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The applied research of four-quadrant converter in motor control

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ABSTRACT

Based on the phenomenon that motor was frequently burned out in application, this article aims to design a control system to solve the problem. It analyzes the function of four-quadrant converter in this system as well as key technical analysis and problem solutions, and details the feature of four-quadrant converter. In the end, the article justifies the rationality of the designed control system with combination of practical application.

KEYWORDS

Motor control; Four-quadrant converter; Control strategy.

INTRODUCTION

In the hydroelectric generating set auxiliary system, the areas related with motor control mainly include the medium-pressure oil pump in oil hydraulic system and drain pump. In drainage system, platforms like leakage sump well's deep-well pump and maintenance sump well's deep-well pump aim to achieve archival management of laboratory, which means that the mentioned normalized management documentation needs to be integrated. This platform should not only meet the management need, but also record data produced in management, as well as automatically generate normalized management documentation.

Different needs of different users toward the platform should be fully considered during designing platform. Starting from the laboratory equipment administrator, these users need to track equipment's initial information and service condition, and monitor computer hardware's damage situation and software's update condition in real time; for teaching superintendent, these users need teacher to provide experimental plan, exam score of related students as well as students' attendance rate; for teachers and students, these users need experimental plan、laboratory analysis report and the final result output. After the information needs of these different users are met, we can have a clear impression the platform which needs to be designed, and then integrate the mentioned information needs so that they can be planned into the laboratory's daily management in form of files. In this way computer laboratory archival management platform can be built.

As the main power source, electromotor plays a crucial role in daily life. Electromotor includes DC motor and AC motor in terms of power supply mode. DC motor has good starting、breaking performance and simple control, it can successfully control the motor speed just by changing DC motor's armature voltage. The motor speed control performance directly determines the machining accuracy and production efficiency. However, the DC speed control system's mechanical reversing devices (i.e. commutator and brush) generate sparks and electromagnetic interference at runtime, limiting the unit capacity and maximum speed of DC motor. In the meantime, brushes are prone to wear so the maintenance costs of system will be increased accordingly. While AC motor has no brush and relatively simple structure; so unit capacity and speed are no longer limited by brush. Before the 1960s, large-capacity power system often adopts AC motor, while speed governing system usually use DC motor.

Since the 1980s, the power electronics technology, computer technology and automatic control theory, especially various AC speed-adjustable theory represented by vector control have been developed rapidly, meanwhile the performance of various high-power power electronic components represented by IGBT have been improved significantly and all kinds of control chips have achieved rapidly development, especially the emergence of a large motor drive control chip aimed at motor drive, therefore AC variable frequency speed control system can be comparable to DC speed control system in term of performance. Meanwhile thanks to AC motor's own characteristics (simple structure, rugged, with no brush, safe), the proportion of AC variable frequency speed control system in field of speed control increase year by year; it has become the mainstream of speed control system.

PROBLEMS IN OIL PRESSURE PUMP MOTOR CONTROL

Large starting current

We can learn from the analysis of problems in oil pressure pump motor control of hydroelectric generating set auxiliary system in Songjianghe factory that this platform needs to combine comprehensive equipment、teaching with its own management. Not only the equipment's hardware information is required in equipment management, but also includes equipment's maintenance and abandonment; each laboratory information and corresponding experimental project have to be clarified in teaching management. Teachers and students can inquire experiment plan by landing; the presentation of scores and the experimental analysis report are also required. In term of platform management, different users should have different permission, so that the security and stability of platform can be ensured.

The platform designed in the paper can meet different needs of the above users, and also integrate other factors in daily management into platform, forming normalized business procedure, represented in the form of files, so it helps bringing out laboratory information conveniently and efficiently, also benefits for the normalized management of laboratory information itself and data sharing between different electronic records. These are the archival processing of laboratory information itself. Due to the real-time factor of the platform, we can track and analyze each procedure between experiment processes in real time. It not only benefits for the maintenance of the laboratory in time, but also generates historical data for the manager to inquire when there is a problem

