Solving AI Data Center Cooling Challenges with the 48V Fan Driver Solution

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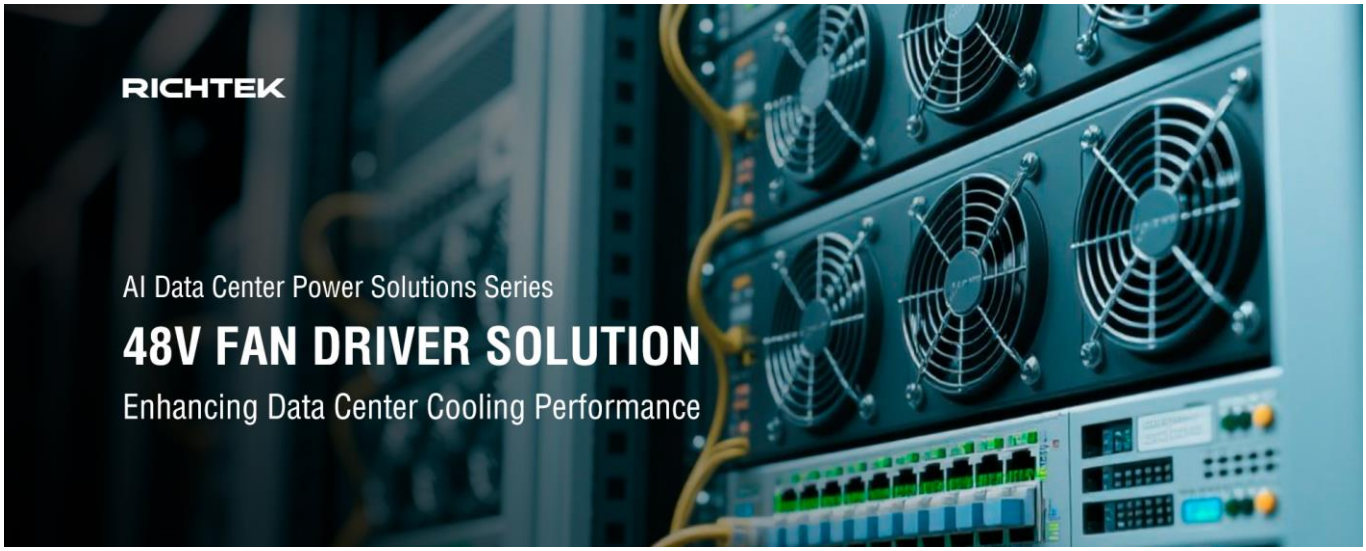

As artificial intelligence advances, from large language model inference and image processing to intelligent driving assistance, the computing density and power demands of data center servers have soared. The thermal output of high-performance chips is climbing to record levels, creating unprecedented challenges for conventional cooling systems. To maintain stable operation, server cooling fans must now provide greater airflow, higher efficiency, and enhanced reliability.

In response to these changes, server power topologies have shifted from the traditional 12V to 48V, reducing power losses and improving energy efficiency. Modern server cooling modules now operate at 48V, bringing demands for speed, airflow, space efficiency, and precise control. Richtek's RT7084 meets these challenges by offering a reliable driver solution for the next generation of high-performance server fans.

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1 Challenges and Solutions for 48V Fan Drivers

As 48V power architectures become the standard in servers, cooling fan designs must deliver high rotational speeds and strong airflow while overcoming challenges such as limited space constraints, startup reliability, and compressed development schedules. This application note outlines the key challenges faced by 48V fan drivers and explains how the RT7084 with its innovative technology and highly integrated design, offers an optimal cooling solution for next-generation server fans.

1.1 Improving Operational Stability and Reducing Vibration and Noise

With the growing demand for cooling performance in today's systems, fan speeds now exceed 50,000 RPM. At these extreme speeds, even minor imbalances can cause unstable rotation, increased vibration, and elevated noise levels, all of which can compromise system reliability and degrade the user experience. To address these challenges, the RT7084 adopts Sensorless FOC (Field-Oriented Control) technology, using sophisticated algorithms to estimate rotor position in real time. This ensures that the motor always maintains the optimal driving angle at high speeds, achieving precise dynamic control. This not only effectively suppresses vibration and torque ripple, enhancing the fan's operational stability, but also significantly reduces noise caused by blade vibration.

