Journal of Education and Educational Research
ISSN: 2957-9465 | Vol. 10, No. 2, 2024

Research on the Construction of Power System Relay Protection Course System in Electrical Engineering Discipline

Tianhao Wang

College of Instrumentation and Electrical Engineering, Jilin University, Changchun 130021, China

Abstract: Power system relay protection is one of the core courses in the discipline of electrical engineering, which is directly related to the students' professional ability in the field of power system operation and protection. With the rapid development of power system, especially the popularization of smart grid technology, the existing curriculum system gradually exposes problems such as obsolete content, insufficient practical teaching, and disconnection with cutting-edge technology. By analyzing the current situation of the existing curriculum system, this paper proposes key elements such as the combination of theory and practice, the introduction of cutting-edge knowledge, the optimal allocation of teaching resources, and the innovation of teaching methods, and discusses the implementation strategy of curriculum system reform. The study aims to build a relay protection curriculum system that better meets the development needs of modern power systems, and to enhance students' practical ability and innovative thinking to meet the challenges of the future power industry.

Keywords: Power System; Relay Protection; Curriculum System; Teaching Reform; Practical Teaching; Smart Grid; Cutting-Edge Technology; Electrical Engineering Education.

1. Introduction

Electrical engineering is an extremely important discipline in the field of modern engineering, covering a variety of directions such as power systems, automation control, electronics and so on [1]. As an important part of electrical engineering, the safe and stable operation of the power system has a vital position in modern society, and power system relay protection is the key technology to ensure the safe operation of the power system[2].

With the continuous development of smart grid, distributed energy and other emerging technologies, power system relay protection technology is also being rapidly updated[3]. However, there are still many problems in the existing power system relay protection course system, such as outdated course content, insufficient practical teaching, and disconnection with cutting-edge technology[4]. These problems not only affect the learning effect of students, but also limit their competitiveness in future career development. Therefore, optimizing and reforming the power system relay protection course system has become an urgent task to improve the quality of electrical engineering education[5].

The purpose of this paper is to analyze the shortcomings of the existing curriculum system, explore how to introduce advanced technology and teaching methods in the power system relay protection course, and construct a more effective and forward-looking curriculum system to cultivate high-quality electrical engineering talents with theoretical knowledge and practical ability.

2. Analysis of the Current Situation of Power System Relay Protection Course System

As a core course in the discipline of electrical engineering, the power system relay protection course usually covers the basic principles of relay protection, the working principle of protection devices, and the treatment of common faults[6]. The course content is based on the traditional power system, focusing on the basic knowledge of current, voltage, distance protection, etc., and the theoretical teaching occupies a large proportion[7]. Although these contents are crucial for laying a solid theoretical foundation, the limitations of such traditional contents are increasingly apparent with the continuous development of power system technology. Ohm's Law (used in relay protection calculations)

$$V = IR \tag{1}$$

The course content can provide students with basic theoretical support, but the current curriculum system still has many problems[8]. First of all, the teaching content is relatively old and fails to fully reflect the rapid development of smart grid, distributed energy and other emerging technologies[9]. Secondly, the practical teaching links are insufficient, and the theoretical knowledge students learn in the classroom is difficult to be verified and strengthened through practical operation. In addition, the curriculum is relatively single and lacks comprehensive interdisciplinary teaching content, which makes it difficult to cultivate students' ability to deal with complex power system problems[10]. Power Calculation (used in relay protection settings):

$$P = VI\cos\theta \tag{2}$$

Compared with domestic colleges and universities, some well-known foreign universities are relatively more cutting-edge in the construction of power system relay protection course system. The foreign curriculum system pays more attention to the docking with the industry demand, and introduces the latest technology and application scenarios into the classroom through school-enterprise cooperation and research projects. At the same time, foreign universities pay more attention to practical teaching, with special laboratory courses, and even through virtual simulation technology for teaching, so that students can better understand and apply relay protection technology in the learning process. The

advanced nature of this teaching mode is worth learning from domestic universities.

In the actual teaching process, students' feedback on the current power system relay protection course also reflects the existing problems. Some students said that the content of the course is out of touch with the industry, which leads to the inability to directly apply the knowledge learned in the actual work after graduation. Lack of practical ability is also an important issue in students' feedback, and many students feel lack of confidence when facing practical work scenarios. In addition, the depth and breadth of the course content was also questioned by students, who felt that the existing curriculum system could not meet their learning needs for emerging technologies. Therefore, improvement of the curriculum system is imperative.

