IGBT

Efficiency Improvement on UPS

About this document

This document mainly to discuss about the function types and efficiency improvement of IGBT on UPS system.

Target Device

IGBT: RBN50H65T1FPQ

Contents

1. Introduction

1.1 Overview

An Insulated-gate bipolar transistor (IGBT) is a three-terminal power semiconductor device primarily designed as an electronic switch. It was developed to achieve a balance between high efficiency and fast switching speeds. Combining the advantages of MOSFET and BJT technologies, the IGBT is widely utilized in power supply and motor control circuits. It is particularly well-suited for high voltage and current applications, making it an ideal choice for large-scale power systems.

1.2 IGBT focus application

Renesas aims to contribute to energy management by prioritizing the development of IGBT products across multiple sectors. This includes power generation, transmission, and distribution, as well as energy storage and charging systems.

Renesas solutions cater to the entire energy lifecycle, from renewable energy sources like wind and solar power transmitted through the power grid to advanced technologies such as solid-state transformer (SST), active power filter (APF), and Static Reactive Power Compensators (SVC). Renesas also specialize in energy storage and charging solutions such as uninterruptible power supplies (UPS) and electric vehicle (EV) charging stations.

1.3 Potential application on UPS Inverter

There are several potential applications where IGBT selection methods can be utilized. Here, we will focus on the UPS inverter application. This product lineup features IGBTs with optimal characteristics tailored for inverters and high-frequency applications

1.3.1 UPS Inverter

The UPS (Uninterruptible Power Supply) inverter is designed to monitor power interruptions, overvoltage, undervoltage, and other electrical issues. In the event of any interruption, it swiftly transitions to a backup power source. The inverter converts DC power from the battery into AC power, which is supplied to connected devices or equipment. The figure below illustrates the working principle of a UPS.

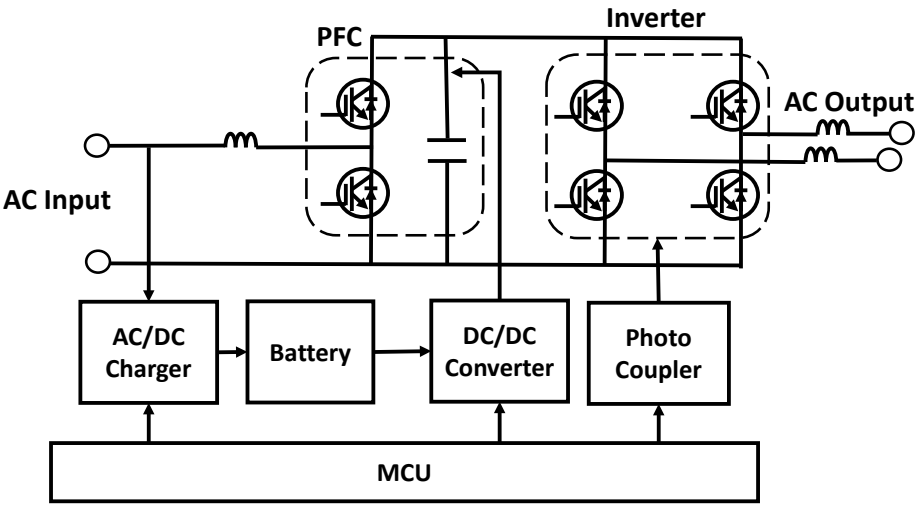


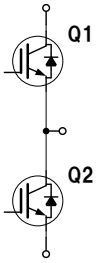
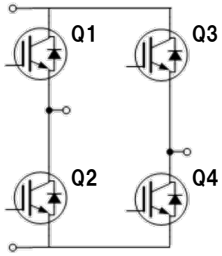
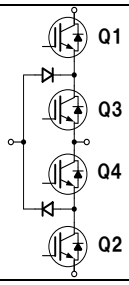
Figure 1-1 UPS Inverter Working principle

1.4 Type of Inverter circuit for UPS

Below are three types of inverter circuit available in the market which's from the conventional until the advanced design.

