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- ✓ High-Performance Vector Control: Supports both synchronous and asynchronous motors
- ✓ Advanced Energy Saving Technology reduces operational costs
- ✓ Industry 4.0 Compatible: Integration with DCS & PLC systems. Modbus-RTU, CANOPEN, PROFINET, PROFIBUS
- ✓ Advanced Functionality: Motor parameter self-tuning and overexcitation braking
- ✓ 60% Smaller than traditional inverters. Can be mounted side by side due to advanced thermal management
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From Concept to Innovation: The Journey of Variable Frequency Drives

by Amir Sami, MBA, BEng (Hons.) Charter Controls, Director of Sales

An inverter also known as Variable Frequency Drive (VFD) is a pivotal component in modern automation and energy systems, converting direct current (DC) into alternating current (AC). This conversion is crucial for controlling the speed and torque of electric motors, offering significant benefits in energy savings, process control, and extending equipment lifespan.

VFDs have revolutionised the way industries control motors, leading to significant improvements in energy efficiency and operational flexibility. To understand the impact of modern VFDs it's essential to take a step back and explore the history of these remarkable devices.

The Birth of Electric Motors and the Need for Control

The story of VFDs begins in the late 19th century with the invention of the electric motor. As industries began to adopt electric motors to replace steam engines and manual labour, the need for precise control of motor speed and torque became evident. Initially, motors were either on or off, offering little control over their operation. Engineers sought methods to regulate motor speed to match the demands of different processes, leading to the early development of mechanical and electrical control systems.

Early Speed Control Methods

Prior to the introduction of VFDs, motor speed control was accomplished using a variety of methods, such as:

- 1. Mechanical Systems:** These included gears, belts, and pulley systems that could vary the speed mechanically. However, these systems were inefficient, bulky, and offered limited control.
- 2. DC Motors:** Direct Current (DC) motors were easier to control in terms of speed, but they were expensive, required regular maintenance, and had limited power ratings.
- 3. Resistor-Based Systems:** Another early method involved the use of resistors to control the amount of current reaching the motor. However, this method was highly inefficient, as excess energy was wasted as heat.

The Emergence of Variable Frequency Drives

The true breakthrough came with the development of semiconductor technology in the mid-20th century. The invention of the thyristor, a type of semiconductor switch, enabled the creation of devices that could control the frequency and voltage supplied to an AC motor. This led to the birth of the first Variable Frequency Drives (VFDs).

VFDs work by converting the fixed-frequency and fixed-voltage power supply into a variable-frequency and variable-voltage output. By adjusting the frequency of the power supplied to the motor, VFDs can precisely control the motor's speed and torque. This



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advancement not only improved energy efficiency but also extended the lifespan of motors by reducing mechanical stress.

Evolution and Modern VFDs

As technology advanced, so did VFDs. The introduction of microprocessors and digital control systems in the 1980s and 1990s allowed for even more precise control and greater functionality. Modern VFDs are capable of dynamic speed adjustments, energy-saving features, and real-time monitoring, making them indispensable in a wide range of industrial applications.

Global and UK VFD Market Trends: Growth, Challenges, and the Path Forward (2013-2030)

The VFD market, both in the UK and globally, is on a positive growth trajectory, driven by technological advancements and the ongoing need for energy efficiency. While there are challenges, particularly related to costs and economic fluctuations, the long-term outlook remains strong, with continued innovation and investment expected to support sustained growth in the sector.

The UK market for Variable Frequency Drives (VFDs) and related components experienced steady growth from 2012 to 2020, with sales £130 million approximately by the end of 2020. This growth was driven by continuous product development, the transition from Fixed Speed Drives (FSDs) to VFDs, and a growing demand for energy-efficient and automated solutions. Key trends during this period included the rise of IoT integration, enhanced control and monitoring capabilities, and a focus on reducing energy consumption and total ownership costs.

However, the onset of COVID-19 in 2020 had a significant impact on the UK VFD market, as it did on many industries globally. The pandemic caused disruptions in supply chains, delays in manufacturing, and a slowdown in industrial and commercial activities, leading to a temporary dip in demand for VFDs and related components. Despite these challenges, the market began to recover as the UK emerged from the pandemic, with industrial activities resuming and businesses adapting to the new normal.

