NGTB15N60R2FG

RC-IGBT Application : Inverter, Fan motor

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1. At the beginning

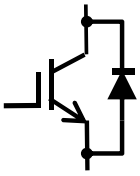
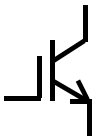
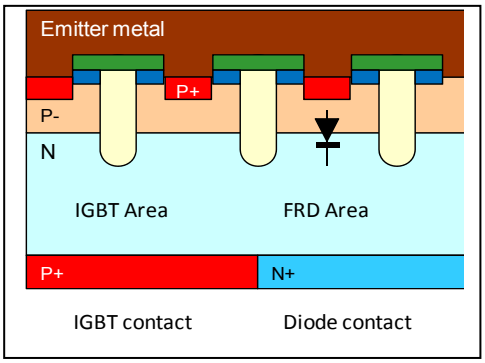
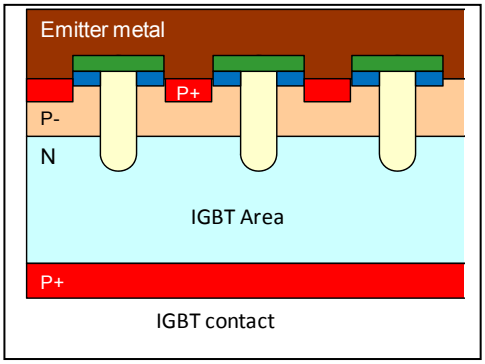
RC-IGBT is the abbreviation of Reverse Conducting Insulated Gate Bipolar Transistor, which is an IGBT that incorporates FWD into one chip.
Like inverter circuit, the needed IGBT and FWD are built into one chip; this enables package downsizing and thermal balance.

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<95ns and high-speed switching performance. Furthermore, RC-IGBT adopts our original FS2 structure; this process is called RC2-IGBT.

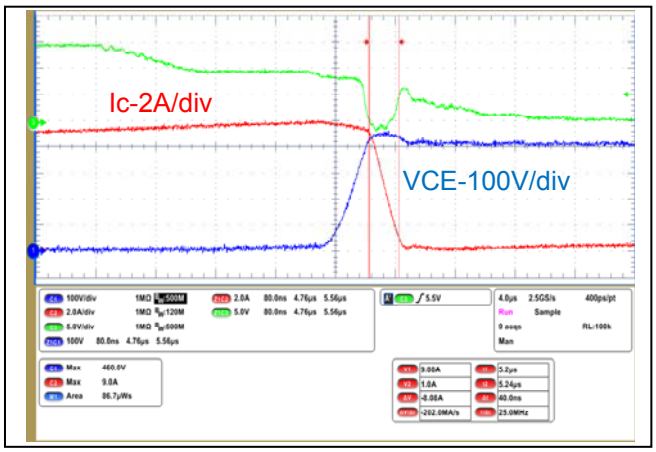
Table.1 Structural comparison between RC-IGBT and IGBT

	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)		

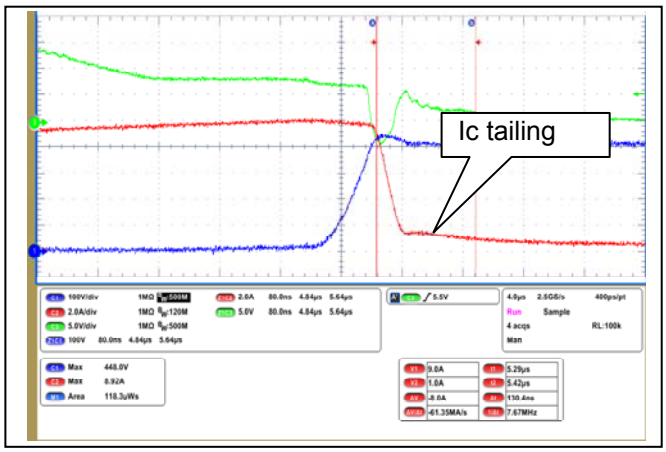
3. RC2-IGBT high-speed SW performance

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.

We compared the operation waveforms of 15A spec. devices (see WP.1 & 2). WP.1 is tf waveform of RC2-IGBT of 15A, while WP.2 is NPT-IGBT of 15A. It is clear that the operation of WP.1 realized high-speed and no tf tailing.



WP.1 FS2-IGBT Ic=10A, tf=40nS



WP.2 NPT-IGBT Ic=10A, tf=120nS

4. Products lineup of RC2-IGBT

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).
In addition, NGTB15N60R2FG in TO-220F package is the device with the largest current of the series.

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

Fig.1 shows the application map. NGTB15N60R2FG in TO-220F package can correspond to a wide range of output power, so can be used in various sets.
when speeds up, RDS(on) becomes higher, the limit of the speeding-up is low.