- Half Bridge
- Full- Bridge
- 3 Level

Table 1-1 Inverter Circuit Types

Item	Inverter Circuit									
	Half-Bridge		Full-Bridge				3 Level			
Topology										
Configuration	Easy		Standard				Difficult			
Efficiency	Standard		Good				Very Good			
IGBT	Q1	Q2	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
VCES	1250	1250	650	650	650	650	650	650	650	650
Required performance	High speed switching		High speed switching Low VCE (sat)				High speed switching Low VCE (sat)		Low *VCE* (sat)	

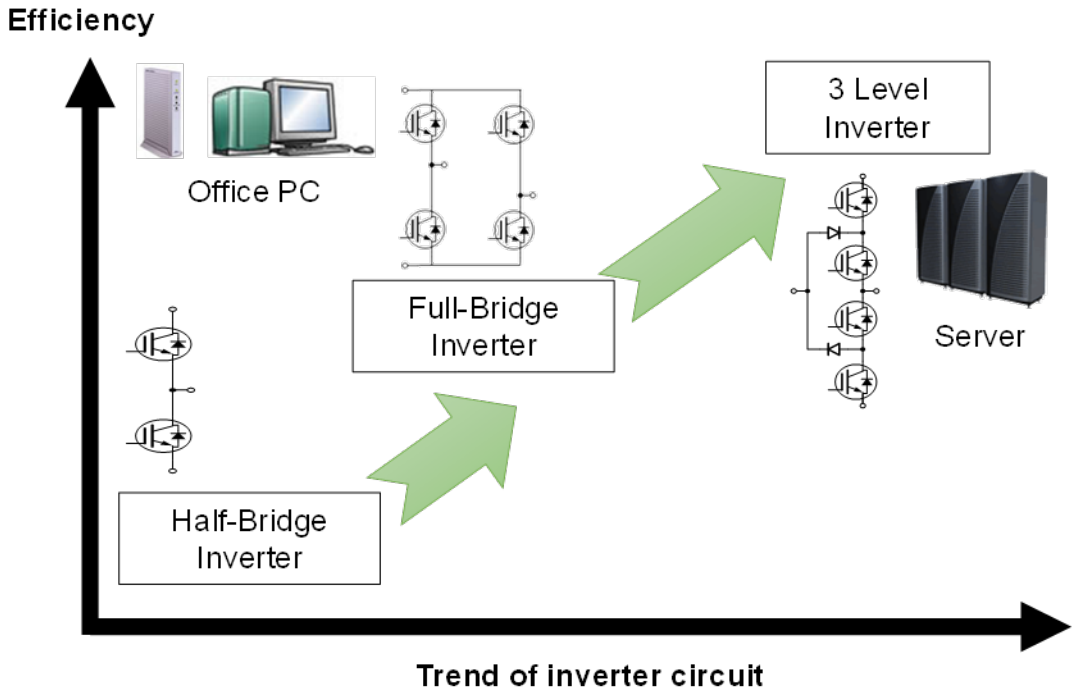


Figure 1-2 Trend of Inverter Circuit

2. IGBT for UPS Inverter

2.1 Introduction

Renesas has improved the process technology for IGBTs to achieve ultra-low loss and high reliability in inverter applications. The advancements include two key technologies:

- **Microfabrication Technology**: This involves a trench field-stop structure that enhances compatibility with low-loss and high-speed switching.
- **Thin Wafer Processing Technology**: This technique uses ultra-thin wafers, as thin as 65 micrometers, to reduce conduction loss.