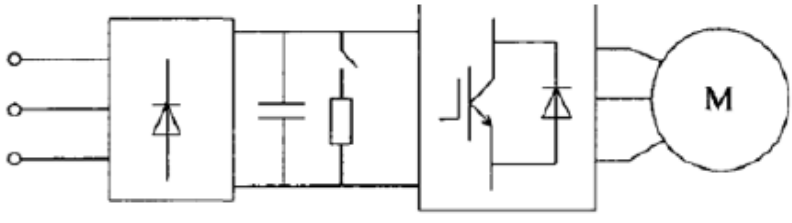

Figure 1: AC-DC-AC (uncontrolled rectifier bridge + inverter bridge) circuit schematic

Low relay protection sensitivity

The designed platform should not only meet management function, but also satisfy the following requirements to ensure the stable operation of system: Firstly, the designed platform liberate the administrator from manual management mode, normalizing working process in larger extent on the basis of improving working efficiency, therefore the platform must be stable and reliable; Secondly, the platform will be applied in universities, so it should be open, setting a solid foundation for other professional laboratory management in the future; again, humanization shall be add into the platform design due to a large number of users; the designed platform should be simple and easy to operate for users; finally, this platform database contains a large number of file information, and could be connected by internet. So security measures are crucial. Authorized specialized staff should be responsible for accessing and modifying data information when storing data.

APPLICATION OF CONVERTER IN MOTOR CONTROL

The function and electrical connection of converter

At the end of 1999, Songjianghe factory decided to select IPF-18.5 converter after careful research, analysis and investigation.

(a) The function of converter

The converter function is developed on the basis of high power rectifier elements. If there is no conflict, the experimental plan stay the same; however if the conflict exists, experimental plan should be modified by teachers. The third module is for lab reports, which includes submission of students' lab reports, teachers' review on lab reports and the final inquiry on experimental results. In this part, the platform administrators endow different users with different permissions, completing the operation of lab report. For primary system wiring, see Figure 2.

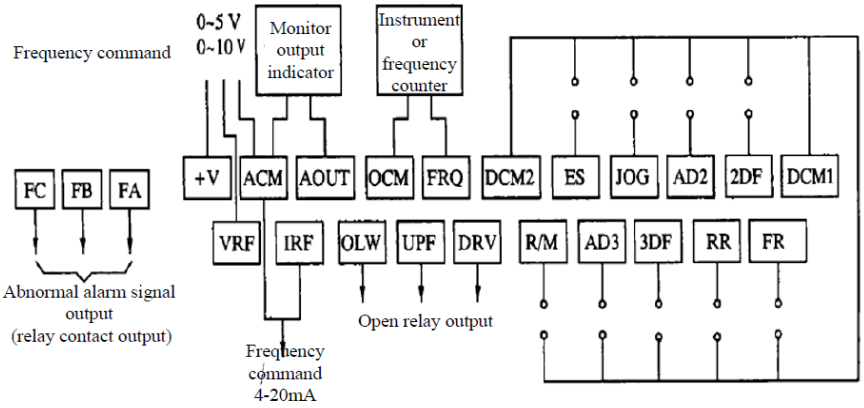

Figure 2: The secondary control power terminal connection diagram

(b) Electrical connection of converter

Finally, the above five modules can all reflect the role of the last module: system setting, which includes file setting, experiment plan approval and permission settings. This module is mainly for platform administrator. The electric records of information like lab equipment, administrator, teaching and students can be set out by file setting; plan approval can achieve the connection of experimental plan in the second module; while permission setting can help platform administrator classify users and distribute privileges.

The setting and character of converter starting frequency, acceleration time and so on

(a). This article will not discuss converter's each entity. In each entity, however, we need to pay attention to two entities. The first is the equipment code; because the equipment is not only for laboratory use, but also for registration of fixed assets in facility division, therefore this code is directly aligned with the code of fixed assets, in order to facilitate the inquiry and registration of equipment. The second is the experimental program code; this code needs to take full account of the laboratory management requirements, including the code content of experimental time, classes, curriculum and instructors.

(b). Acceleration time can be set arbitrarily In this design, the achievement of public data component is critical; this component's function is to achieve the data validation and data access. This component should include its own four classes and two classes written in addition, in which the component's own AssemblyInfo.cs class is used to specify the version information of program. This article will not discuss it.