As shown in Figure 1, compared to traditional 12V fan solutions, the RT7084 demonstrates a smoother current waveform, indicating its excellent performance in maintaining low vibration and low noise even during high-speed operation, bringing a new level of experience to high-efficiency cooling systems.

Traditional 12V Solution
Sensorless Sinusoidal (Zero-Crossing Detection)

Richtek 48V Solution
Sensorless FOC

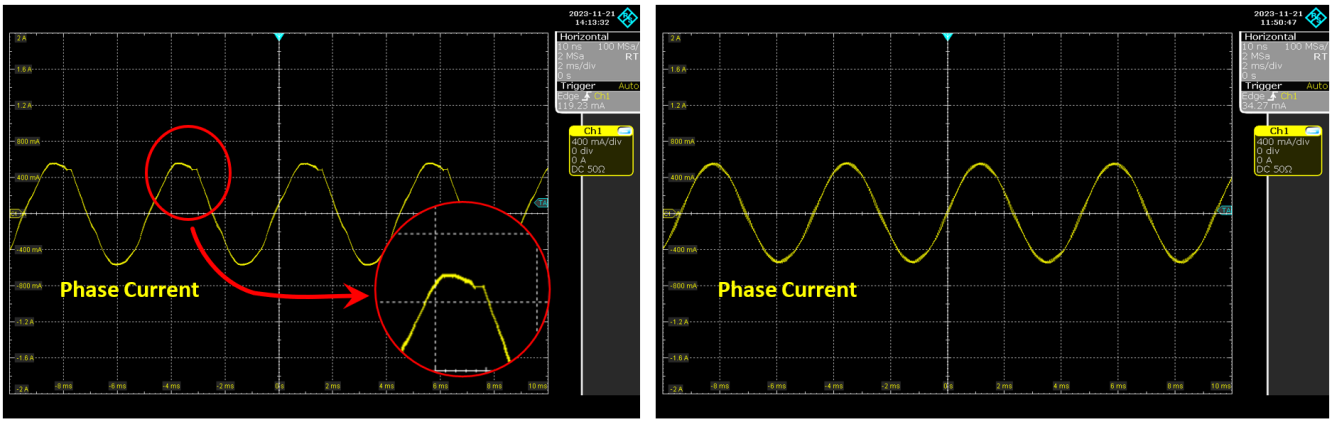

Figure 1. Operating Waveform of the RT7084 Motor Control Algorithm

1.2 Enhancing Start-Up Performance and Counter-Rotation Reliability

Server systems are equipped with multiple fans to ensure optimal cooling performance. However, timing differences in control signal transmission can cause certain fans to start later than others, leading to counter-rotation during startup. In traditional 12V fans, counter-rotation is less of an issue due to lower rotational speeds and reduced air pressure. In contrast, next-generation 48V fans operate at much higher speeds and generate significantly stronger airflow, making counter-rotation much more pronounced. This has made resistance to counter-rotation during startup a critical specification when evaluating 48V server fan solutions. Without a robust startup method to address this issue, the overall reliability of the cooling system can be severely compromised.

The RT7084 features a unique counter-rotation startup method that effectively mitigates the impact of counter-rotation, delivering excellent resistance during startup and further improving overall system stability. As shown in Figure 2, when starting from a counter-rotating state, the RT7084 first applies braking control. When the speed approaches zero, it then uses enhanced starting torque to overcome the counter-rotation, allowing the fan to smoothly enter normal operation. This innovative technology brings higher reliability and stability to next-generation server systems.

