RJH65T46DPQ

Efficiency Improvement on PFC Circuits

Overview

This application note mainly discusses the Power Factor Correction (PFC) function and the improvement with the IGBT device - RJH65T46DPQ to compare with competitor product.

Target Device

IGBT: RJH65T46DPQ

Contents

1. Introduction

Power factor measures how efficiently electrical power is used, calculated as the ratio of real power (output) to apparent power (supplied). Power factor correction improves this ratio by adjusting the phase relationship between voltage and current, thereby reducing reactive power and enhancing energy efficiency. There are two main types of PFC: passive PFC and active PFC.

2. Passive Power Factor Collection

2.1 Introduction

Passive Power Factor Correction (PFC) consists of passive components and is a method used to enhance the efficiency of electrical devices by regulating how electricity flows through them. The power factor efficiency typically ranges between 70% and 80%.

This correction method employs a low-pass harmonic filter at the AC input. A capacitor and inductor form a series resonance circuit to filter out the high distortion harmonic waveforms, allowing only the 50 or 60Hz fundamental wave to increase the power factor. Therefore, its simple structure and affordability make it ideal for low-power applications, typically used in small power supplies of about 100W or less. However, this method also comes with disadvantages such as requiring a large filter size, heavy weight design, and lower efficiency compared to others design.

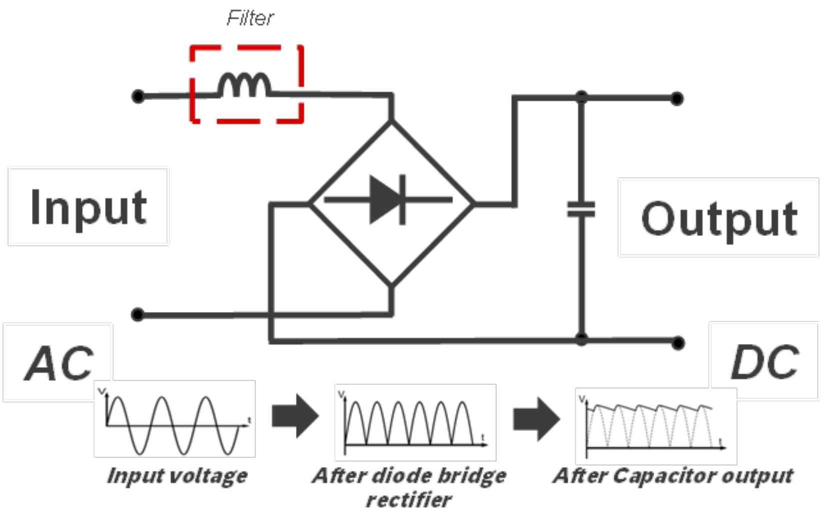

Figure 2-1 Passive Power Factor Correction

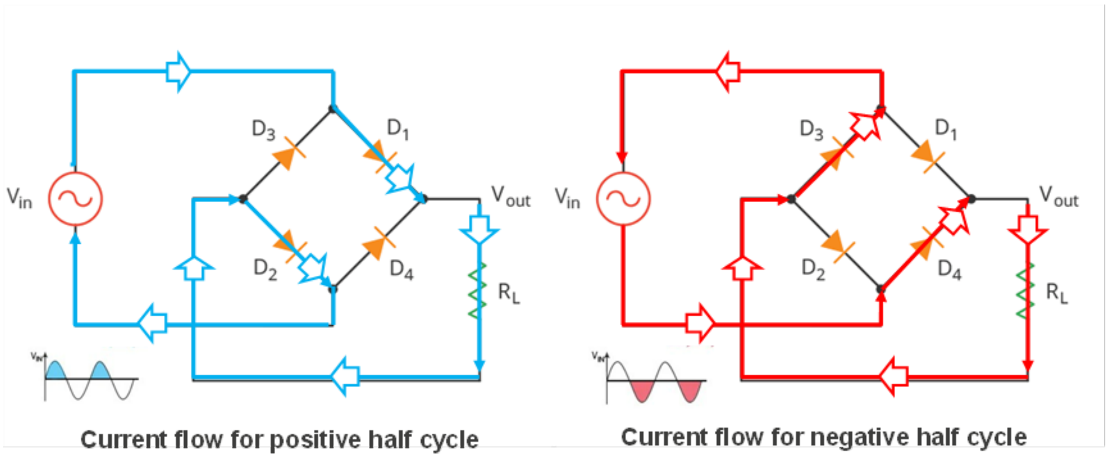

Figure 2-2 Current flow in Full Bridge rectifier

The illustration above shows the input voltage flow through the diode bridge circuit configuration, which controls full-wave AC voltage by allowing only positive voltage to pass through the rectifier.