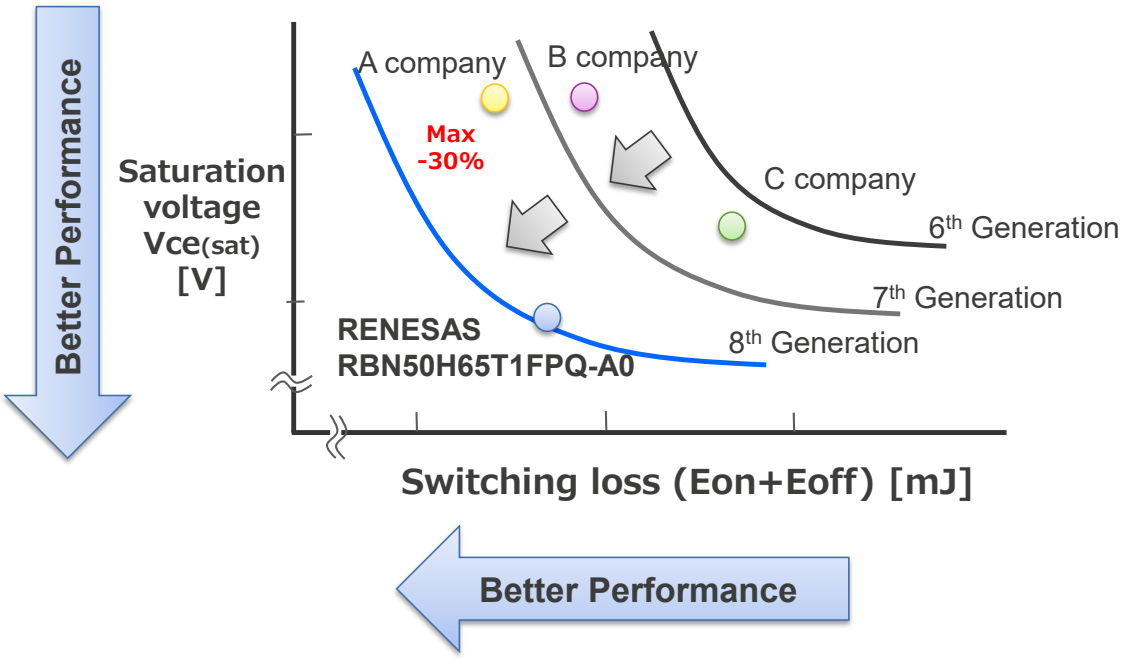


Figure 2-1 IGBT Trend

Benefits of selecting the latest generation of Renesas IGBT products (G8H):

- **Reduced Total Loss**: The G8H is designed to achieve a balanced low loss, which minimizes overall losses in inverter applications.
- **Enhanced Performance under Heavy Load**: With its low Vce(sat) characteristic, the G8H delivers high efficiency even under heavy load conditions.
- **Cost and Size Reduction**: The G8H's low noise and low oscillation characteristics can decrease the need for noise-reducing components and contribute to the miniaturization of the system. This results in a reduction in both the size and cost of the heatsink and other related parts.

2.2 Product selection

The IGBT (RBN50H65T1FPQ) selected for this UPS inverter solution. It has capability of 650V with 50A of power switching.

The main reasons for selecting this IGBT are its features:

- Trench gate and thin wafer technology (G8H series)
- Build in fast recovery diode in one package
- Low collector to emitter saturation voltage VCE (sat) = 1.5V typ. (at IC =50A, VGE = 15V)
- High-frequency switching
- High current 75A single package
- Tjmax = 175 °C
- TO-247 and TO-247 Plus lineup
- Applications: UPS, Welding, photovoltaic inverters, Power converter system