3. Key Elements in Building a Power System Relay Protection Curriculum System

When constructing the power system relay protection course system, it is necessary to comprehensively consider the updating of course content, the innovation of teaching methods and the optimization of teaching resources and other key elements. By combining theory and practice, introducing cutting-edge technology, and rationally allocating teaching resources, the teaching effect and practicality of the course can be effectively enhanced to ensure that students have the ability to cope with the complexity and technical challenges of modern power systems. The following three sections will explore these key elements in detail.

3.1. Integration of Theoretical and Practical Teaching

Theoretical knowledge is the basis for students to master power system relay protection technology. The power system relay protection course needs to systematically teach the basic principles of relay protection, the working mechanism of various types of protective devices and the protection measures under different fault conditions. These theoretical contents can help students establish a solid knowledge framework, so that they can make reasonable judgment and decision in the face of complex power system problems. Therefore, the theoretical teaching should focus on logic and systematicity, and let students deeply understand the core concepts and working principles of relay protection technology in a step-by-step manner, showed in Figure 1 :

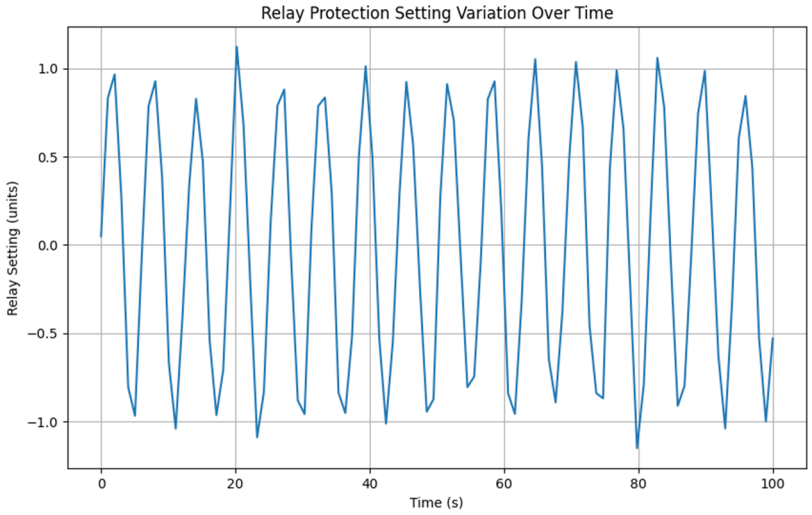

Figure 1. Relay Protection Setting Variation Over Time

However, the mastery of theoretical knowledge cannot be separated from the support of practical operation. Relying only on theoretical learning, it is often difficult for students to understand the actual operation of relay protection devices, and it is also difficult to effectively deal with complex problems in the actual work. Therefore, practical teaching links in the course system is also crucial. Through laboratory courses, field internships, simulations and other practical activities, students can apply the theoretical knowledge they have learned to real-world scenarios and improve their hands-on ability and problem-solving ability. This kind of practical teaching helps students to deepen their understanding of relay protection technology, and at the same time cultivate their comprehensive ability to deal with practical engineering problems.

In order to better combine theory and practice, the curriculum system should adopt diversified teaching modes. For example, while teaching theoretical knowledge, students can be allowed to apply what they have learned instantly through case studies and simulation experiments. In addition, project-based learning can also be used as an effective teaching tool, through the setting of real or simulated power system problems, students are required to complete the actual operation under the guidance of theory, so as to realize the organic combination of theory and practice. This teaching mode can not only improve students' learning enthusiasm, but also enhance their ability to apply knowledge in a complex environment, showed in Figure 2:

To realize the effective combination of theory and practice, it is also necessary for schools to invest more in practical teaching resources. Modern laboratory equipment, simulation software, and internship bases for school-enterprise cooperation are all important support tools for practical teaching. Through abundant practical resources, students can operate and rehearse in a near real environment, thus gaining valuable practical experience. In addition, the practical teaching ability of the teaching team needs to be improved to ensure that they can effectively guide students' practical activities. Only with the comprehensive combination of theory and practice can the curriculum system truly realize the

goal of cultivating high-quality professionals.