The pandemic further emphasized the importance of energy efficiency, automation, and cost reduction key drivers in the VFD market. As businesses sought to enhance control, reduce energy consumption, and lower operational costs, the demand for VFD technologies gained renewed importance. This focus supported the market's recovery and contributed to continued growth. As of 2024, the UK VFD market remains robust, reflecting the sustained emphasis on innovation, efficiency, and adaptability in response to evolving industrial needs.

Globally, the VFD market was valued at USD 25.92 billion in 2022 and is expected to grow at a compound annual growth rate (CAGR) of 5.6% from 2023 to 2030. The market's growth is being fuelled by the increasing adoption of connected devices across various sectors, the demand for energy-efficient and adjustable speed drives, and sig-



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nificant investment in infrastructure, particularly in HVAC systems. Rapid industrialization in developing countries and the growing need for energy management in various sectors further support this growth.

Key Drivers and Trends

- **Energy Efficiency:** Both the UK and global markets are driven by the need for energy-efficient solutions, with VFDs playing a crucial role in reducing energy consumption and meeting environmental regulations.
- **Technological Advancements:** Innovations in AI, IoT, and automation are propelling the demand for more sophisticated VFDs that offer enhanced control, monitoring, and scalability.
- **Market Challenges:** The global market faces challenges such as high initial costs, economic slowdowns, and supply chain disruptions, particularly highlighted during the COVID-19 pandemic. However, the market is expected to recover and grow as industrial activities rebound.

Tracing the Development and Contribution of VFDs from Veichi:

A Look at the AC10 and AC310 Series

Veichi Electric Co., Ltd., a leading manufacturer of industrial automation products, active in more than 80 countries worldwide. The company has established a strong global presence, providing its industrial automation solutions, including VFDs, to a wide range of markets across different regions. Veichi has recently selected Unipower (UK) Ltd, T/A Charter Controls as their UK strategic import agents and stockist following a successful launch at the Drives and Controls Exhibition.

Veichi has played a significant role in advancing VFD technology and has steadily risen to prominence as one of the leading provider of industrial automation solutions, with a particular focus on VFDs. Their AC10 and AC310 series exemplify the modern capabilities of VFDs.



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VEICHI AC10 Series Variable Frequency Drives



- ✓ Smart and compact, with a narrow book design.
- ✓ Temperature resistance, no derating in 50 degree environments
- ✓ Supports a variety of installation methods.
- ✓ Hidden line design makes wiring more convenient.
- ✓ High protection, isolated air duct, taking into account heat dissipation and dust prevention of devices.
- ✓ Compatible with asynchronous/synchronous motors with high performance vector control.



From its beginnings, Veichi has been dedicated to innovation, quality, and customer satisfaction, which has fuelled its growth in the competitive field of VFD technology. In its early years, Veichi concentrated on developing basic VFDs that catered to simple motor control needs. These early models were reliable and cost-effective, gaining traction in the market due to their straightforward design and ease of use. Veichi's commitment to quality and robust performance quickly earned the company a reputation for producing durable and dependable VFDs.

As Veichi gained experience and customer feedback, the company began to expand its product lineup, introducing more advanced VFDs with enhanced features. By incorporating the latest technological advancements in electronics and software, Veichi developed VFDs capable of more precise control, energy efficiency, and versatility. This period marked the introduction of VFDs with vector control technology, which allowed for more accurate motor control, especially in demanding applications.

The Veichi AC10 is designed for straightforward and economical motor control, offering easy installation and operation. Ideal for applications requiring basic speed control, it delivers reliable performance in a compact and cost-effective package. The AC10 is particularly well-suited for general-purpose use in industries such as light manufacturing, textiles, and operations involving conveyors, fans, and pumps, where space and cost-efficiency are key considerations.

On the other hand, the Veichi AC310 caters to more complex and demanding industrial environments. This advanced VFD provides enhanced functionality and flexibility, featuring sophisticated vector control for both asynchronous and synchronous motors, along with multiple control modes and robust protection mechanisms. It is designed for high-demand applications in sectors like petrochemicals, power generation, and advanced manufacturing. The AC310 also supports Industry 4.0 integration, with capabilities such as motor parameter self-tuning and overexcitation braking, which contribute to improved operational efficiency, precision, and lower overall costs.