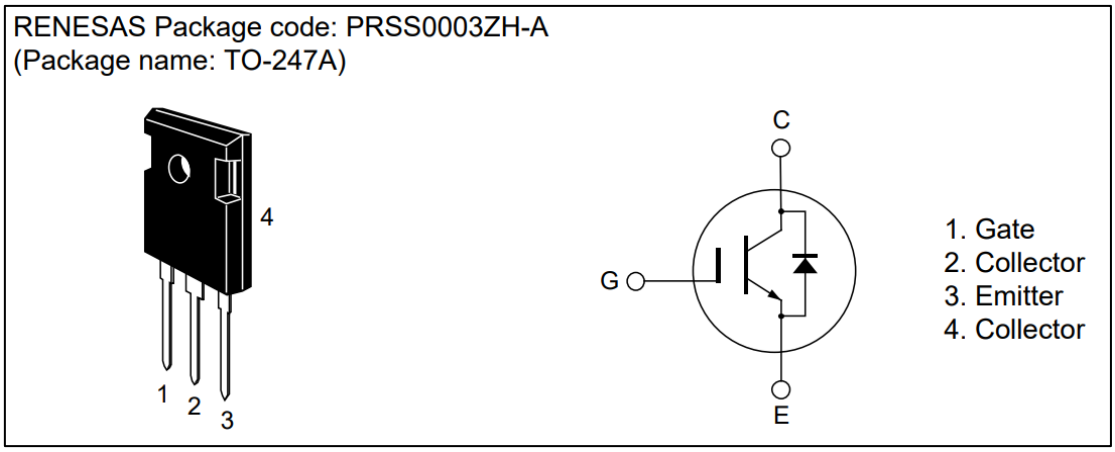


Figure 2-2 RBN50H65T1FPQ IGBT Outline

3. Improvement efficiency in UPS

Renesas has designed an inverter evaluation board for internal product evaluation. It is used to measure the efficiency of the IGBT and to compare its performance with that of other competitor products. The figure below shows the image of the inverter circuit design.

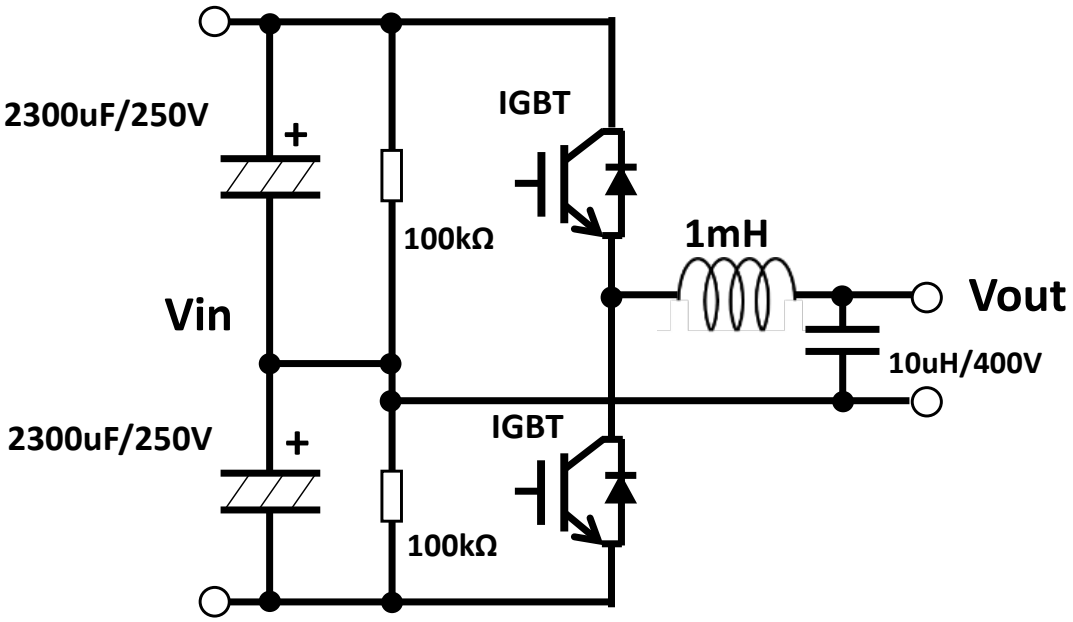


Figure 3-1 Circuit design for the Inverter

3.1 Measurement Result

The graph in the figure compares the efficiency between RBN50H65T1FPQ and a competitor product. The results indicate that Renesas' product (blue line) has better efficiency compared to the competitor (red line) after reaching an output power of 1.5kW.