In addition, NGTB03N60R2DT4G, 05N60R2, 10N60R2 in DPak are compact, which are optimal for refrigerator or fan motors of a high operation frequency (15kHz).

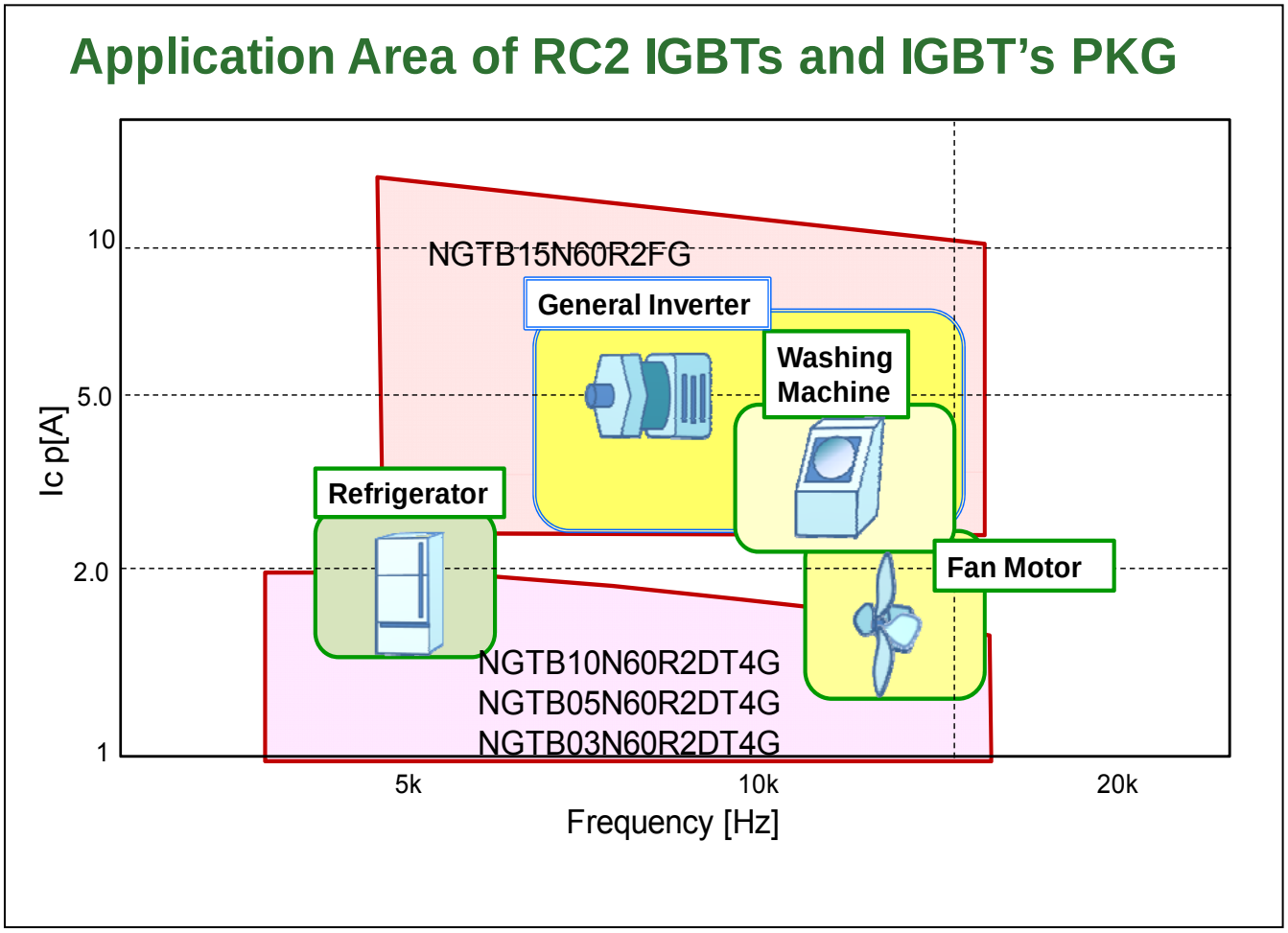


Fig.1 Application Area of RC-IGBT

6. Operation with BLDC motor

6-1) MOSFET with FRD vs. Diode

In small-output inverter fan, MOSFET with built-in FRD (Fast Recovery Diode) is always a competitor as output device. Because the diode of the MOSFET with FRD is parasitic diode generated to MOSFET structurally, trr speeding-up of the parasitic diode becomes necessary. What happens is that, for MOSFET,