Together, the AC10 and AC310 inverters exemplify Veichi's dedication to delivering versatile and efficient solutions tailored to the diverse needs of various industrial sectors.

Conclusion

The shift from the basic speed control methods of the early 20th century to the advanced VFDs like Veichi's AC10 and AC310 shows the significant progress in electrical engineering and industrial automation. VFDs are now a key part of modern industry, providing efficient, adaptable, and reliable motor control that boosts productivity and supports sustainability. As technology keeps advancing, VFDs are likely to play an even more important role in shaping the future of industrial operations.



VEICHI VFD's DEEP DIVE

AC10 and AC310 Series inverters: highlighting their suitability for various operational needs and industry requirements. Each model is designed to meet specific challenges, with the AC10 focusing on general applications and cost efficiency, while the AC310 excels in demanding industrial environments requiring advanced vector control and energy efficiency.

AC10 Inverter: Technical Features and Benefits

Technical Features

1. Vector Control Technology (PG-free and V/F Control):

- **Definition:** Vector control, or field-oriented control (FOC), directly regulates voltage and frequency to maintain the desired speed and torque across the motor's operational range. PG-free refers to vector control without the use of a Pulse Generator (encoder), while V/F control adjusts voltage and frequency in a fixed ratio.
- **Benefit:** Provides precise motor control, enabling smooth operation and optimal efficiency even at lower speeds. This is particularly useful in applications like pumps and fans where precise speed control can significantly reduce energy consumption and enhance process control.



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VEICHI AC310 Series Variable Frequency Drives

- ✓ High performance vector universal platform.
- ✓ Brand new motor control algorithm.
- ✓ Synchronous and asynchronous drives are integrated, open-loop and closed-loop are comprehensive.
- ✓ The entire series of book-based design to ensure the rationality of hardware arrangement.
- ✓ Software and hardware modular design requirements and powerful expansion capabilities.

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2. Protection Systems:

- **Definition:** Includes mechanisms to protect against overcurrent, overvoltage, overheating, and other potential electrical or mechanical failures.
- **Benefit:** Enhances the reliability and durability of the inverter by preventing damage that can occur from electrical anomalies or operational extremes. This extends the lifespan of both the inverter and the motor it controls.

3. Heat Management with Independent Air Ducts:

- **Definition:** Uses specially designed air ducts that isolate the cooling process from the electrical components, thereby preventing dust accumulation and enhancing heat dissipation.
- **Benefit:** Allows the inverter to operate effectively in high-temperature environments (up to 50 degrees C) without derating, ensuring consistent performance without the risk of thermal damage.

4. User-Friendly Installation:

- **Definition:** Features designs that allow for side-by-side installation without clearance and use European-style terminals, which simplify the electrical connections.
- **Benefit:** Simplifies the installation process, reducing time and labour costs, and makes it easier to integrate the inverter into various industrial settings.

Benefits

- Enhanced durability and operational reliability under various environmental conditions.
- Flexible installation options support diverse industrial applications, ensuring a broad adoption potential.
- Cost efficiency through advanced technological integration that does not compromise on performance for affordability.

AC310 Inverter: Technical Features and Benefits

Technical Features

1. High-Performance Vector Control:

- **Definition:** An advanced form of vector control that supports both asynchronous and synchronous motors, capable of handling complex control methods like voltage-frequency separation.
- **Benefit:** Delivers superior precision in motor control, optimizing performance for a variety of demanding industrial applications, from heavy machinery to precise tooling systems.



2. **Energy Efficiency with Advanced Energy-Saving Technology:**

- **Definition:** Incorporates sophisticated algorithms to reduce power and motor losses significantly, which is crucial for industries with high power demands.
- **Benefit:** Reduces operational costs by minimizing energy consumption, an essential feature for energy-intensive industries aiming to improve sustainability and reduce environmental impact.

3. **Advanced Functionality (Motor Parameter Self-Tuning and Overexcitation Braking):**

- **Definition:** Motor parameter self-tuning automatically adjusts the parameters for optimal motor control; overexcitation braking provides rapid deceleration capabilities without additional hardware.
- **Benefit:** Enhances usability and performance by adapting to changing operational conditions automatically and providing safe, rapid stops when necessary.