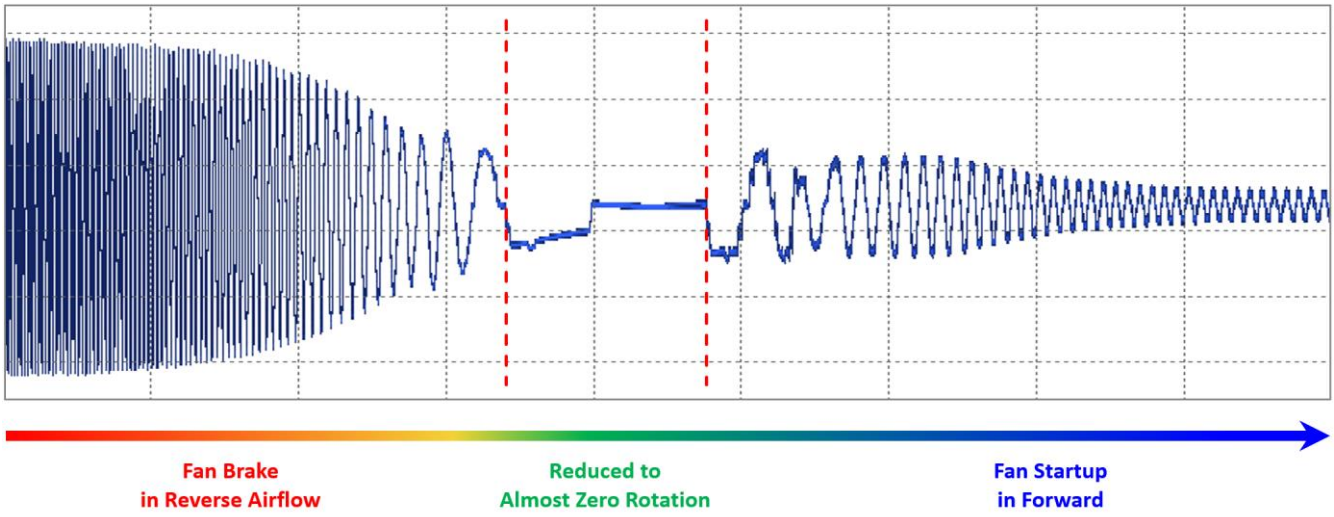

Figure 2. Counter-Rotation Startup Waveform of the RT7084

1.3 Achieving High Integration: Compact Size as the Core Key

Server systems are often highly compact, with fans as small as 4cm (length) by 4cm (width), placing exceptional demands on component integration and layout. The transition from a traditional 12V to a 48V power topology adds further complexity, as designers must now include a front-end buck module to supply the control chip with the correct operating voltage. This makes it even more challenging to fit the 48V fan solution within the limited space and development constraints of modern servers, a challenge the RT7084 is specifically designed to meet.
The RT7084 is housed in a compact 4mm x 4mm QFN package, combining the MCU, gate driver, and buck converter into a single chip. This integration removes the requirement for a separate buck module, ensuring a stable and reliable power supply for the controller. Its built-in buck converter, based on Richtek's patented ACOT® control technology, operates with just an 0806-size inductor. By integrating most external components directly into the chip, the RT7084 simplifies PCB layout and lowers BOM costs. As shown in Figure 3, it enables PCB designs for 4cm server fans.

