

# AND9391/D

## NGTB03N60R2DT4G Application Note for Refrigerator



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### 1. At the beginning

RC-IGBT is the abbreviation of Reverse Conducting Insulated Gate Bipolar Transistor, which is an IGBT that incorporates FWD into one chip.

Like inverter circuit, the needed IGBT and FWD are housed in one chip; this enables package downsizing and thermal balance.

This paper introduces the operation application of RC-IGBT in DPAK.

### 2. Cross-section structure of RC-IGBT and IGBT (general explanation)

Table.1 shows the similarities and differences between RC-IGBT and IGBT in structure and operation.

### APPLICATION NOTE

RC-IGBT: diode is formed due to the formation of a part of backside with N+(high-concentration N-layer). Collector (C) is cathode, Emitter (E) is anode, so it can be functioned as FWD of IGBT. Surely, as a diode, it is designed high-speed that ensures  $t_{rr} < 65\text{ns}$  and high-speed switching performance. Furthermore, RC-IGBT adopts our original FS2 structure; this process is called RC2-IGBT

Table.1 Structural comparison between RC-IGBT and IGBT

	RC-IGBT	IGBT
Chip structure	For FRD area, a part of backside P+ layer is replaced with N+ layer	The entire backside is formed by P+ layer. FRD is a separate chip
Circuit symbol		
Chip cross-section (explain with ordinary structure)		

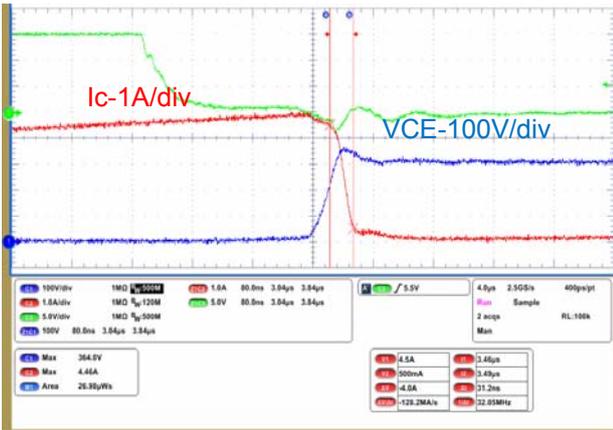
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## 3. High-speed SW performance of RC2-IGBT

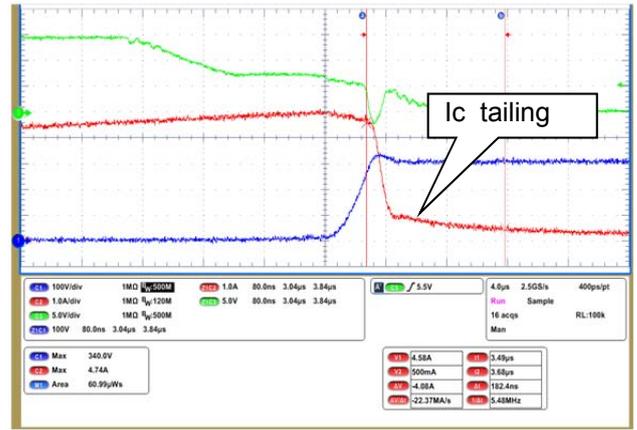
FS2 process is by nature developed by ON Semi to be used for high-speed switching IGBT, for example, IGBT for full-switching PFC. By adopting this structure in RC2-IGBT,  $t_f$  is greatly improved (faster speed) compared with earlier-type (NPT structure) IGBT.

Sample waveforms are shown in WP.1 and WP.2.

WP.1 is  $t_f$  waveform @5A operation for RC2-IGBT. Compared with WP.2 (10A NPT), RC2-IGBT realized high speed and  $t_f$  tailing-less operation.



WP.1 FS2-IGBT  $I_c=5A$   $t_f=31.2ns$



WP.2 NPT-IGBT  $I_c=5A$   $t_f=102ns$

## 4. RC2-IGBT products lineup

RC2-IGBT features small size by housing IGBT and FRD into 1chip, therefore ON Semi provides its lineup with a focus on DPAK products.

With compact package,  $I_c$  rating ranges from  $I_c=4.5A$  (NGTB03N60R2DT4G) to  $I_c=10A$  (NGTB10N60R2DT4G).

