



Vincotech

GET MORE OUT OF YOUR HEAT PUMP WITH VINCOTECH

EMPOWERING YOUR IDEAS



Contents

1	Abstract	2
2	Introduction	2
3	Efficiency gains that add up over a lifetime	2
4	Delivering high functional integration and power density	3
5	The unique features of our 600V <i>flow</i> PIM + PFC family	3
6	A new era starts now with the PIM + 3-ph PFC product family	5
7	A one-stop solution provider	7

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Get more out of your heat pump with Vincotech

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1 Abstract

High functional integration and power density are at the foundation of our energy-efficient, cost-effective power modules for motor drives tailored to the needs of advanced heat pump solutions.

2 Introduction

Heat pumps are in the spotlight these days, for good reasons. They dramatically increase the energy efficiency of indoor heating, cooling, and hot water production. This allows them to contribute to meeting growing demand for renewable energy sources and curb global CO2 emissions. And, thanks to their high efficiency and the availability of government subsidies promoting sustainable heating and cooling technologies, they have become a smart investment that pays for itself.

It's no wonder that heat pumps are already the most popular form of heating in Europe's residential buildings, accounting for almost 80% of renewable energy systems deployed on the continent. Around the world, they are finding their way into the heating infrastructure of shopping centers, logistics centers, and other commercial buildings, driven, for instance, by the Chinese government's "Coal to Electricity" program, promoting a shift from coal-based to electrical heating systems in the colder parts of China.

3 Efficiency gains that add up over a lifetime

Unlike conventional heating systems that produce heat through combustion, heat pumps work by extracting heat from a source – the outdoor air, or underground – and transferring it to a desired destination. To do so, they rely on several mechanical components. These include a compressor, a condenser, an expansion valve, and an evaporator.

Operating continuously throughout the system's lifetime, the compressor makes up for most of the system's power demand. As a result, even small improvements to its efficiency add up, resulting in considerable energy and carbon emissions savings. Fortunately, there continue to be underexploited avenues that promise efficiency gains by the compressor.



For one, heat pumps require reliable power modules that convert all the power they receive into performance. This makes active power factor correction an indispensable feature in these applications. Additionally, today's heat pumps often feature a motor inverter capable of controlling their output to maximize both efficiency and comfort. Vincotech, we've been leading the market for products that integrate both of these functionalities into one module for the past 15 years.

4 Delivering high functional integration and power density

Vincotech solutions are designed to deliver high functional integration and power density, enabling the design of cost-effective embedded systems. Their high level of integration lets system engineers take advantage of a proven combination of power components and gate drive circuits to develop more compact final products. And because Vincotech's modules integrate multiple functionalities into a single package, they cut the development time of new drives, dramatically reducing costs at a system level and time to market.

Drawing on our vast experience and know-how in developing power modules with power factor correction and a motor inverter, Vincotech has developed a power-efficient, cost-effective product portfolio specifically tailored to the needs of today's heat pump applications. Designed around key constraints identified by the customers, the modules offer an optimal solution combining multiple innovative technologies that all aim to increase the degree of integration:

- Thick-film technology for intelligent power modules
- Power-integrated modules with integrated power factor correction circuits
- Thin ceramic for improved thermal performance

At the same time, Vincotech has been spearheading the trend towards the integration of other key features such as shunt systems, on-board capacitors, and interleaved power factor correction topology that support the complex electrical and thermal design of motor drives.

5 The unique features of our 600V *flowPIM* + PFC family

As we've seen, one of the main goals in the design of heat pump systems is to increase their power density, simply defined as the ratio between the power output and the volume of the system. There are many ways to achieve this:

- Moving towards more compact designs
- Increasing the efficiency of the energy conversion
- Integrating more cost-effective solutions



Vincotech's power-integrated module (PIM) with an interleaved power factor correction (PFC) circuit is a unique and innovative topology for power modules featuring a high level of integration as well as improved energy conversion efficiency.

The interleaved configuration offers several benefits:

- Simplified PCB design
- Higher energy conversion efficiency
- Better heating distribution
- Smaller components on the PCB
- Easier EMI filtering design
- Reduced output RMS current

Designed for power ranges up to 8 kW, Vincotech's 600V *flowPIM* + PFC family comprises three different sub-families featuring a two-leg interleaved PFC circuit, both with and without an integrated input rectifier, and a three-leg interleaved PFC without an input rectifier (see Figure 1).