2.2 Application

The passive PFC is utilized in various low-power applications which's below 100W, spanning low-power electronics, small household appliances, and basic electronic devices.

- Lower power electronics benefit from efficient power management, enhancing devices like chargers and adapters.
- Small household appliances such as coffee makers and hair dryers benefit from passive PFC without needing high power.
- Basic electronic devices like LED lights, small fans, and radios prioritize cost-effectiveness and simplicity, making Partial switching PFC an ideal choice.

3. Active Power Factor Correction

3.1 Introduction

Active Power Factor Correction (PFC), also known as full-switching PFC, utilizes a switching converter to modulate the distorted waveform and this helps improve power efficiency and quality by optimizing electrical systems. This is achieved through rapid switching of components such as transistors or MOSFETs, adjusting incoming AC voltage, and shaping current waveforms. It enables the power factor value to reach above 90%, and in specific designs, it can even achieve 99.99%. Active PFC can detect input voltages of 110V and 240V AC, resulting in smaller dimensions and weight compared to passive PFC for high-power applications.

This technology improves power factor, enhances efficiency by minimizing energy wastage and heat generation, and mitigates harmonic distortions, ensuring more effective use of electrical power and higher quality in electrical networks and devices. A boost converter as below figure is the most widely used circuit for these applications. The simplest boost converter consists of an inductor, a transistor, and a diode.

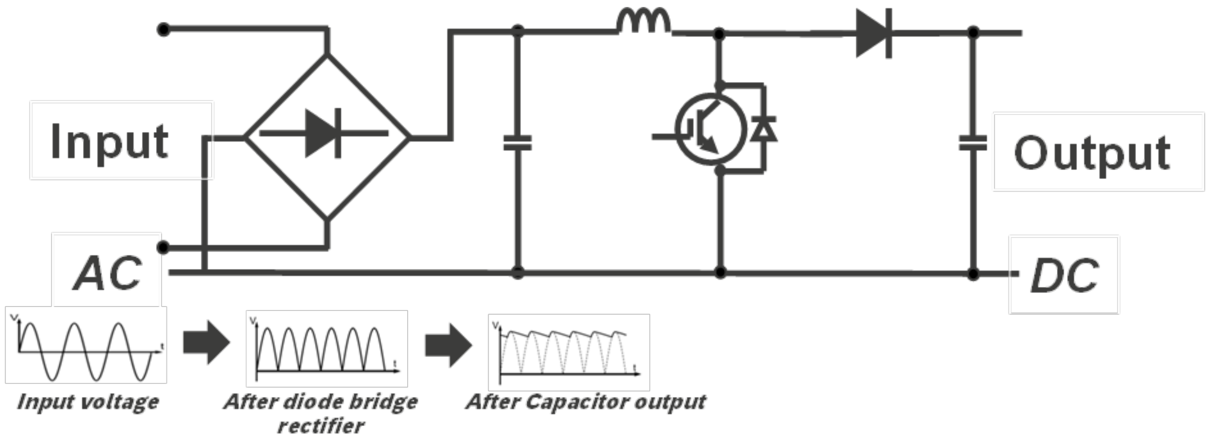

Figure 3-1 Active Power Factor Correction with switching

3.2 Application

Full switching power factor correction (PFC) is typically used in applications where maintaining a high-power efficient operation and compliance with power quality standards. Some common applications include:

- Industrial Motor Drives: Ensures efficient operation of large motors and reduces energy losses.
- Data Centers: Optimizes power usage of servers and equipment for reliable operation.
- Telecommunications: Maintains efficiency and power quality in communication systems.
- Consumer Electronics: Meets regulatory standards and improves energy efficiency in devices like computers and TVs.
- Renewable Energy Systems: Ensures smooth integration of solar and wind power systems with the grid.
- Electric Vehicle Chargers: Provides efficient charging and compliance with grid standards.

3.3 Interleaved Power Factor Correction

Interleaved Power Factor Correction (PFC) represents a more advanced and efficient alternative compared to traditional boost-type PFC systems. In this topology, two IGBTs work in tandem to emulate the functionality of a boost converter. This configuration not only enhances power efficiency by minimizing energy losses but also significantly reduces current ripple, thereby stabilizing fluctuating currents and mitigating harmonic distortions.

The integration of interleaved PFC is particularly beneficial in high-power applications where reliability and energy efficiency are paramount. By synchronizing the operation of multiple power stages, this method ensures smoother power delivery and superior performance across industrial machinery, telecommunications equipment, and server farms.