(c). Reference voltage and reference frequency is adjustable Validator.cs class and ErrMessage.cs class is mainly used for data verification. ErrMessage.cs class is a virtual data table storing error message which mainly refers to the information when the ASPX page is error. This data sheet is provided with a total of three virtual fields that contains the

project name, project value and the error message. The purpose is to inspect data, such as returning error message through this class. The main circuit and control power terminal connection is shown as Figure 3.

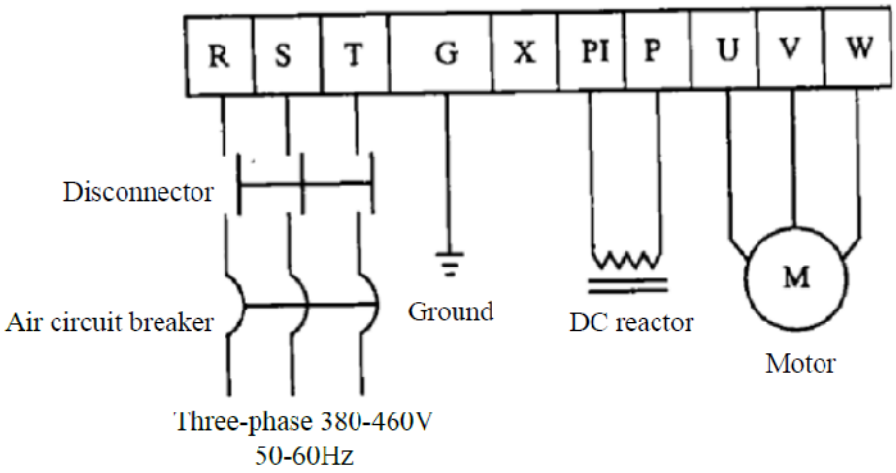

Figure 3: Main circuit and control power terminal connection

(d). Selection of command code with computer and internet prevailing continuously, computer technology improving constantly and computer hardware prices declining continuously, computer has enjoyed popularity and become an essential part of our life. In universities, laboratories is the place to experiment, known as scientific research base and the generation of technological development, and thus universities often put large investment on laboratories, such as the rapid development of computer labs in recent years. All kinds of computer labs have emerged in order to meet the requirements of study and work. And the classification has a tendency to be increasingly clear. Therefore computer lab management requires deeper-level requirement. The manager should not only manage the various laboratories equipment, but also make classified analysis on each kind of file based on optimizing computer resources, providing basis for manager to establish long-term development policy.

The main function of motor protection in converter

It should be mentioned that variable frequency starting and variable frequency operation of converter are the best protection for motor. Furthermore, it has all the protection that secondary protection system has, including the following items:

(a). Overcurrent limit (preventing stall) when the current exceeds the set current value, the change rate of frequency can be changed to limit the increase of current. Acceleration: when the output current reaches the set value, you should temporarily reduce the frequency increases or decreases the change rate of frequency, preventing stall, and accelerating by limiting current value; constant speed: if the motor overloads, the output current reaches the set value, the frequency should be reduced; when the overload condition is lifted, the frequency should return the set point. Songjianghe factory converter's limit set point is 150%I.

(b). Overcurrent protection when the current is too large and exceeds the permissible value range of converter, protective circuit will make the converter close down (converter automatically determine, without user settings).

(c). Overcurrent protection when DC loop voltage exceeds specified value due to large renewable energy of motor, the protection circuit comes into operation and stop converter. If renewable energy exceeds the consumption of braking resistor when motor decelerates, increasing DC voltage of motor, frequency changing rate will slow down and decelerate again. In addition, low-voltage protection, overload protection, incoming line protection, external thermal protection, CPU abnormality protection can all play a role in protecting motor.

Three-phase PWM rectifier adopt controlled rectifier IGBT instead of diode, achieving energy bidirectional flow. Input power factor is close to 1; the input current harmonics is small, and the output voltage is controllable. Since the 1990s, the study of its topological expansion and control strategy has attracted the attention of many scholars. Due to its superior characteristics, three-phase PWM rectifier technology not only serve as a separate feedback device, widely used in motor drive, but also become subsystem and widely used in uninterruptible power supply, high-performance DC power systems, and the new energy field, such as wind power generation, solar energy, electric cars and other occasions that related to the AC-DC power conversion. The voltage-mode and current-mode PWM rectifier schematic is shown as Figure 4.