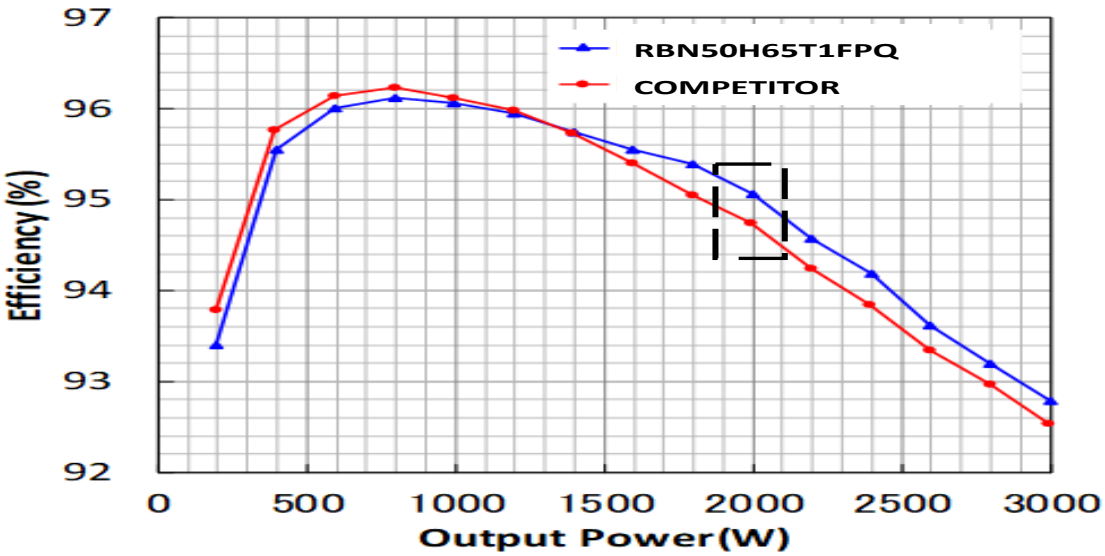


Figure 3-2 Output Power versus Efficiency Change

The graph below plots data comparing conduction loss and switching loss, specifically capture at 2kW output power. It illustrates that Renesas' product outperforms the competitor in both conduction and switching losses. Renesas' IGBTs exhibit low on-state resistance, enabling better thermal performance control to improve the energy efficiency and minimized power losses. These features make Renesas IGBTs particularly suitable for high-power applications.

