IGBT

Alternative proposal for RC-IGBT

About this document

This document will discuss the basics of the differential IGBT and the RC-IGBT.

Target Device

IGBT + FRD & RC-IGBT

Contents

1. Introduction

1.1 Insulated Gate Bipolar Transistors (IGBT) with Fast Recovery Diode (FRD)

Insulated Gate Bipolar Transistor (IGBT) are switching components that combine the advantages of both MOSFET and bipolar junction transistor (BJT). They have high switching speeds and low conduction losses, making them ideal for applications requiring high-power/high-current handling and fast switching capabilities. Fast Recovery Diode (FRD) are commonly used alongside IGBTs to manage the reverse recovery characteristics in switching operations. Their rapid switching capabilities complement the IGBT's performance, reducing switching losses and improving overall efficiency.

1.1.1 Advantages and application

There are several advantages to using FRDs in combination with IGBTs. FRDs are known for their shorter recovery time (trr) compared to standard diodes. This faster recovery time helps reduce overlap losses during switching periods when both the IGBT and diode conduct simultaneously. Additionally, FRDs have lower reverse recovery charge, which further contributes to improved efficiency in power electronic circuits. By minimizing overlap losses and improving switching efficiency, FRDs enhance the overall performance and reliability of systems using IGBTs.

IGBTs with FRDs are commonly employed in medium to high power inverters used in industries such as renewable energy systems (like solar and wind), industrial motor drives, uninterruptible power supplies (UPS), and electric vehicles. These applications often require inverters with output powers ranging from several hundred watts to multiple megawatts, depending on the specific industrial or consumer needs.

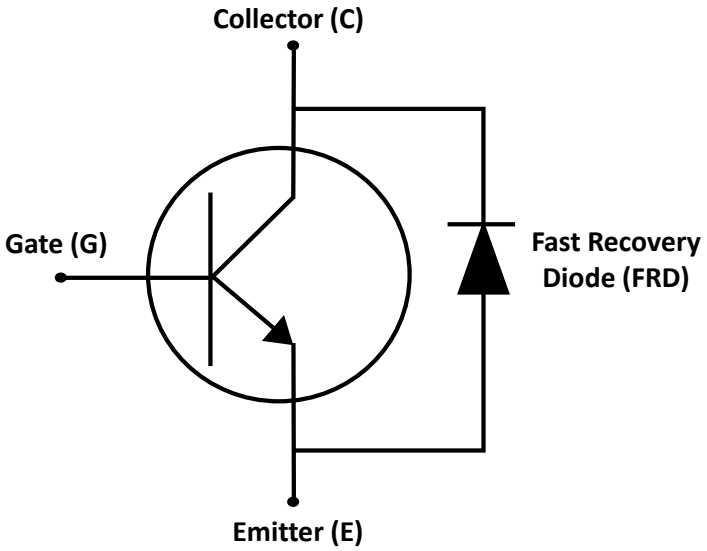


Figure 1-1 IGBT with FRD symbol

1.2 Reverse Conducting IGBT (RC-IGBT)

An RC-IGBT integrates both the IGBT and a freewheeling diode (FWD) on a single chip, ensuring smooth current flow from emitter to collector during operation. When the IGBT is turned off, the FWD connects in anti-parallel, effectively preventing damage by conducting any reverse current caused by inductive loads or components. This integrated design addresses the need for efficient commutation and minimizes power losses in power electronic circuits.

1.2.1 Advantages and application

Integrating the IGBT and RC diode into a single package streamlines circuit design and reduces component count, thereby saving space and enhancing overall system efficiency by minimizing switching losses. The fast recovery time of the RC diode improves commutation performance, ensuring smoother transitions and reducing stress on components. These modules are commonly used in motor drives, inverters, and power supplies, where efficiency, reliability, and compact size are very important.

In motor drives, RC-IGBTs efficiently regulate the speed and torque of electric motors, ensuring precise control and energy efficiency. They are integral components in inverters used for converting DC (Direct Current) to AC (Alternating Current) power, crucial for renewable energy systems like solar and wind inverters, as well as in industrial machinery and grid-tied applications. Their ability to handle high frequencies and fast switching transitions makes RC-IGBTs indispensable in power supplies where stable and efficient power delivery is essential for reliable operation.