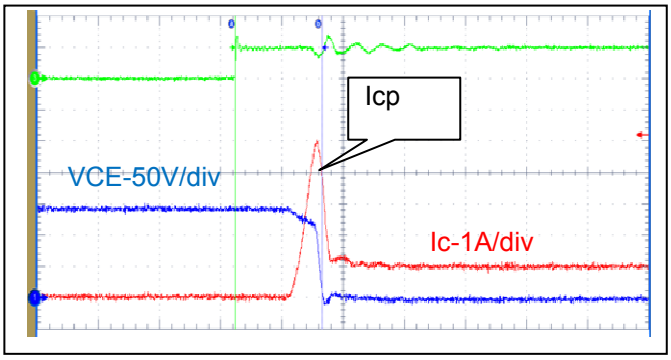
By contrast, for RC-IGBT, because IGBT part conductivity modulates, such impact is low, so that trr can be further improved. For example (see Table.3), when comparing with BFL4007 (MOSFET with FRD built in), although the values of trr are the same in the spec., differences in trr as well as in operation characteristic occur in actual operation.
See 6-2 for reference.

Table.3 IGBT vs. MOSFET in key parameters

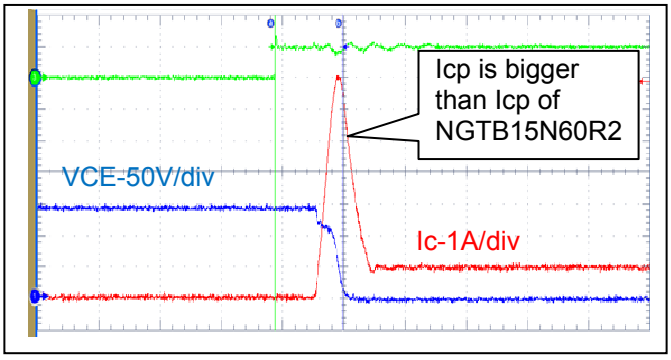
	NGTB15N60R2FG	BFL4007
VCES(VDSS) [V]	600	500
Ic(ID)[A]	15	14
VCE(sat)[V]	1.4(Ic=15A)	—
RDS(on)[Ω]	—	0.52(ID=7.0A)
trr[nS]	95(IF=15A)	95(IF=14A)

When comparing the operation waveforms (high-side), we observed Icp at the current rise of the MOSFET was large (WP.1 vs. WP.2). For example (see Table.3), when comparing with BFL4007 (MOSFET with FRD built in), although the values of trr are the same in the spec., differences in trr as well as in operation characteristic occur in actual operation. It is considered, in case of MOSFET, attention due to the current noise is necessary.

6-2). Behavior comparison
With the circuit composition of Fig.2, under the heatsink-less condition for both RC-IGBT and MOSFET, we drove the 3-phase BLDC motor with comparatively low output, and compared the operations. (120°PWM operation, fc=15kHz).



WP.1 NGTB15N60R2FG Pout=80W
Icp=5.0A



WP.2 BFL4007 Pout=80W
Icp=7.0A

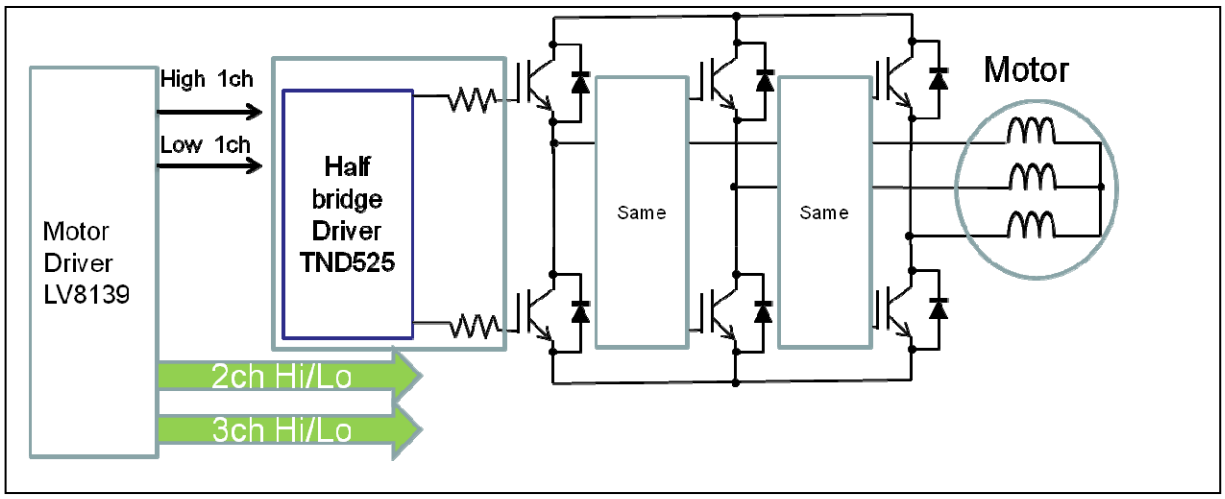


Fig.2 Operation circuit block