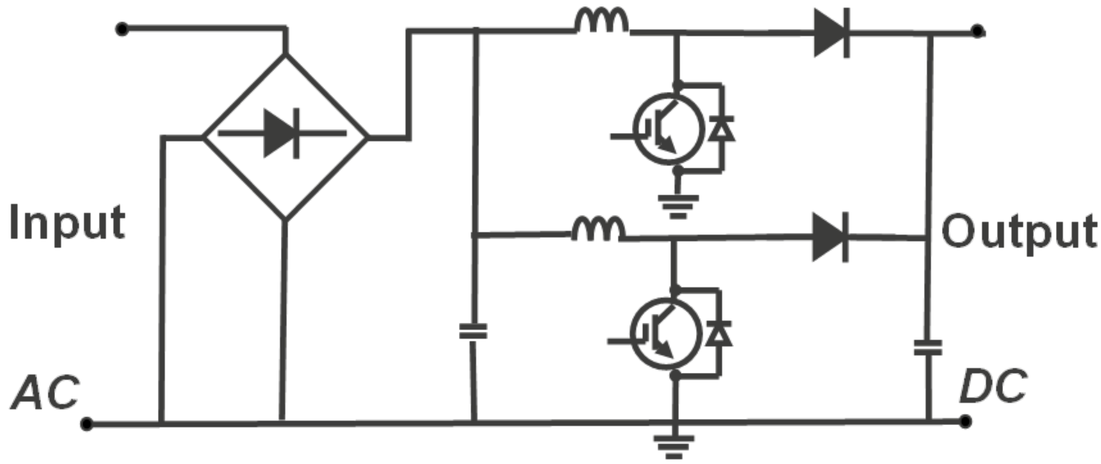

Figure 3-2 Interleaved Power Factor Correction

4. Result Measurement

4.1 Evaluation Method

Renesas has designed an evaluation board featuring an Interleaved PFC circuit for product internal evaluation. The board is primarily used to measure and compare the switching losses (ON/OFF) and conduction losses against competitor products during development.

4.2 Measurement Result

The graph in the figure below compares the efficiency of RJH65T46DPQ with a competitor product having similar specifications and power ratings. The results show that Renesas' product (blue line) achieves higher efficiency compared to the competitor (green line).

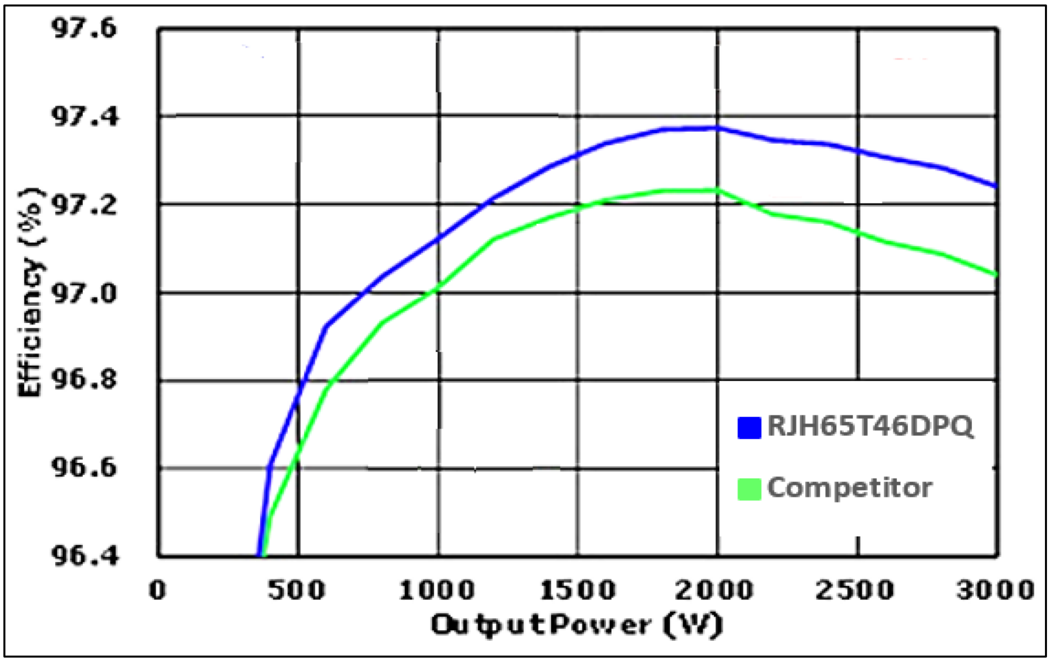

Figure 4-1 Output Power versus Efficiency Change

The graph below shows the switching (ON/OFF) and conduction losses. From the graph, it is evident that the RJH65T46DPQ manages losses better, at approximately 19 watts, compared to the competitor's 23 watts. This represents a 17% improvement over the competitor.
The improvement in the evaluation is attributed to its lower VCE(SAT) of typically 1.8V and a good trr (100ns) due to the integrated FRD in the RJH65T46DPQ.

