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NGTB05N60R2DT4G
RC-IGBT Application Note

For Refrigerator compressor, fan motor

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1. At the beginning

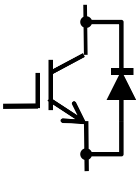
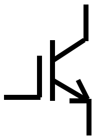
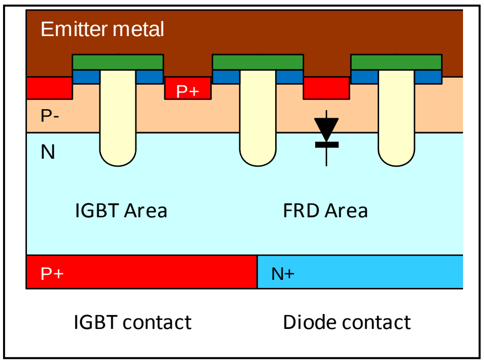
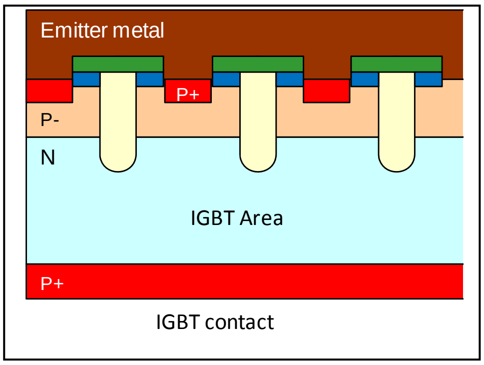
RC-IGBT is the abbreviation of Reverse Conducting Insulated Gate Bipolar Transistor, which is an IGBT that incorporates FWD into one chip.
Like inverter circuit, the needed IGBT and FWD are housed in one chip; this enables package downsizing and thermal balance.
This paper introduces the operation application 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.

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 trr<75ns 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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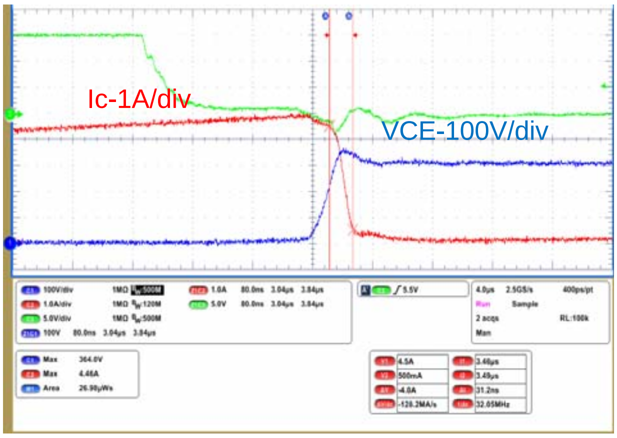
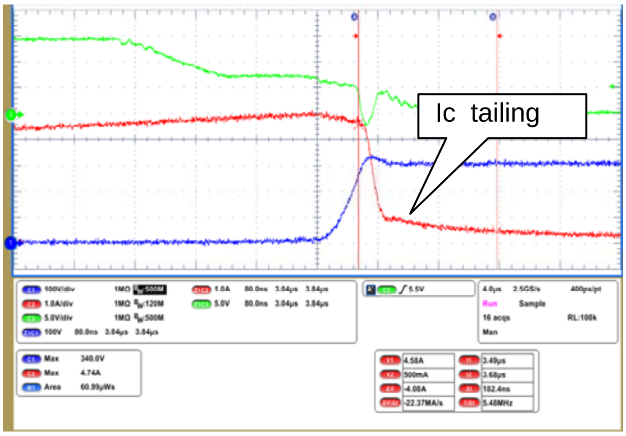
3. High-speed SW performance of RC2-IGBT

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



WP.1 FS2-IGBT Ic=5A tf=31.2ns



WP.2 NPT-IGBT Ic=5A tf=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, Ic rating ranges from Ic=4.5A (NGTB03N60R2DT4G) to Ic=10A (NGTB10N60R2DT4G).