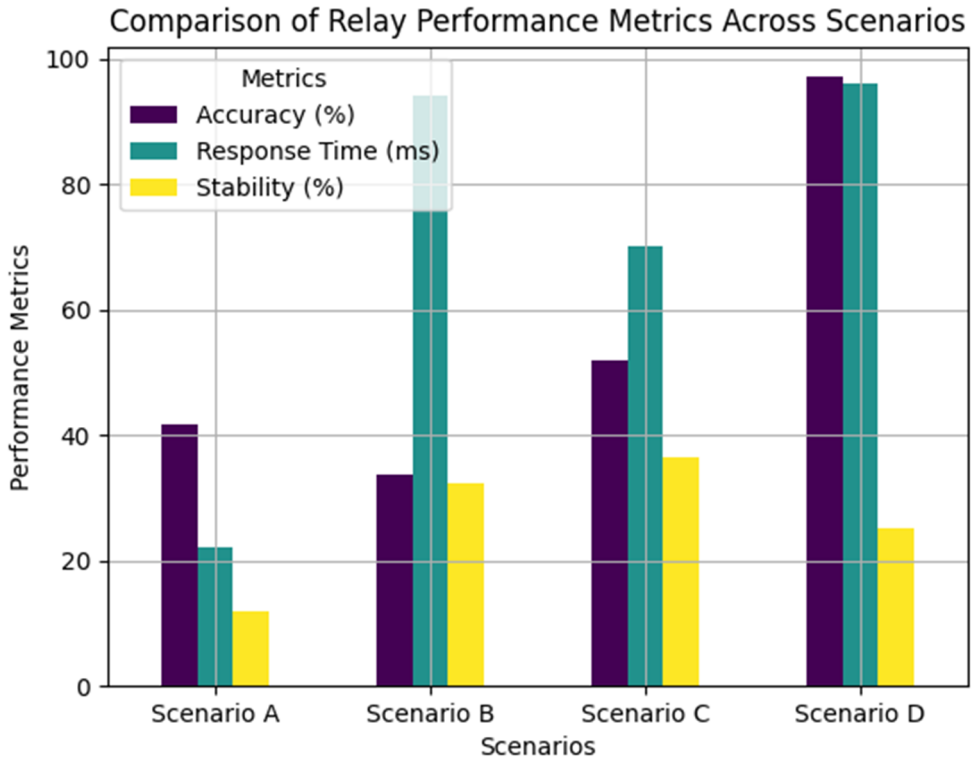

Figure 2. Comparison of Relay Performance Metrics Across Scenarios

3.2. Introduction of Cutting-edge Technology and Knowledge

With the acceleration of intelligentization and informatization of power system, new technologies such as smart grid, distributed energy, microgrid and so on are developing rapidly, and these technologies put forward new requirements for power system relay protection. The traditional relay protection technology and teaching content have been difficult to meet the development needs of the industry. In order to ensure that students can adapt to future technological changes, it is crucial to introduce cutting-edge technology and knowledge into the curriculum system. This will not only help students grasp the latest industry trends, but also enhance their ability to cope with complex power system problems, laying a solid foundation for their careers.

Smart grid technology is an important direction in the development of the current power system, involving advanced communication technology, intelligent protection equipment and automation control systems. In the relay protection course, smart grid-related content, such as intelligent terminals, digital substations, wide-area protection, etc., must be introduced to help students understand the new features and challenges of relay protection under smart grid. In addition, the widely used scenarios and cases of smart grid can also be used as teaching materials so that students can better understand the application of theoretical knowledge in practice and further enhance their innovative thinking and adaptability.

The popularization of distributed energy sources and microgrid technologies has posed new challenges to traditional power system relay protection, such as the diversity and complexity of protection schemes. Therefore, it is particularly important to integrate the impact of distributed energy access on power system relay protection and microgrid protection strategies into the course. The introduction of these cutting-edge knowledge not only enables students to understand the future changes in power systems, but also develops their ability to analyze and solve complex problems. In addition, through actual cases and simulation experiments, students can understand the practical application and operation principles of these new technologies more intuitively.

