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CONTROL ALGORITHMS AND MODERN PROGRAMS OF MODULES.

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Annotation: Until recently, despite the relatively lower complexity, energy efficiency, and reliability compared to AC machines, DC machines have been commonly used as driving motors in most controlled electrical drives. The course "Power Electronics and Supply Sources for Electromechanical Systems" covers devices like semiconductor-controlled rectifiers, inverters, reversers, and frequency converters. A common feature of these devices is their control via special ventilation control systems. Initially, autogenerators and multivibrator circuits were used to control the power switches such as thyristors (or more recently IGBT transistors), but now, microprocessor-controlled circuits are widely used. The evolution of control methods and circuits is explored in detail, with applications for various control systems in electromechanical and power electronics contexts.

Keywords: DC machines, AC machines, semiconductor-controlled rectifiers (SCR), inverters, frequency converters, thyristors, IGBT transistors, microprocessor control, power electronics, electromechanical systems, autogenerators, control systems, electrical drives, energy efficiency, ventilation control systems.

Introduction

Until recently, almost all adjustable electric drives utilized direct current (DC) machines as the driving motor, despite their lower energy efficiency, more complex construction, and lower reliability compared to alternating current (AC) machines.

The subject *"Power Conversion Technology and Power Supply Sources of Electromechanical Systems"* covers devices such as semiconductor-controlled rectifiers, inverters, reversible converters, and frequency converters. Initially, the thyristors (or more recently, IGBT transistors) used as power switches in these devices were controlled using self-oscillators and multivibrator circuits. However, in more recent developments, microprocessor-based circuits have become widely used for this purpose.

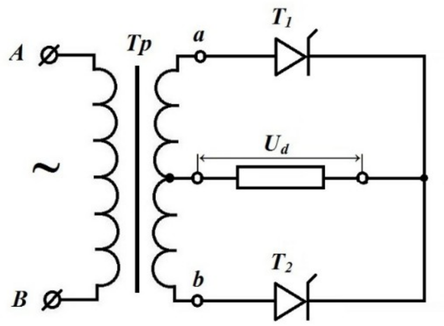

Figure 1. A Simple Controlled Semiconductor Circuit.

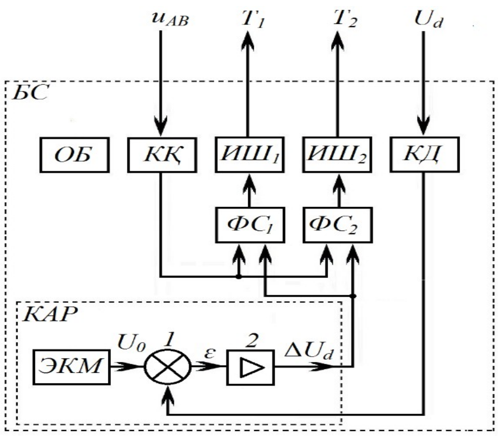

Figure 2. Operating Principle of a Controlled Semiconductor

OB ─ power supply unit,KQ ─ input device,a center-tapped transformer with two half-windings,FS1, FS2 ─ phase-shifting devices,KAR ─ automatic voltage regulation,EKM ─ reference voltage source,KD ─ voltage sensor,1 ─ summing device,2 ─ amplifier,ISh1, ISh2 ─ pulse shapers

PROBLEMS

Complexity of AC Machines and Control Limitations: Although AC machines offer high complexity, energy efficiency, and reliability, they come with challenges in control systems. In contrast, DC machines have a simpler construction and more convenient operating conditions, but their control capabilities are limited.

Technical Aspects of Semiconductor-Controlled Converters: The need to further develop the working principles of semiconductor-controlled rectifiers and inverters, improve their efficiency, and achieve energy savings requires the creation of new control systems.

Development of Microprocessor-Based Control Systems: Initially, autogenerators and multivibrator circuits were used, but today microprocessor-based control systems are widely employed. The development and optimization of these systems to improve their speed and accuracy present ongoing challenges.

Advantages and Issues with Vector Control: The primary aim of vector control methods is to control the rotor magnetic flux and optimize the electromagnetic torque. However, the technical and economic limitations, along with the complexity of applying this method in practice, could pose significant challenges.