Three-phase PWM Rectifier has many species. In term of power supply nature, at the present, the majority of university computer lab management methods are relatively lag, mainly dominated by labor management, which brought the laboratory management personnel heavy work pressure. Therefore, the development of a computer lab management platform becomes necessary. The platform can not only manage laboratory regularly and scientifically, liberating managers from heavy labor, but also provide decision-makers data for reference in a certain sense.

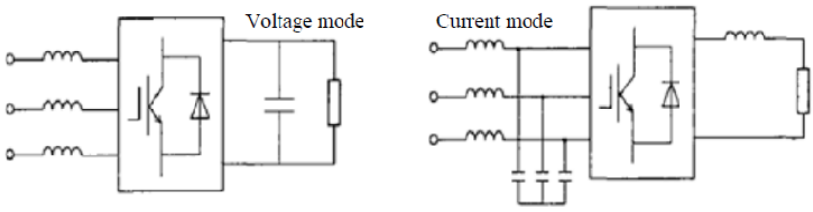

Figure 4: Voltage-mode and current-mode PWM rectifier schematic

In recent years, some the computer labs in China have developed the similar system, such as the comprehensive management system designed by Tsinghua University, which achieve fully automated management toward computer room; Central South University of Technology has developed laboratory information management system which can put equipment and network resources into rational use. It is based on Web, mainly completing computer lab automation management. At present, a certain university has designed and completed computer lab management system. Furthermore, the preliminary open laboratory management concepts have already generated, and there have been some developed commercial software for use. But these software are mostly for enterprises, not applicable for university computer laboratory, only providing reference. The lab management system abroad developed earlier and developed faster. At present it has applied three stages. The present stage pays more attention on the overall management of laboratory.

Based on the information needs of most colleges and universities at present, learning from the advanced experience and technology at home and abroad, the NET-based computer lab management platform involved in this paper, can manage laboratory scientifically and effectively. On the basis of reducing managers' work stress, the platform can effectively support the work processes, and provide effective guarantee on the normal operation of equipment and laboratories.

This platform aims to achieve archival management of laboratory, which means that the mentioned normalized management documentation needs to be integrated. This platform should not only meet the management need, but also record data produced in management, as well as automatically generate normalized management documentation.

Different needs of different users toward the platform should be fully considered during designing platform. Starting from the laboratory equipment administrator, these users need to track equipment's initial information and service condition, and monitor computer hardware's damage situation and software's update condition in real time; for teaching superintendent, these users need teacher to provide experimental plan, exam score of related students as well as students' attendance rate; for teachers and students, these users need experimental plan、laboratory analysis report and the final result output. After the information needs of these different users are met, we can have a clear impression the platform which needs to be designed, and then integrate the mentioned information needs so that they can be planned into the laboratory's daily management in form of files. In this way computer laboratory archival management platform can be built.

Moreover, the designed platform should not only meet management function, but also satisfy the following requirements to ensure the stable operation of system: Firstly, the designed platform liberate the administrator from manual management mode, normalizing working process in larger extent on the basis of improving working efficiency, therefore the platform must be stable and reliable; Secondly, the platform will be applied in universities, so it should be open, setting a solid foundation for other professional laboratory management in the future; again, humanization shall be add into the platform design due to a large number of users; the designed platform should be simple and easy to operate for users; finally, this platform database contains a large number of file information, and could be connected by internet. So security measures are crucial. Authorized specialized staff should be responsible for accessing and modifying data information when storing the data.

CONCLUSION

Based on the phenomenon that motor was frequently burned out in application, this article aims to design a control system to solve the problem. It analyzes the function of four-quadrant converter in this system as well as key technical analysis and problem solutions, and details the feature of four-quadrant converter. In the end the article justifies the rationality of the designed control system with combination of practical application. To supply a better solution, the next step is to install this kind of converter in leakage sump well's control motor (55 kW, 2 sets) and maintenance sump well's control motor (75 kW, 2 sets).

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