In order to keep the curriculum cutting-edge and practical, the teaching content should be updated in tandem with the development of the power industry. This requires educational institutions to maintain close contact with enterprises and research institutes, regularly update the syllabus, and incorporate new technologies, equipment and standards into the curriculum in a timely manner. At the same time, students can be helped to better understand the practical application scenarios of cutting-edge technologies by inviting industry experts to give special lectures or carry out school-enterprise cooperation programs. This dynamic adjustment and industry integration will keep the curriculum system at the forefront of the industry and ensure that students are equipped with the latest technical knowledge and practical skills.

3.3. Optimizing the Allocation of Teaching Resources

The optimization of teaching resources is first reflected in the updating of teaching materials and content. Existing teaching materials often focus on traditional relay protection technology, which is difficult to reflect the latest development of modern power systems. Therefore, it is crucial to update the content of teaching materials and introduce the latest technical information and industry standards. At the same time, teachers should revise the syllabus regularly according

to industry needs and technology frontiers, and integrate the content of smart grid, distributed energy and other emerging technologies into the course system. This dynamic updating of teaching materials and teaching content helps students learn the most cutting-edge technological knowledge and improves the practicality of the course.

In order to improve the practical ability of students, it is necessary to optimize the experimental teaching resources and upgrade the experimental equipment and laboratory facilities. Traditional relay protection experimental equipment is often limited to simulating simple power system faults, and cannot meet the experimental demand for complex protection schemes of modern power systems. Therefore, the university should invest funds to purchase advanced relay protection testing devices, smart grid simulation systems and other equipment. At the same time, multifunctional laboratories or virtual simulation platforms are established to allow students to perform experimental operations in a more realistic environment. The upgrading of such equipment and facilities can significantly improve the effect of practical teaching and enable students to better understand theoretical knowledge in hands-on operation.

The optimization of teaching resources is also reflected in the construction of the teaching staff. Power system relay protection technology is constantly developing, and teachers must keep their own knowledge up-to-date in order to effectively teach cutting-edge knowledge. Therefore, the university should provide more opportunities for teachers to further their education and training, and encourage them to participate in industry conferences, scientific research projects and enterprise practice. In addition, the professionalization and practical experience of the teaching force can be enhanced through the introduction of industry experts and joint training. This will not only improve the quality of teaching, but also inject more innovative thinking and practical examples into the curriculum system.

In order to better combine theory and practice, schools should actively establish cooperative relationships with electric power enterprises and build off-campus practice bases. Through school-enterprise cooperation, students can have the opportunity to go deep into the enterprise to participate in actual projects and understand the actual application process of relay protection technology. At the same time, enterprise experts can come to school regularly to carry out lectures or training, providing students with the latest industry trends and technical guidance. In addition, school-enterprise cooperation can also promote the updating of teaching materials and course content, so that the curriculum system is closer to the industry needs. The construction of practice bases, on the other hand, provides students with more internship opportunities and enhances their hands-on ability and employment competitiveness.

4. Implementation Strategies for Reform of Power System Relay Protection Curriculum System

In order to make the power system relay protection course better adapt to the development needs of the industry, the optimization and updating of the course content is the first task of reform. Schools should review and adjust the course content regularly according to the development trend of power system technology. For example, the relevant knowledge of cutting-edge technologies such as smart grid, distributed energy, microgrid, etc. should be added to the curriculum to ensure that students can learn the latest technical theories. In addition, more case studies and project practices should be introduced to help students better understand complex power system problems and improve their problem-solving abilities. Through the continuous optimization of the course content, the course system will be more comprehensive and practical, and will be able to better meet the learning needs of students.

Teachers are the core driving force of the curriculum reform, so the construction and training of the teaching force is crucial in the reform. In order to ensure that teachers are capable of teaching the new curriculum system, schools should provide teachers with more training opportunities, including attending industry conferences, academic exchanges, and practice in enterprises, etc., so as to help them keep abreast of the latest developments and technologies in the industry. At the same time, the school can also further improve the professional level of the teacher team by introducing industry experts and engineers with rich practical experience. In addition, encouraging teachers to participate in scientific research projects and topics will also help improve their teaching level and scientific research ability, thus better serving the needs of curriculum reform.