Table.2 RC2-IGBT Lineup

Type No.	Package	Absolute maximum ratings				Electrical characteristics /Ta=25°C	FRD Electrical Characteristics /	
		VCES	IC @Tc= 25°C	IC @Tc= 100°C	ICP @Tc= 25°C	VCE(sat) typ	VF typ	trr typ
		[V]	[A]	[A]	[A]	[V]	[V]	[ns]
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=Ic(Tc=100°C). VR=300V, di/dt=300A/µs

5. Application Map of RC-IGBT

The application map centers with NGBT03N60R2DT4G in DPAK package. (Fig.1)

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

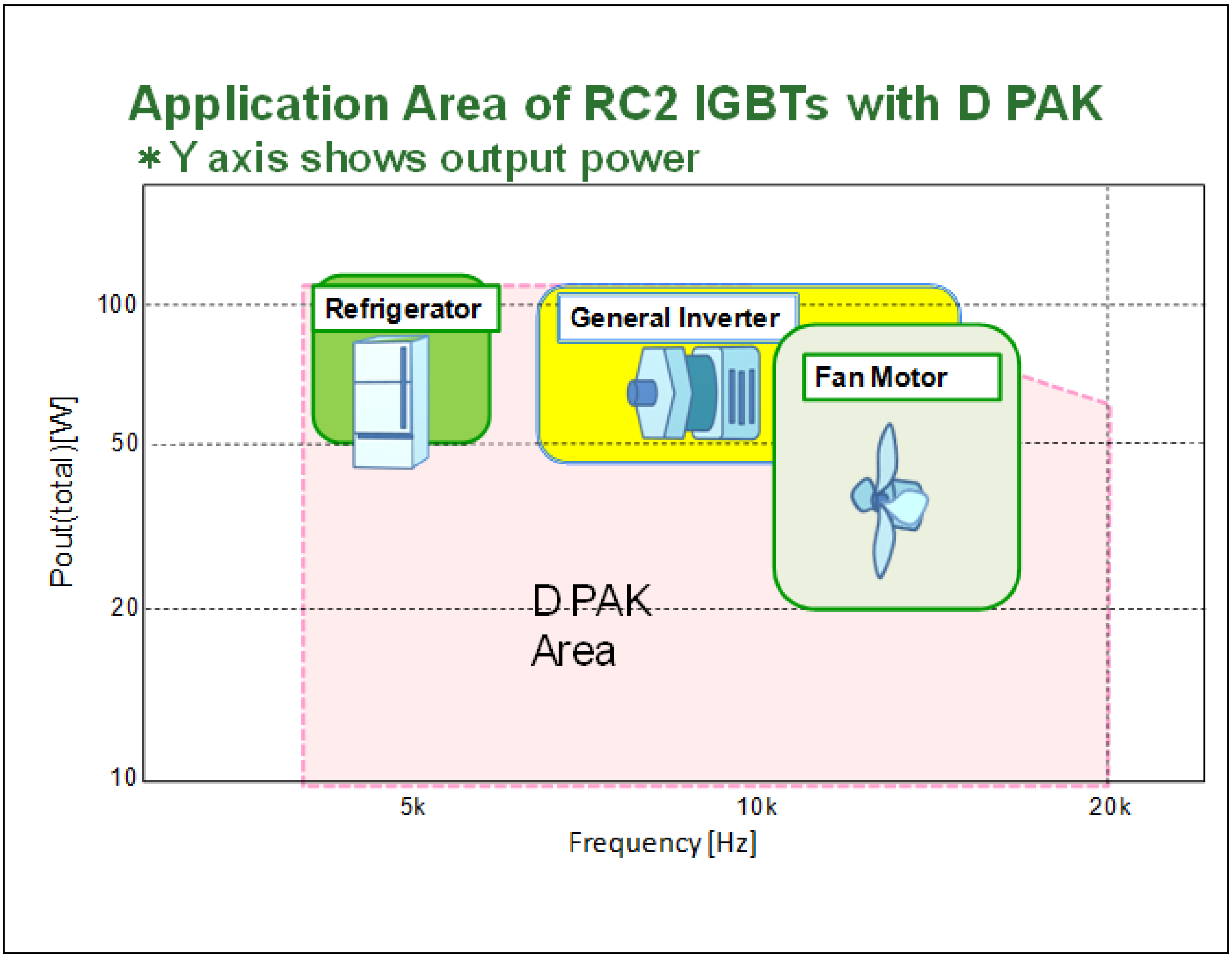


Fig.1 Application area of RC-IGBT (D PAK)

6. Operation in BLDC motor

6-1) DC rating comparison with competitors

Table.2 shows DC rating comparison with competitor's IGBT used in refrigerator compressor. Both NGTB03N60R2DT4G and 05N60R2DT4G have lower VCE(sat) than A IGBT does, which enable conduction loss reduction.