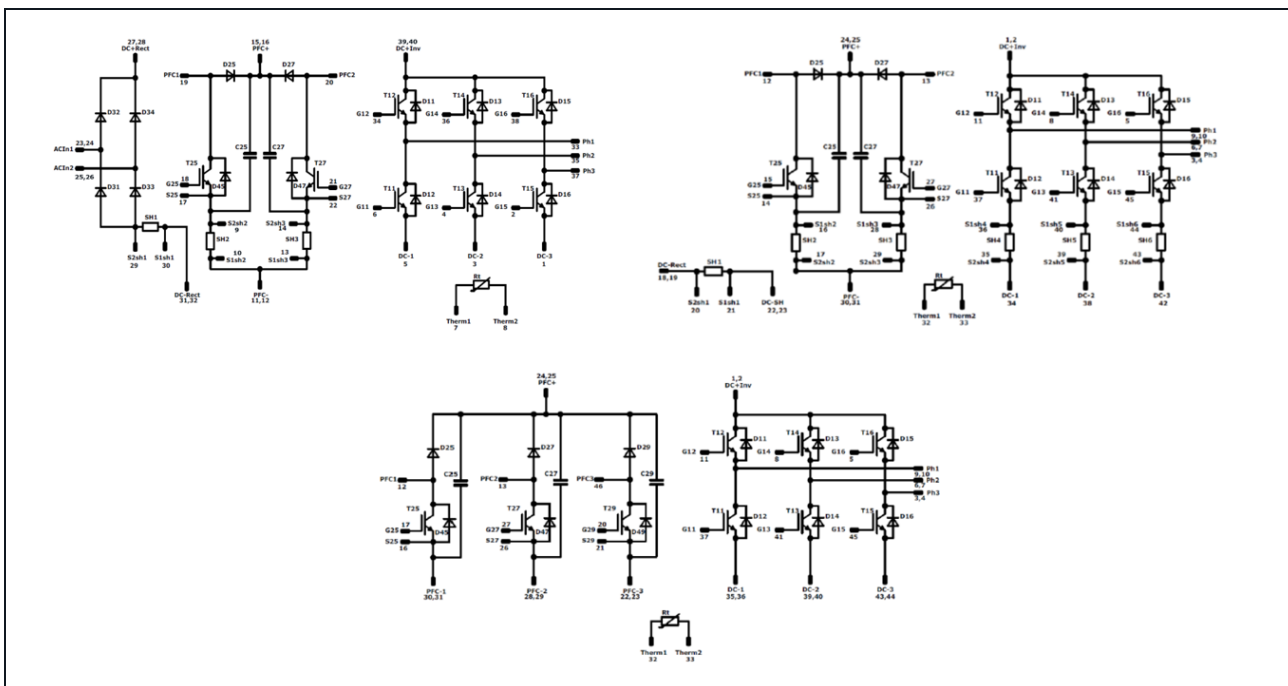


Figure 1: The three sub-families of the Vincotech 600V *flowPIM* + PFC family featuring a two-leg interleaved PFC circuit with and without an integrated input rectifier and a three-leg interleaved PFC without an input rectifier

All variants are equipped with a three-phase motor inverter and a temperature sensor.

Products with two-leg interleaved PFC also feature shunt resistors in the motor inverter and in the PFC circuit. The PFC's common and leg shunts make it possible to perfectly balance the current in the PFC circuit, increasing the chipset's lifetime. Shunt resistors integrated in each leg of the inverter vastly improve motor control.



Furthermore, on-board capacitors dramatically reduce the DC-link voltage overshoot (see *Figure 2*).