4. **Industry 4.0 Compatibility (Integration with DCS and PLC Systems):**

- **Definition:** Ready to integrate with Distributed Control Systems (DCS) and Programmable Logic Controllers (PLC) through various communication protocols such as Modbus-RTU, CANOPEN, and PROFINET.
- **Benefit:** Facilitates seamless integration into automated environments, enhancing connectivity and enabling sophisticated control strategies across industrial networks.

Benefits

- Offers versatility and precision in controlling a wide range of motor types and applications, ensuring optimal performance tailored to specific needs.
- Reduces operational costs by lowering energy usage and minimizing maintenance needs through intelligent diagnostics and self-tuning capabilities.
- Improves overall equipment efficiency and reliability, reducing downtime and maintenance efforts, thus enhancing productivity and operational safety.

Preventive Maintenance (PM) and Predictive Maintenance (PdM) are strategies used in asset management to increase equipment availability and reliability while reducing costs. PM involves conducting regular, planned maintenance activities regardless of the equipment's condition, aimed at preventing failures before they occur. PdM, on the other hand, uses condition-monitoring tools and techniques to predict equipment failures before they happen, allowing maintenance to be scheduled at a convenient time.

Historical Development

The concept of preventive maintenance began with the industrial revolution when machinery maintenance became crucial for production lines. As technology evolved, particularly with the advent of complex machinery during and after World War II, the need for more sophisticated maintenance strategies became apparent, leading to the development of predictive maintenance techniques in the latter half of the 20th century. The introduction of computers and advanced analytics in the late 20th century propelled the adoption of predictive maintenance, which relies on data analysis to predict failures.

Implementation



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Preventive Maintenance is implemented by scheduling regular inspections and maintenance tasks based on a predetermined schedule derived from historical data or manufacturer recommendations. This approach is straightforward but can lead to unnecessary maintenance, as it does not consider the actual condition of the equipment. Predictive Maintenance utilizes data-driven analytics and condition-monitoring technologies such as vibration analysis, thermal imaging, and oil analysis. The implementation of predictive maintenance has been significantly enhanced with the rise of IoT (Internet of Things), which allows real-time data collection and analysis. This real-time capability helps in accurately predicting when maintenance should be performed, thus optimizing maintenance schedules and resource allocation.

Cost Implications and ROI

The cost implications of preventive maintenance include potential over-maintenance, as it is not based on the actual condition of the equipment. Predictive maintenance, although initially more expensive due to the need for advanced monitoring technologies and analytical tools, can lead to significant cost savings by preventing unplanned downtime and extending the life of equipment.

The ROI (Return on Investment) for predictive maintenance can be substantial. According to studies, implementing predictive maintenance can result in:

- A 25-30% reduction in maintenance costs.
- A 70-75% decrease in breakdowns.
- A 35-45% reduction in downtime
- A 20-25% increase in production.

Advantages

Preventive Maintenance:

- Reduces the likelihood of unexpected equipment failures.
- Extends the operational life of equipment through regular upkeep.
- Simplifies budgeting for maintenance tasks.

Predictive Maintenance:

- Minimizes unnecessary maintenance, thereby reducing costs.
- Enhances the reliability of equipment by addressing issues before they lead to failure.
- Improves safety by reducing the risk of catastrophic equipment failures.

Conclusion

Both preventive and predictive maintenance play crucial roles in modern maintenance strategies, with each method offering distinct benefits. The choice between them depends on the specific requirements and capabilities of the operation. With advancements in technology, particularly in data analytics and IoT, predictive maintenance is becoming more accessible and cost-effective, offering significant advantages in terms of cost savings and operational efficiency.



AC10 Inverter and Preventive Maintenance

The AC10 inverter is suitable for preventive maintenance, which involves regular, scheduled maintenance to prevent unexpected equipment failures. Its features that support preventive maintenance include:

- **Robust Protection Features:** With advanced protection against over-voltage, over-current, and overheating, the AC10 helps in maintaining the reliability and longevity of the motor and drive system, reducing the likelihood of sudden failures.
- **Heat Management:** The effective heat management system ensures that the devices operate within safe temperature limits, which can prevent premature wear and tear caused by overheating.

These features enable operators to maintain a consistent maintenance schedule, potentially extending the lifespan of both the inverter and the connected equipment by ensuring they operate within their designed parameters.