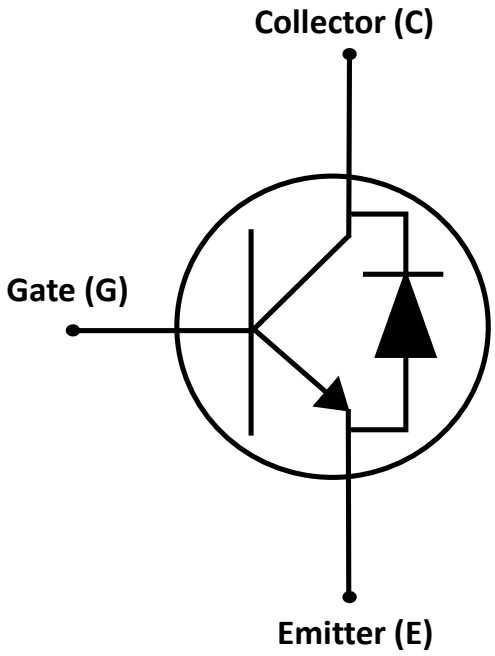


Figure 1-2 RC-IGBT symbol

2. Comparison between IGBT with FRD and RC-IGBT

2.1 Features comparison

On below table mainly to point out the different between both type of IGBT.

Table 2-1 Features comparison

Item	IGBT with FRD	RC-IGBT
Focus on	• Focus on performance of the system	• Focus on size and assembly
Advantages	• Characteristic optimization on each chip • High heat dissipation by the large chip • Support high current / inverter output	• Small chip size • Ease of module assembly
Applicable on INV	• Low to High output (~200kW)	• Low to Mid output (70kW)
Electrical Characteristics	• Can optimize individually for IGBT and FRD	• Switching loss large compared to another.
Process Cost	• Medium	• High

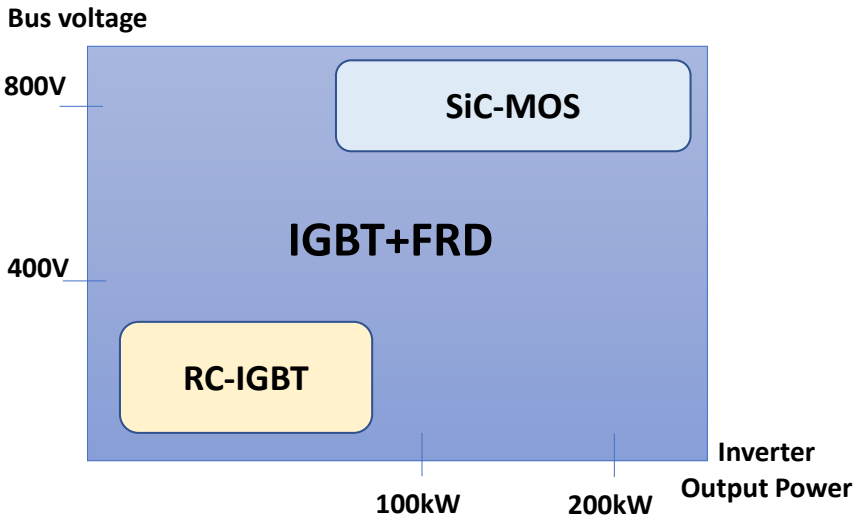
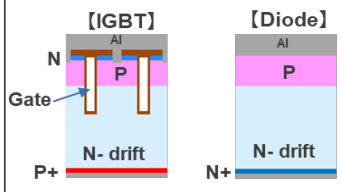
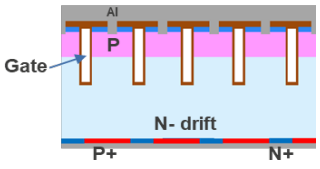
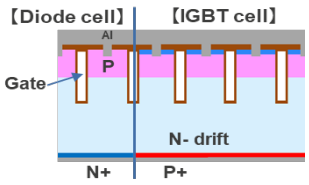


Figure 2-1 Corresponding device for inverter output power

2.2 Structure comparison

On below table mainly point out the structure different between both types of IGBT.