Table.2 DC Spec. Comparison

	Ic[A] @Tc=100°C	VCE(sat) typ [V]	VF typ [V]
NGTB03N60R2DT4G	4.5	1.7(3A)	1.5(3A)
NGTB05N60R2DT4G	8.0	1.65(5A)	1.5(5A)
A IGBT	4.2	1.9(3A)	1.9(3A)

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, fc=6.8kHz). Operation temp. of each IGBT mounted on PCB is measured. Like the above-stated DC rating, compared with IGBT A, NGTB03N60R2DT4G and 05N60R2 with low VCE(sat) showed decreased temp. Photo.1 shows the condition of the device mounted on board and the board for operation review (a part).

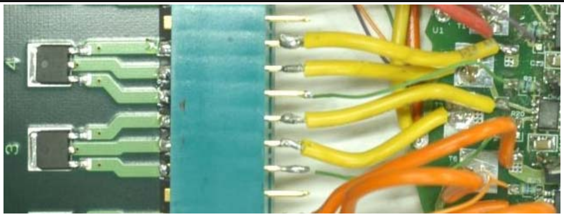


Photo.1 Board for operation review (a part)

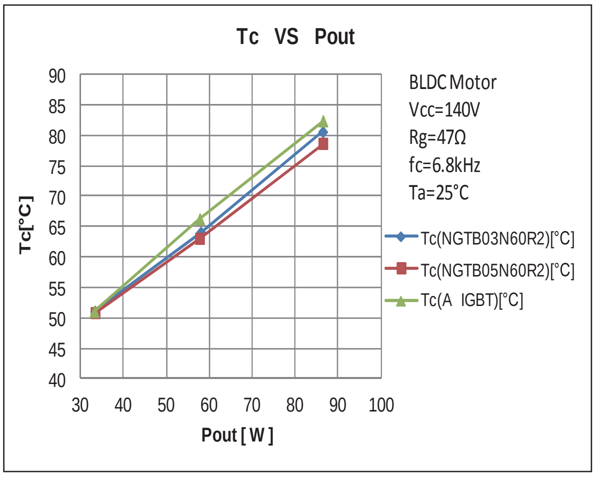


Fig.2 Operation characteristic Tc VS Ic

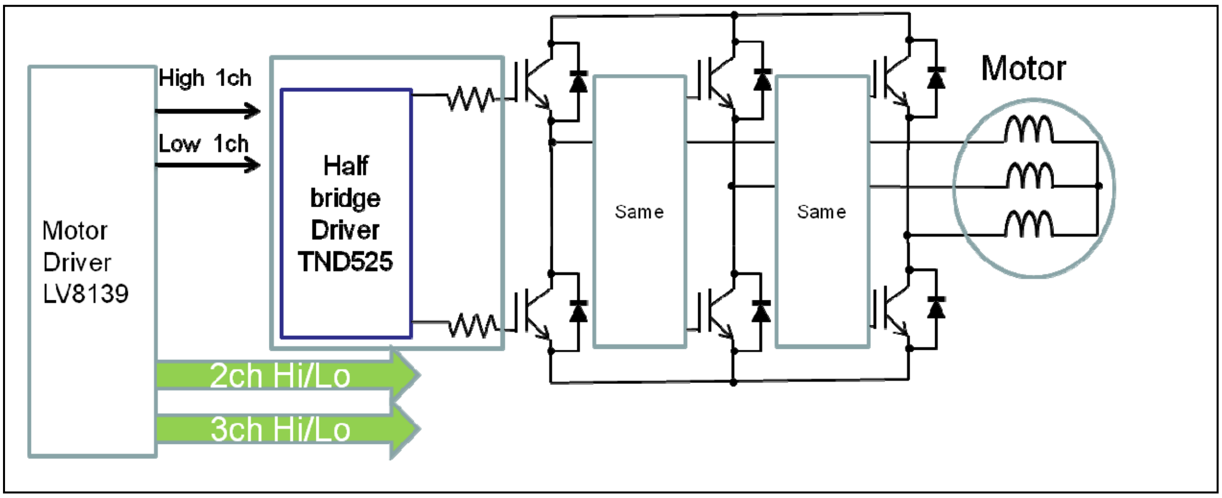


Fig.3 Operation Circuit block

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