Efficiency of Control Systems for Converter Devices: There is a need to develop control systems for converter devices and resolve issues between multi-channel and single-channel systems to improve overall performance and efficiency.

MAIN PART

The main reason for the need for vector control is that the squirrel-cage induction motor is the most popular, inexpensive to manufacture, reliable and least demanding during operation (there is no mechanical collector or slip rings in the design), and its speed is difficult to adjust. For this reason, it was initially used in uncontrolled drives or with mechanical adjustment (speed changer). Special multi-speed induction machines allowed for step-by-step (from two to five) speed changes, but their cost was much higher than usual, in addition, a special control station was used for such motors, which further increased the cost of the control system. Despite the high consumption, it was not possible to maintain a constant engine speed when the load changed. Later, methods for adjusting the speed of a squirrel-cage induction motor were developed (scalar control). During transient processes, the interaction of the rotor (rotating magnet) with the current changes during scalar control (when the stator and rotor currents change), which leads to a decrease in the rate of change of the electromagnetic torque and a deterioration in dynamic characteristics.

The idea of vector control is to create a system for controlling a short-circuited rotor induction motor in which the torque and magnetic flux can be controlled separately, as in a DC motor. In this case, the interaction between the magnetic flux and the rotor is kept constant and, importantly, the change in electromagnetic torque is maximized.

Control systems for transformers.

In a broad sense, a control system for transformers is understood as a set of functional units and elements. These units and elements must ensure the performance of the following tasks and functions:

control of the nonlinear elements of the power units of the transformer that perform the conversion process;

adjustment of the parameters of the output units of the transformer;

connection (to the circuit), disconnection (disconnection from the circuit) of the transformer and distribution of electrical energy between individual consumers;

control of the protective devices of the transformer and its components;

provision of information about the operation of the transformer when used in an automated power supply system.

The system that monitors the operability of the transformer and its components is sometimes included in the control system.

Although various converters - rectifiers, frequency converters, autonomous inverters, etc. - differ in their respective functions, they have a common similarity -

the diagrams show the power source without indicating its connection to other functional units.

Rectifiers, network-connected inverters and other valve converters can be generally divided into two groups: multi-channel and single-channel converters.

In multi-channel structures of control systems, the phase of the opening pulses (i.e., the control angle) is adjusted in each control channel. The number of such channels is usually equal to the number of controlled valves in the circuit or the number of phases of the circuit. In single-channel structures, the phase of the opening pulses is adjusted in a channel common to all valves and is distributed among the valves of the circuit. It is better to carry out such a classification of the control system only for multi-phase converters consisting of a large number of valves. The multi-channel structure of the control system is the most common.

In thyristor converters, the main function of the control system is to generate opening pulses on the control electrodes of the thyristors of the circuit based on a certain program. The requirements for the pulse parameters are determined by the types of thyristors, the circuit in which the thyristor is used, and its operating mode. For reliable connection of the thyristor, it is necessary to provide such current and voltage values at the control electrode that these values \u200b\u200bare within the guaranteed connection range, taking into account the voltage, current, and peak power dissipation at the control electrode.

Depending on the circuit in which the thyristors are used, the opening pulses can have different shapes and lengths. The most common opening pulses are rectangular pulses. The minimum duration of the opening pulses is determined by the time it takes for the thyristor anode circuit to rise to the value of the turn-on current. This current value is usually 2-3 times greater than the turn-off current. When the circuit switched by the thyristor has an active resistance, this time is practically the same as the turn-on time of the thyristor, that is, this time falls in the range from several microseconds to several tens of microseconds. The presence of inductance in the anode circuit can further increase the minimum required pulse length compared to the thyristor turn-on time.

During the interval between opening pulses, it is advisable to apply a small closing voltage (negative voltage) to the control electrodes of the thyristors. The turn-off voltage allows you to increase the resistance of thyristors to false opening pulses.