AC310 Inverter and Predictive Maintenance

The AC310 inverter is more adept at supporting predictive maintenance strategies, which involve monitoring equipment during its normal operation to predict potential failures before they occur. This is possible due to its more advanced features:

- **Advanced Functionality:** Features like motor parameter self-tuning and overexcitation braking not only optimize performance but also monitor and adjust to the motor's needs in real-time, which can be critical data points for predictive maintenance analysis.
- **Industry 4.0 Compatibility:** The ability to integrate with modern control systems (DCS, PLC) and communication protocols (Modbus-RTU, CANOPEN, PROFINET) allows for continuous monitoring and data collection. This data can be analysed to predict wear trends, identify potential issues before they result in downtime, and schedule maintenance more effectively.

Additionally, the enhanced diagnostic capabilities of the AC310 make it possible to implement sophisticated predictive maintenance algorithms that can analyse data trends to forecast when maintenance should be performed, thereby reducing unnecessary maintenance operations and preventing unexpected equipment failures.

Achieving Preventive and Predictive Maintenance with AC10 and AC310 Inverters

Both the Veichi AC10 and AC310 inverters can facilitate preventive and predictive maintenance through various routes, leveraging their technical capabilities to enhance operational efficiency and reduce downtime. Here's how each can achieve this:



AC10 Inverter: Routes to Preventive Maintenance

1. **Scheduled Maintenance Reminders:**

- The AC10 can be programmed to remind operators of regular maintenance checks based on operational hours or calendar time. This helps in maintaining the inverter and associated machinery in peak condition.

2. **Protection System Feedback:**

- The inverter's robust protection features (like over-voltage and over-current protection) can help in identifying potential issues that require preventive maintenance. For example, frequent trips due to over-current could indicate that a motor is overloaded or experiencing wear that needs addressing.

3. **Thermal Monitoring:**

- By continuously monitoring the heat output and using its effective heat management system, the AC10 can signal when temperatures approach critical thresholds, prompting pre-emptive maintenance actions to avoid overheating and potential damage.

AC310 Inverter: Routes to Predictive Maintenance

1. **Data Analytics and Trend Analysis:**

- With its Industry 4.0 capabilities, the AC310 can collect and analyse operational data from connected devices. This data can be used to predict failures by identifying patterns or anomalies in operation, such as irregular motor behaviour or energy consumption spikes.

2. **Real-Time Monitoring and Alerts:**

- The AC310's integration with DCS and PLC systems allows for real-time monitoring of all operational parameters. The system can alert operators to deviations from normal performance metrics, suggesting when components may be nearing failure and require inspection or replacement.

3. **Self-Tuning and Performance Optimization:**

- The self-tuning functionality adjusts parameters for optimal performance continuously. Observations from these adjustments can provide insights into the motor's health, indicating potential issues like bearing failures or misalignment before they lead to downtime.

4. **Integration with Maintenance Software:**

- The AC310 can be integrated with advanced maintenance software that uses AI and machine learning to predict maintenance needs. This software can analyse the inverter's operational data along with external factors like environmental conditions to optimize maintenance schedules.



Practical Implementation

- **Setup and Configuration:** Ensure that both inverters are correctly set up and configured to communicate with the central monitoring systems. This may involve adjusting settings for data transmission frequency, alert thresholds, and integrating with existing IT infrastructure.
- **Training and Protocols:** Operators and maintenance personnel should be trained on interpreting the data and alerts provided by the inverters. Establishing clear protocols for responding to different types of alerts can enhance the effectiveness of maintenance routines.
- **Regular Reviews and Updates:** Maintenance protocols should be regularly reviewed and updated based on the insights gathered from ongoing operations. This helps in continuously refining the processes to better prevent and predict maintenance needs.

While both inverters are suitable for maintenance routines, the AC310's advanced capabilities make it particularly well-suited for predictive maintenance, leveraging data analytics and real-time monitoring to optimize maintenance schedules and improve overall operational efficiency. The AC10, with its robust design and protective features, is more tailored towards traditional preventive maintenance routines. Each model offers unique benefits depending on the complexity of the application and the specific maintenance needs of the operation.

By leveraging these routes, the AC10 and AC310 inverters not only help in maintaining operational efficiency but also extend the life span of the equipment they control, reducing both downtime and long-term maintenance costs.



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