Table.2 RC2-IGBT Lineup

Type No.	Package	Absolute maximum ratings				Electrical characteristics $T_a=25^\circ C$ VCE(sat) typ	FRD Electrical Characteristics /	
		VCES [V]	IC @ $T_c=25^\circ C$	IC @ $T_c=100^\circ C$	ICP @ $T_c=25^\circ C$		VF typ	trr typ
			[A]	[A]	[A]	[V]		
NGTB03N60R2DT4G	DPAK	600	9	4.5	12	1.7(3A)	1.5	65*1
NGTB05N60R2DT4G	DPAK		16	8	20	1.65(5A)	1.5	75*1
NGTB10N60R2DT4G	DPAK		20	10	40	1.7(10A)	1.5	90*1
NGTB15N60R2FG	TO-220F-3FS		24	14	60	1.85(15A)	1.7	95*1

\*1  $IF=I_c(T_c=100C)$ .  $VR=300V$ ,  $di/dt=300A/\mu s$

5. Application Map of RC-IGBT

Best suited for refrigerators and fan motors of a high operation frequency (15kHz).

The application map of NGTB03N60R2DT4G with DPAK package. (Fig.1)

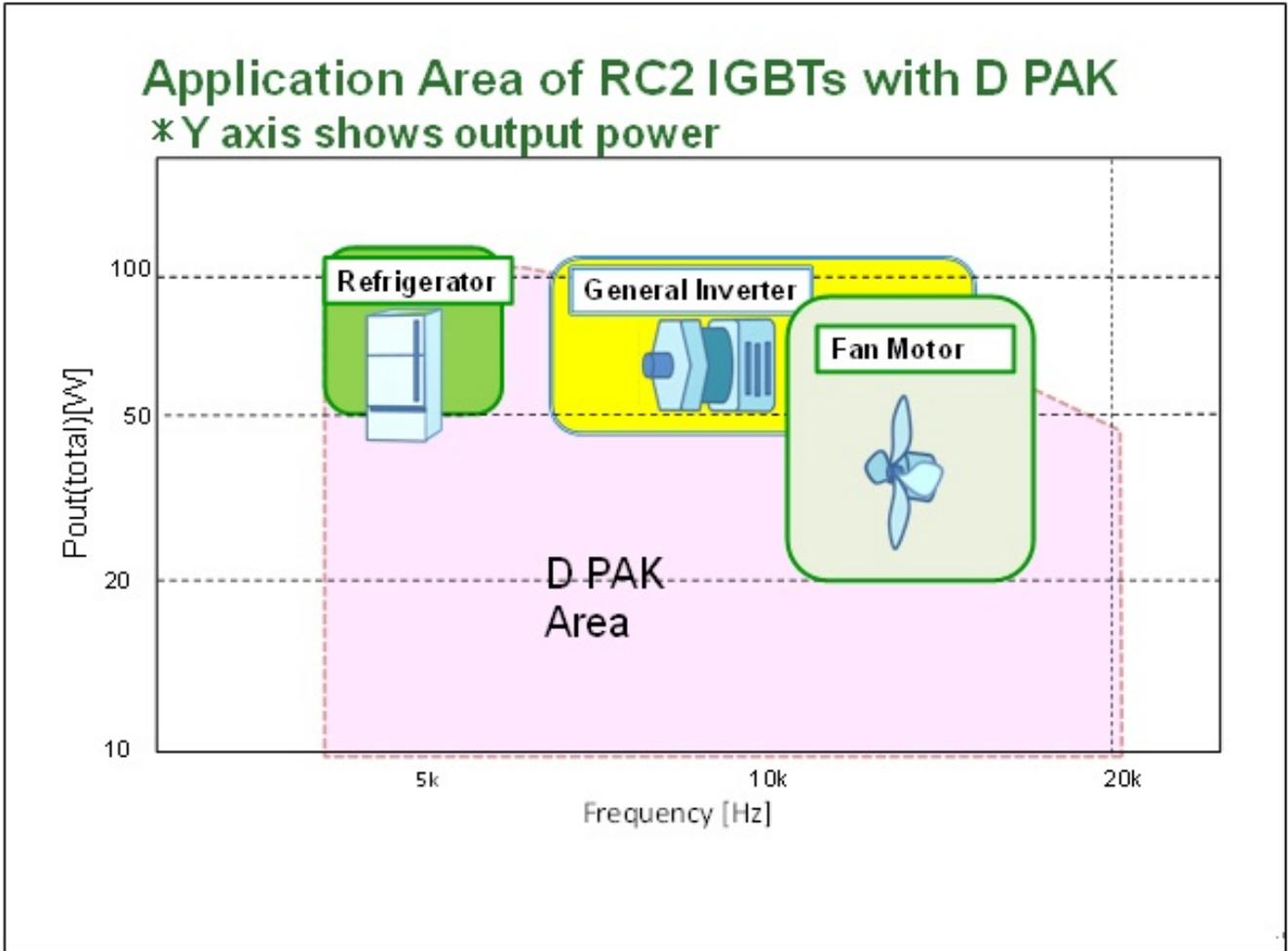


Fig.1 Application area of NGTB03N60R2DT4G (D PAK)

6. Operation in BLDC motor

Table.2 DC Spec. Comparison

6-1) DC rating comparison with competitors

	$I_c$ [A] @ $T_c=100^\circ\text{C}$	$V_{CE}(sat)$ typ[V]	$V_F$ typ[V]
NGTB03N60R2DT4G	4.5	1.7(3A)	1.5(3A)
A IGBT	4.2	1.9(3A)	1.9(3A)

Table.2 shows DC rating comparison with competitor's IGBT used in refrigerator compressor.