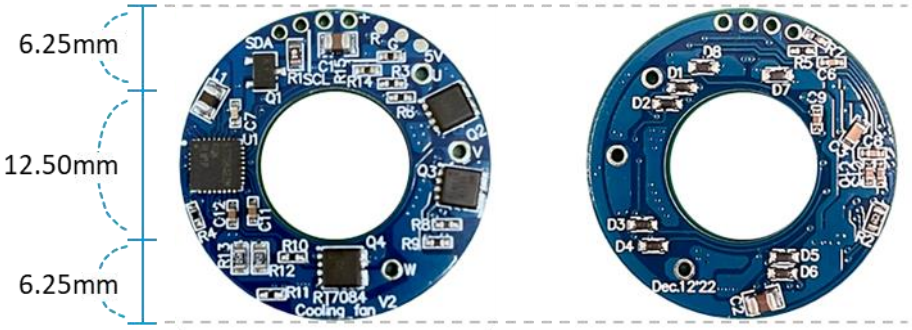

Figure 3. The RT7084 PCB Layout in a 4cm Server Fan

1.4 Simplifying the Development Process and Accelerating Time-to-Market

The RT7084 features an innovative Code-Free development architecture that eliminates the need for programming. Control parameters can be easily adjusted through an intuitive graphical user interface. As shown in Figure 4, the Tuning GUI and ADA (Application Development Assistant) GUI are dedicated tools for this Code-Free architecture, allowing users to configure functions and complete application development quickly. Richtek also provides comprehensive technical documentation to help customers get started and optimize their designs. To obtain the GUI software and related materials, please contact your local Richtek sales or technical support team.

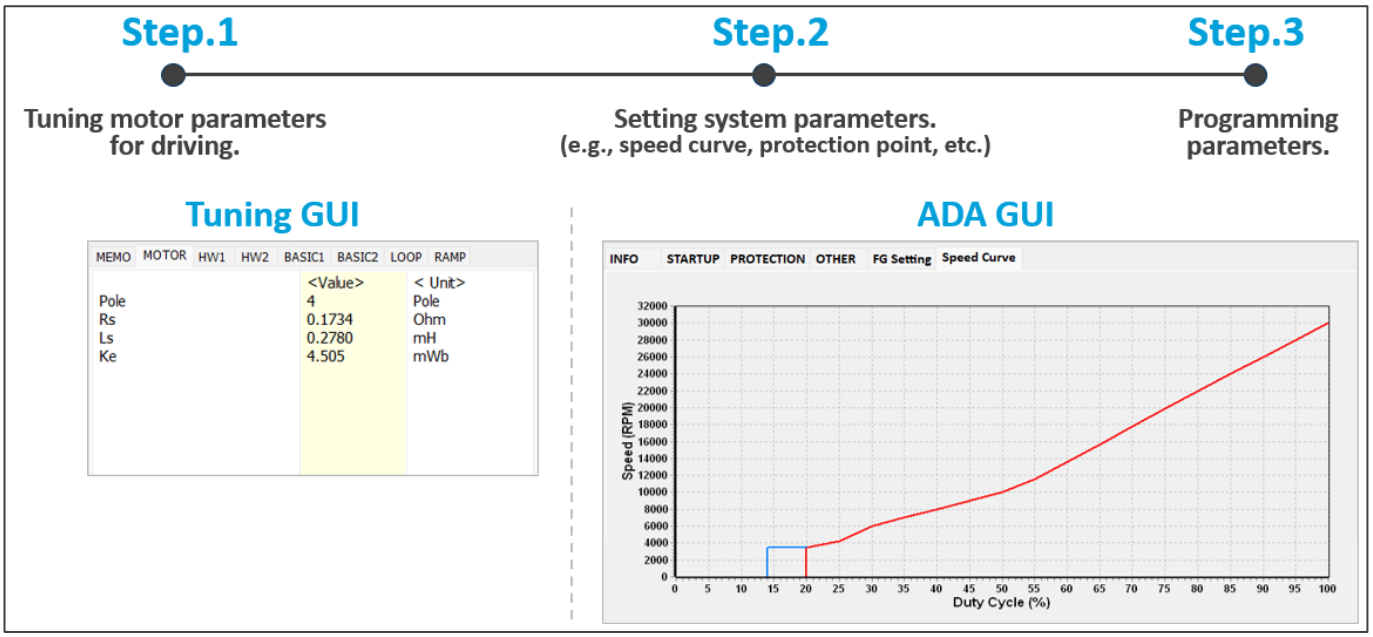

Figure 4. Dedicated GUI for the RT7084

2 Conclusion

As server computing power increases significantly, cooling performance has become a critical factor in system reliability. The RT7084, with its advanced Sensorless FOC algorithm and robust counter-rotation startup capability, effectively addresses the core challenges of 48V fan drivers in high-performance applications. In addition, the RT7084 features a highly integrated design and a Code-Free architecture, greatly simplifying the design process and lowering the development threshold, making it the ideal solution for next-generation server fan cooling.

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