4G
(Low side)

3-3) Performance Comparison (with competitor)

Table.1 shows the main DC ratings comparison data when being used for refrigerator compressor. NGTB03N60R2DT4G : compared with (A) IGBT, V_{CE}(sat) is lower, ON loss can be reduced.

Table.1 Comparison data (with competitor's IGBT [A])

	Ic [A] @Tc = 100°C	V_{CE}(sat) Typ [V]	VF Typ [V]
NGTB03N60R2DT4G	4.5	1.7 (3 A)	1.5 (3 A)
(A) IGBT	4.2	1.9 (3 A)	1.9 (3 A)

· Comparison in Operation Circuit (esp. Tc)

Fig.4 shows Tc of (A) IGBT when operating under the same conditions as the previously stated circuit. Tc of NGTB03N60R2DT4G is lower, so the set efficiency is superior.
When observing the operation waveform and current during reverse-recovery period of NGTB03N60R2DT4G and (A) IGBT's FRD, you will find that ringing noise occurred to (A) IGBT's VCE waveform (see WP.4). This will become noise origin toward outside.
In contrast, the above-stated waveform is not seen for FRD of NGTB03N60R2DT4G (see WP.5). So it is superior in terms of noise.

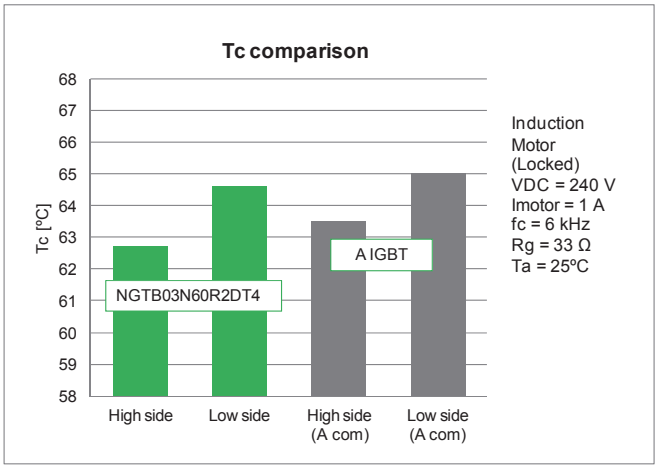
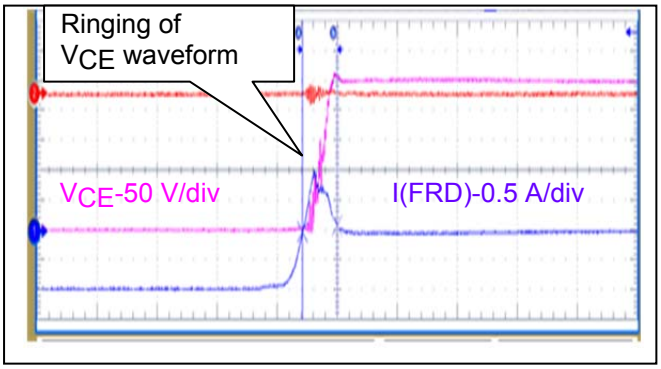
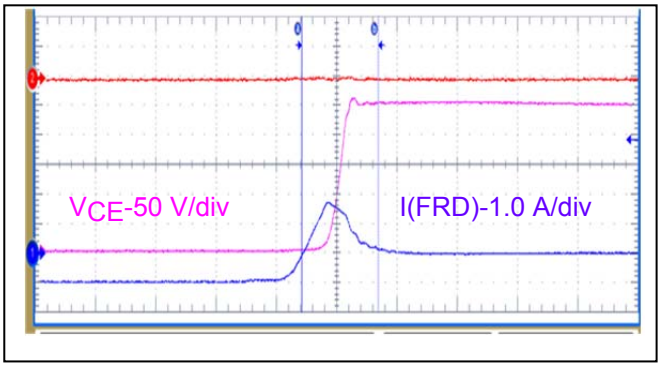


Fig.4 Test result of Tc comparison



WP.4 (A) IGBT I (FRD) and V_{CE} waveforms



WP.5 NGTB03N60R2DT4G I(FRD) and V_{CE} waveforms