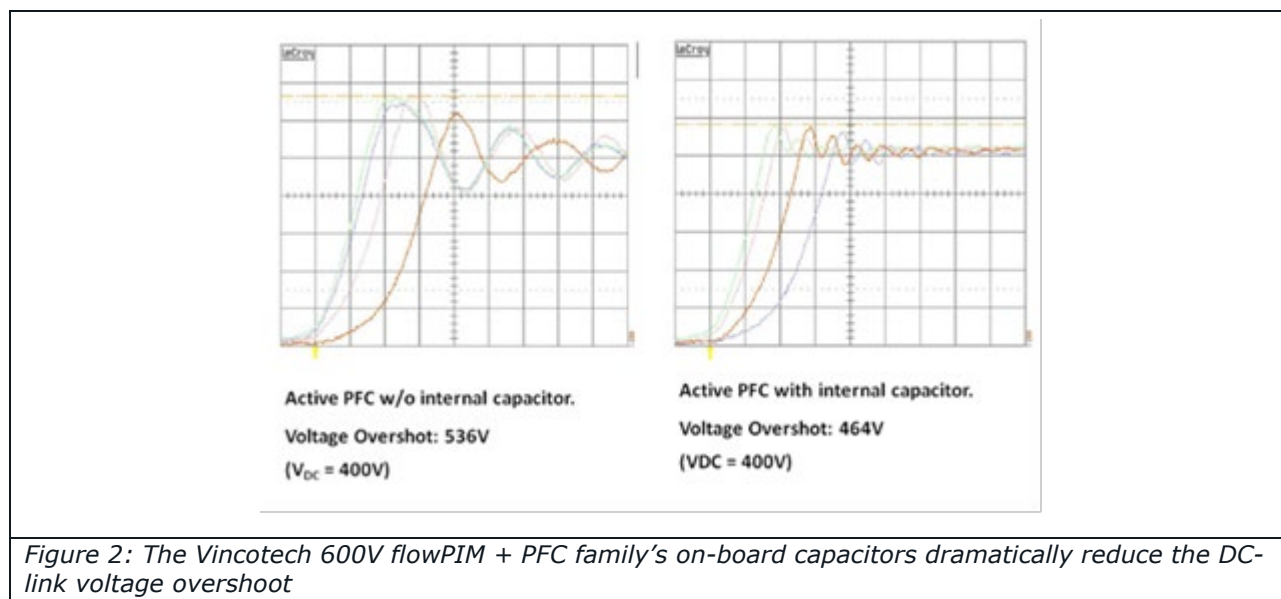


Figure 2: The Vincotech 600V flowPIM + PFC family's on-board capacitors dramatically reduce the DC-link voltage overshoot

The products' carefully designed layout offers the best compromise between cost and performance. For one, positioning the power pins at the edge of the power modules simplifies their PCB design and lowers their cost. Moreover, separating the inverter and PFC parts optimizes their thermal design.

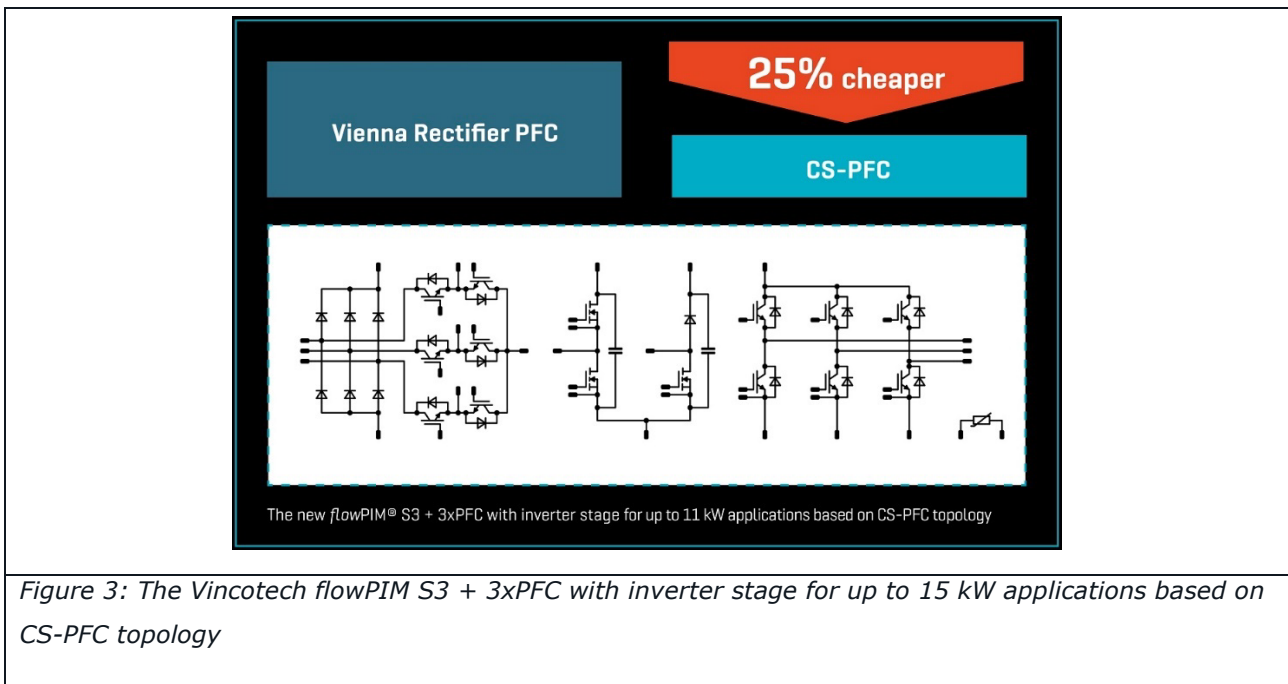
6 A new era starts now with the PIM + 3-ph PFC product family