SOLUTIONS

Complexity reduction in AC (induction and synchronous) motor control: It is recommended to employ advanced simulation and computation-based platforms. For example, using environments like MATLAB/Simulink combined with DSP- or FPGA-based real-time controllers enables efficient implementation of complex model-based control algorithms. These approaches help reduce control complexity by enabling high-fidelity modeling and automation of the control system. In addition, implementing both sensor-based and sensorless vector control methods can improve system stability. For instance, an observer-based vector control scheme with rotor flux and torque observers has been shown to minimize copper and magnetic losses, thereby improving energy efficiency

Improving semiconductor converter technology: Employing wide-bandgap semiconductor technologies (SiC, GaN) can significantly increase converter efficiency. These devices are designed for high-voltage and high-frequency operation, reducing losses compared to traditional silicon components. Furthermore, using multilevel inverter topologies and modular converter designs can suppress noise and harmonics, improving power quality. Such enhancements allow reduction in converter control complexity and enable more compact system designs.

Advancement of microprocessor-based control systems: It is advised to use high-performance multicore microcontrollers and DSPs in control platforms. Real-time operating systems (RTOS) and high-speed ADC/PWM modules can enhance the precision and responsiveness of the control system. It has been demonstrated that modern microcontroller-based variable-speed drives can reduce energy consumption by approximately 30% compared to older drives. Additionally, incorporating Internet-of-Things (IoT) technologies and remote monitoring capabilities can improve diagnostics and maintenance efficiency.

Solutions for vector and scalar control challenges: To improve robustness against parameter variations and external disturbances in vector control, model-reference adaptive algorithms (e.g., MRAS) and fuzzy logic or neural-network-based methods are recommended. Attention should also be given to sensorless control systems to reduce the number of physical sensors and simplify the system. For example, a vector control scheme supported by rotor flux and torque observers can ensure minimal losses while keeping the system at an optimal operating pointt. Nonlinear control strategies (such as model-predictive control) that account for system nonlinearities may also be implemented.

Enhancing converter control efficiency: Implement optimized PWM algorithms, dedicated filtering, and dynamic load balancing in power converters. These measures provide precise torque control and stable operation for high-frequency drives. Moreover, improving thermal management (e.g., high-efficiency cooling) and strengthening current protection algorithms increases overall device reliability. Such optimization methods, including load sharing and energy-saving control strategies, help reduce losses during power conversion

Discussion

The advancement of modern electric drive and motor control systems presents not only significant opportunities but also notable challenges. Developing and implementing high-precision control algorithms for traditional AC motors in real-world applications involves technical complexity and cost-related concerns. Particularly in vector control, maintaining system stability under varying operating conditions such as temperature and load fluctuations remains a critical issue due to the reliance on sensors and observers.

While wide-bandgap semiconductor devices like SiC and GaN offer promising improvements in energy efficiency and reliability, their higher costs currently limit widespread adoption. On the other hand, the development of microprocessor and DSP technologies enables simplified real-time control systems with faster response rates, though this requires advanced programming and engineering expertise.

Overall, technological advancements in converter and motor control fields are paving the way toward energy-efficient, reliable, and environmentally friendly solutions. However, achieving these outcomes demands systematic, multidisciplinary approaches and the development of sophisticated control algorithms tailored to real-world conditions.

Conclusion

The analysis indicates that the future development of electric drive and motor control systems is closely tied to the integration of advanced semiconductor technologies, modern microprocessors, and intelligent control algorithms. By applying sensorless vector control methods, energy-efficient converter topologies, and real-time operating systems, it is possible to reduce system complexity and improve reliability. Moreover, it is essential to thoroughly analyze the practical aspects of each technical solution, considering economic feasibility and operating conditions. Future research should focus on simplifying complex systems and promoting the widespread adoption of cutting-edge technologies.

List of used literature.

1.“O‘zbekiston Respubikasi Konstitutsiyasi” T-2015 y

2.Авезов Р.Р., Орлов А.Ю. Солнечные системы отопления и горячего водоснабжения. -Ташкент.: Фан, 1988. -288с.

3.Авезов Р.Р. Повышение эффективности использования низкопотенциальных солнечных нагревателей в системах теплоснабжения. Дис. … докт.техн.наук. –Ташкент: 1990. - 447с.