Table 2-2 Structure comparison

Product	Discrete [IGBT+FRD]	RC-IGBT	
		Cell integration	Cell separation
Cell Structure			
Judgement	Simple Design	Most Complex Design	Complex Design
Chip Size	Spacing moderate	Spacing better (~Discrete×80%)	Spacing better (~Discrete×95%)
Wafer Process Cost	Cost lower	Cost moderate	Cost moderate
Electrical Performance	Better Performance	Poor performance	Average Performance
Heat Dissipation	Better Performance	Poor performance	Average Performance
Assembly Cost	Cost higher	Cost lower	Cost lower
Application adaptability	Easily in performance tuning	Difficulty in performance tuning	Difficulty in performance tuning

2.3 Product Lineup

Renesas offers two types of products: IGBTs and fast recovery diodes. Both products come with automotive grade and non-automotive grade.

2.3.1 IGBT – Industrial Grade (GxH Series)

Below is the product line examples for industrial grade of IGBT for 650V and 1250V.

Table 2-3-1-1 Product Lineup for 650V IGBTs

Technology	Series	Application	Features	Frequency
G8H	RBNxxH65T1	Inverter	Fast Switching & Low V_{CE}(sat), No tsc	10kH to 100kHz
G7H	65Sx	Inverter	Low V_{CE}(sat), tsc ≥ 10µs	1kH to 5kHz
G7H	65Dxx	Inverter	Low V_{CE}(sat), tsc ≥ 3µs	10kH to 20kHz
G7H	65T4x	PFC	Fast Switching, No tsc	10kH to 100kHz

**Note: tsc = short-circuit withstand time*

Table 2-3-1-2 Product Lineup for 1250V IGBTs

Technology	Series	Application	Features	Frequency
G8H	RBNxxH125S1	Inverter	Fast Switching & Low V_{CE}(sat), tsc ≥ 10µs	10kH to 50kHz
G7H	1CSxx	Inverter	Low V_{CE}(sat), tsc ≥ 10µs	1kH to 5kHz

**Note: tsc = short-circuit withstand time*

2.3.2 IGBT – Automotive Grade (AE Series)

Below is the product line examples for automotive grade of IGBT for 750V and 1200V.

Table 2-3-2 Product Lineup for 750V and 1250V IGBTs

Technology	Series	Application	Features	Frequency
AE4	RJP6831JWS	xEV	750V, tsc ≥ 6µs	10kH to 100kHz
AE4	RJP1C05JWS	xEV	1250V, tsc ≥ 6µs	1kH to 5kHz
AE5	RBN220N75A5JWS	xEV	750V, tsc ≥ 3.4µs	5kH to 15kHz
AE5	RBN220N75A5PJWS	xEV	750V, tsc ≥ 3.4µs	10kH to 20kHz
AE5	RBN300N75A5JWS	xEV	750V, tsc ≥ 3.4µs	10kH to 100kHz

**Note: tsc = short-circuit withstand time*

2.3.3 Fast Recovery Diode (FRD)

Below is the product lineup examples for the fast recovery diodes (FRDs) offered by Renesas, which can be combined with the IGBTs product line.

Table 2-3-3 Product Lineup for FRD

Type of Grade	Series	Features
Industrial	RJU1CF0xDWA	Fast Recovery Diode
Industrial	RJU60C6x	Fast Recovery Diode
Industrial	RJU65F2xDWA	Fast Recovery Diode
Automotive	RJUxxxxJWS	Diode Chip
Automotive	RBCxx0A75F3JWS	Diode Chip

3. Conclusion

In conclusion, the comparison reveals that the combination of an IGBT with an FRD offers superior performance and advantages over the RC-IGBT. This integrated design merges the benefits of both components, enabling users to optimize characteristics and reduce switching and recovery losses, which enhances overall performance. Furthermore, the IGBT with FRD is particularly well-suited for high-power applications, such as renewable energy systems, industrial motor drives, UPS systems, and electric vehicles, making it a preferred choice in these demanding fields.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Sep.03.24	-	First edition

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