Higher power ranges in heat pumps are accelerating the adoption of three-phase PFC topologies, driven by the requirements for high power density and more efficient and effective power distribution and power conversion.

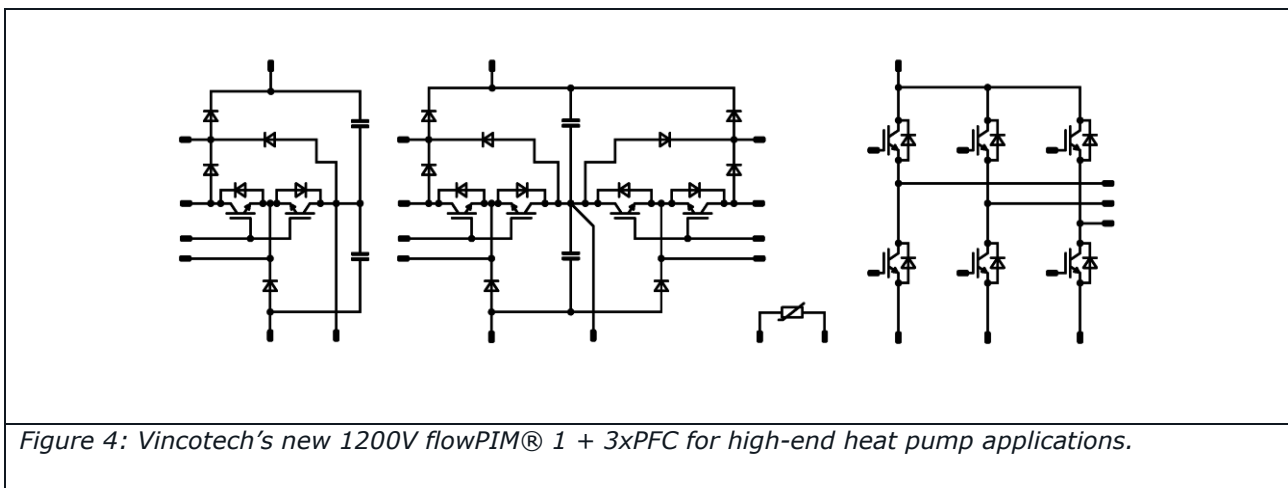
Enabling power ranges up to 15 kW, Vincotech's new 1200V *flowPIM*® S3 + 3xPFC featuring current-synthesizing PFC (CS-PFC) addresses these challenges, optimally balancing performance and system cost.

The current synthesizing PFC requires more switching components than the state-of-the-art NPFC topology, but only the half-bridge switches at a high switching frequency (HF) and only at the 3rd harmonic current.