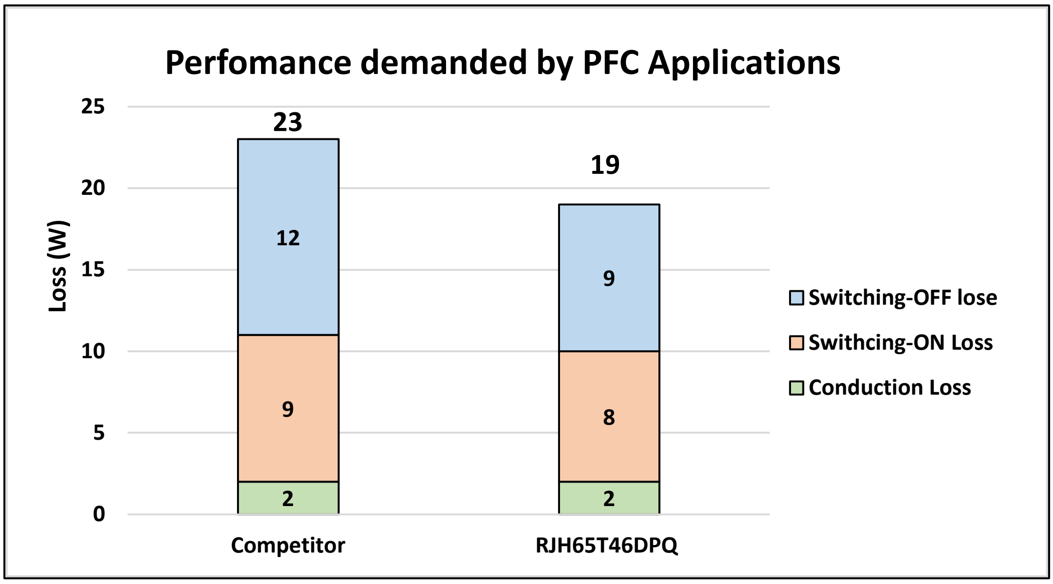

Figure 4-2 Performance demanded by PFC Applications

5. IGBT Introduction

The IGBT (RJH65T46DPQ) has been selected as the core component for this Power Factor Correction (PFC) circuit solution. With a voltage capability of 650V and a power switching capacity of 40A, this IGBT is specifically designed for PFC applications, ensuring efficient power conversion and improved power factor.

The RJH65T46DPQ IGBT is ideally suited for Power Factor Correction (PFC) circuits as:

- Trench gate and thin wafer technology (G7H series)
- Build in fast recovery diode in one package
- Low collector to emitter saturation voltage VCE (sat) = 1.8V typ. (at IC =40A, VGE = 15V)
- High speed switching
- Operation frequency (20kHz ≤ f < 100kHz)

Applicable applications include air conditioner outdoor units, industrial machinery, power supplies, and renewable energy systems

5.1 IGBT Outline

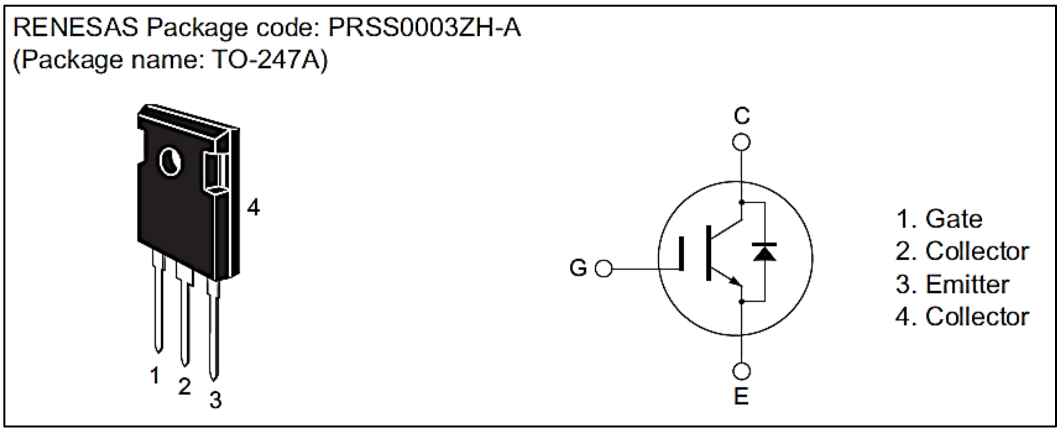

Figure 5-1 RJH65T46DPQ IGBT Outline

Note: The details of the IGBT can refer to datasheet at Renesas webpage.

6. Conclusion

In conclusion, Interleaved PFC offers superior performance and is well-suited for large power applications. It enhances power efficiency by reducing current ripple and switching losses. Renesas has conducted simulations using the interleaved PFC circuit board, demonstrating significant improvements in switching losses. This allows users to make more informed choices when selecting IGBT products.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Jul.24.24	-	First edition

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