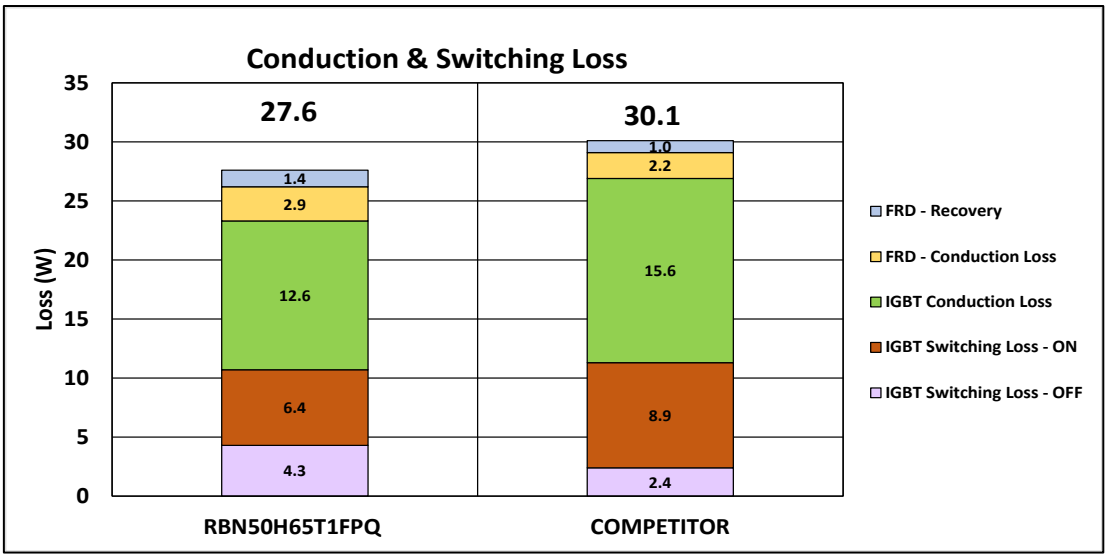


Figure 3-3 Conduction & Switching Loss Comparison

The graph below plots data comparing the noise characteristic comparison, specifically capture at 2kW output power. It illustrates that Renesas' product has lower noise compared to competitor.

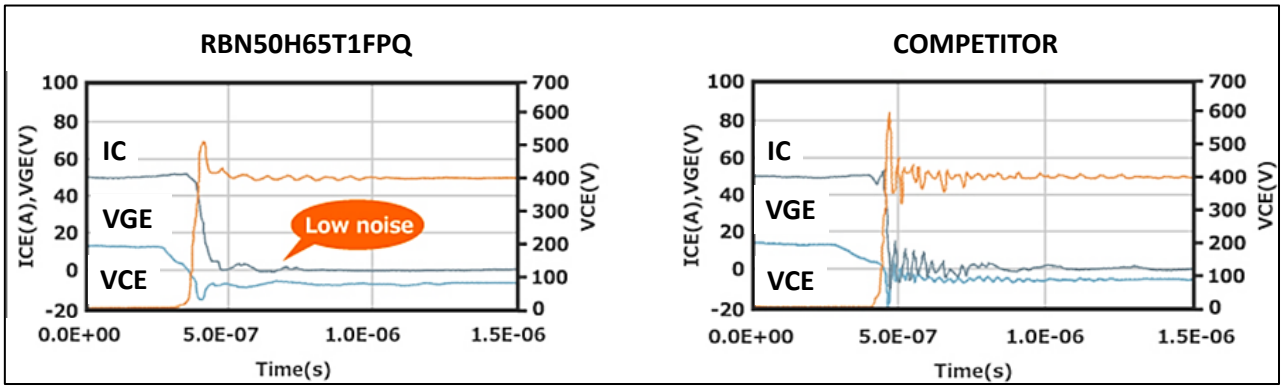


Figure 3-4 Noise Characteristic Comparison

3.2 Others

Below is Renesas product list with different ratings in the package TO-247 and TO-247-Plus.

Table 3-1 Model list for the G8H series of IGBTs

Model	V_{CES} [V]	V_{GES} [V]	IC [A] @100 °C	V_{CE} (sat) [V] @V_{GE} =15V	T_{SC} [us]	Package
RBN40H65T1FPQ	650	±30	40	1.5	-	TO-247
RBN50H65T1FPQ	650	±30	50	1.5	-	TO-247
RBN75H65T1FPQ	650	±30	75	1.5	-	TO-247
RBN25H125S1FPQ	1250	±30	20	1.8	10	TO-247
RBN40H125S1FPQ	1250	±30	40	1.8	10	TO-247
RBN75H125S1FP4	1250	±30	75	1.8	10	TO-247 Plus

4. Conclusion

From the product evaluation for comparison, it can be observed that Renesas' product offers better switching performance and less ringing noise compared to others. Additionally, at high output power ranges (1.5kW to 3.0kW), Renesas' TO-247 package also provides superior power efficiency. This is attributed to the product's design characteristics such as low loss VCE (sat), high-frequency switching, and integrated FRD.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Aug.05.24	-	First edition

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