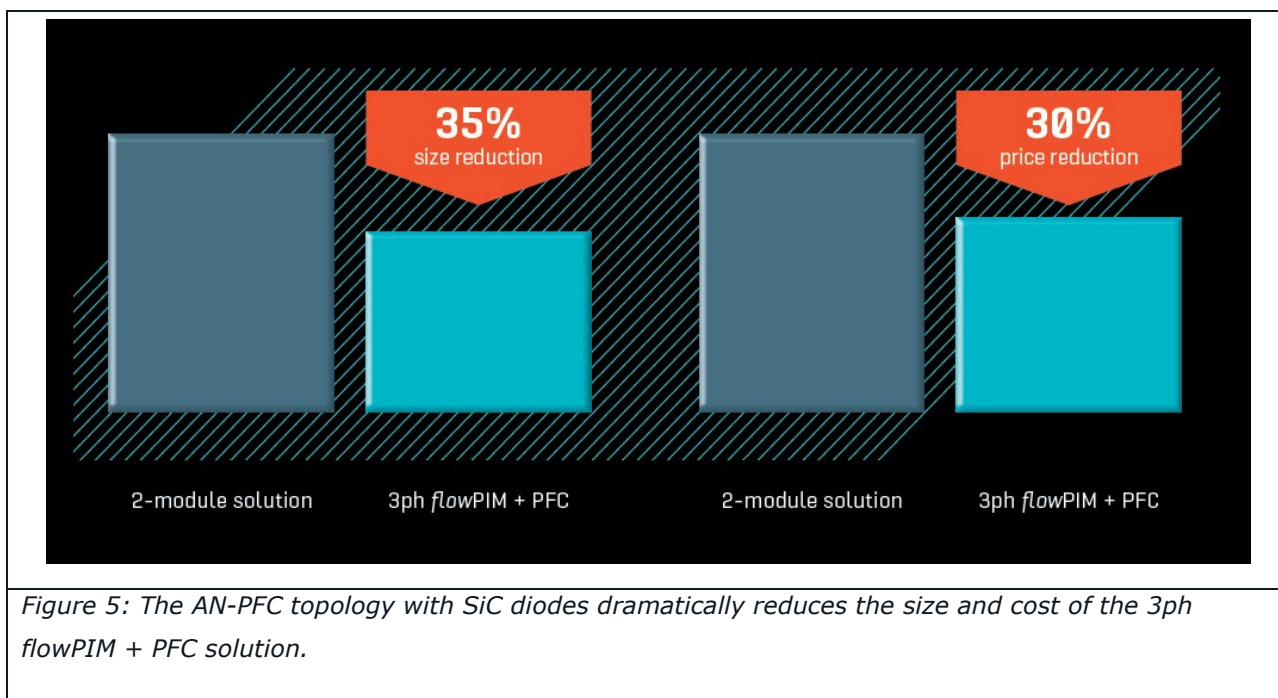
It's a tradeoff that pays off. Current-synthesizing PFC slashes module costs by 25% (up to 40% without a booster stage) while achieving a conversion efficiency up to over 99% (*Figure 3*).



Meanwhile, our new 1200V flowPIM® 1 + 3xPFC targets high-end applications in heat pumps. It is an all-in-one solution that uses 3-phase PFC, the AN-PFC topology, and an inverter stage to achieve a superior level of efficiency while reducing the system costs (Figure 4).



The AN-PFC topology with SiC diodes assures high efficiencies for switching frequencies up to 150kHz. This lets drive designers dramatically reduce the size and cost of the passive components on the PCB, leading to huge cost savings at the system level (Figure 5).



Finally, the inverter stage’s high-speed IGBTs and diodes enable high switching frequency operation and enhance efficiency.

7 A one-stop solution provider

Vincotech’s motion control solutions for heat pump applications build on the deep experience developing power electronics solutions for public grid-connected motion control applications. Combining speed and flexibility, we can help you design and develop applications that meet your power range and design specifications, optimally balancing the cost and performance of the end solution.

Vincotech’s one-stop power solution offering for complex motion control applications includes application-specific power modules, such as the 600V *flowPIM + PFC* and 1200V *flowPIM® 1 + 3xPFC* families presented in this article, full PCB design services, and a feature-rich evaluation board. And as a chip-independent power module manufacturer, we can build solutions around all chips on the market, offering you the best compromise between cost and performance.

Learn more about our product offering for heat pump motion control solutions at Vincotech.com/EmbeddedDrives

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