NGTB03N60R2DT4G has lower  $V_{CE}(sat)$  than A IGBT does, which enables conduction loss reduction.

6-2) Operation comparison in BLDC motor

Fig.2 shows the characteristic when operating 3-phase BLDC motor with circuit composition like Fig.3 (120° PWM operation,  $f_c=6.8\text{kHz}$ ). Operation temp. of each IGBT mounted on PCB is measured. Like the above-stated DC rating, compared with IGBT A, NGTB03N60R2DT4G with low  $V_{CE(sat)}$  showed decreased temp. Photo.1 shows the condition of the device mounted on board and the board for operation review (a part).

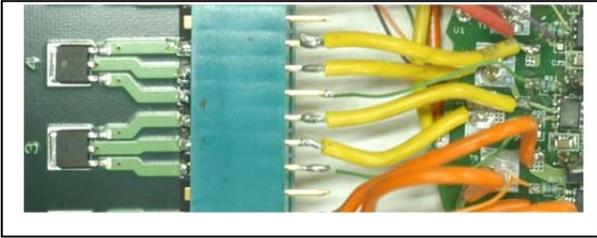


Photo.1 Board for operation review (a part)

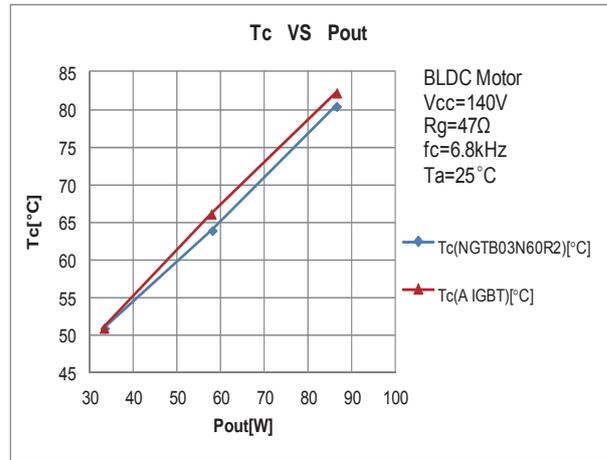


Fig.2 Operation characteristic Tc VS Pout

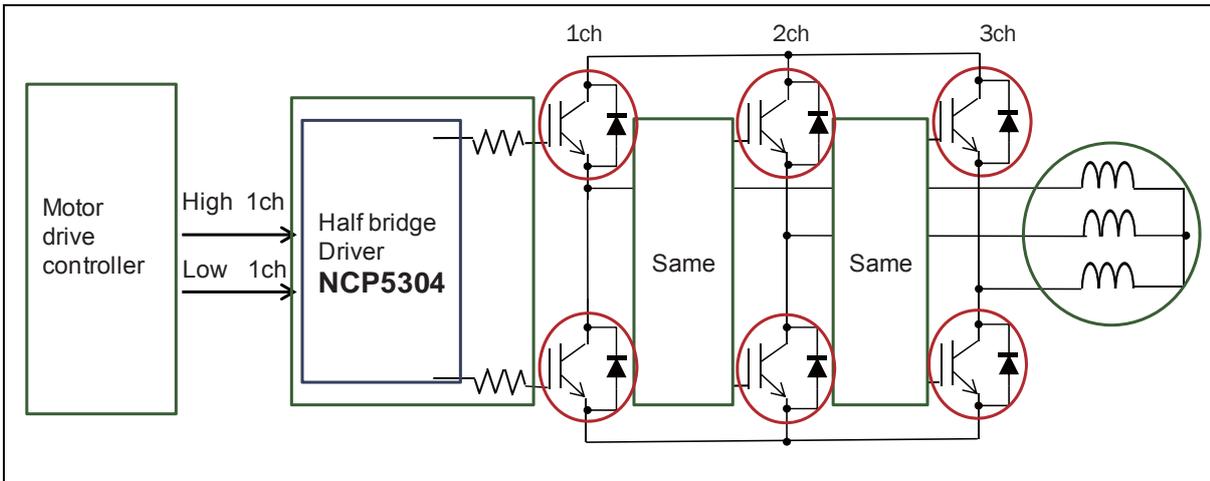


Fig.3 Operation Circuit block

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