Practice teaching is an important part of the reform of relay protection course system, so the construction of practice teaching base is crucial. Schools should strengthen cooperation with electric power enterprises, establish off-campus practice bases, and provide abundant internship and practice opportunities, so that students can apply what they have learned in the actual engineering environment. At the same time, schools should also upgrade the conditions of on-campus laboratories, purchase advanced experimental equipment, and develop virtual simulation platforms to simulate faults and protection operations in real power systems, so as to enhance students' practical operation capabilities. This multi-level practical teaching system will effectively enhance the comprehensive quality and hands-on ability of students, so that they can better adapt to the future working environment.

In order to ensure the effectiveness of the reform of the curriculum system, it is indispensable to establish a scientific evaluation mechanism of students' learning effects. The traditional evaluation method is usually based on written tests, focusing on the assessment of theoretical knowledge and neglecting the assessment of practical ability and comprehensive quality. The reformed evaluation mechanism should be more diversified, combining theoretical examination, practical operation assessment, project report and teamwork evaluation to comprehensively examine students' learning outcomes. In addition, a dynamic feedback mechanism can be introduced to continuously improve and refine the course content and teaching methods by regularly collecting feedback from students and enterprises. This scientific evaluation mechanism will ensure the implementation effect of the curriculum reform and promote the overall development of students.

5. Conclusion

As a core course in the discipline of electrical engineering, the construction and reform of the curriculum system of power system relay protection is of great significance for cultivating high-quality professionals. By analyzing the deficiencies of the existing curriculum system, this paper puts

forward the reform ideas in the combination of theory and practice, the introduction of cutting-edge technology, and the optimization of teaching resources. Through systematic reform measures, students' theoretical knowledge, practical ability and innovative thinking can be effectively enhanced to help them better cope with the challenges of the future power industry.

At the same time, the construction of the curriculum system is a dynamic development process, which needs to keep pace with the development of the industry and technological progress. The future curriculum reform should pay more attention to the cooperation with enterprises, continuously introduce the latest technical content, optimize the teaching mode and evaluation mechanism, and ensure the cutting-edge and practicality of the curriculum system. Through continuous improvement and refinement, the power system relay protection course system will better serve the development of the electric power industry and cultivate more high-quality engineering talents to meet the needs of the times.

References

[1] Henzinger T A , Sifakis J .The Discipline of Embedded Systems Design[J].Computer, 2007, 40(10):32-40.DOI:10. 1109/ MC.2007.364.

[2] Shooter S , Mcneill M .Interdisciplinary Collaborative Learning in Mechatronics at Bucknell University[J].Journal of Engineering Education, 2002, 91(3):339–344.DOI: 10.1002/j. 2168-9830.2002.tb00712.x.

[3] Brawner C E , Camacho M M , Lord S M ,et al.Women in Industrial Engineering: Stereotypes, Persistence, and Perspectives [J]. Journal of Engineering Education, 2012, 101(2): 288-318.DOI:10.1002/j.2168-9830.2012.tb00051.x.

[4] Joos G , Marceau R J , Scott G ,et al.An innovative industry-university partnership to enhance university training and industry recruiting in power engineering[J].IEEE Transactions on Power Systems, 2004, 19(1):24-30.DOI:10.1109/ TPWRS. 2003.821015.

[5] Castles R T , Zephirin T , Lohani V K ,et al.Design and Implementation of a Mechatronics Learning Module in a Large First-Semester Engineering Course[J].IEEE Transactions on Education, 2010, 53(3):445-454.DOI:10. 1109/TE. 2009. 2027 333.

[6] Radojevi Z , Terzija V .Effective Two-terminal Numerical Algorithm for Overhead Lines Protection[J].Electrical Engineering, 2007, 89(5):425-432.DOI:10.1007/s00202-006-0014-6.

[7] Gero A .Enhancing systems thinking skills of sophomore students: An introductory project in electrical engineering [J]. International Journal of Engineering Education, 2014, 30(3): 738-745.

[8] Deshpande V K , Singh K .Influence of eutectic addition on the electrical conductivity of Li 2 O:B 2 O 3 system[J].Bulletin of Materials Science, 1986, 8(5):577-580.DOI:10. 1007/ BF027 44357.

[9] Hoddinott J , Young D .Generic Skills Teaching in Materials Science and Engineering[J].Journal of Engineering Education, 2001, 90(4):707–711.DOI:10.1002/j.2168-9830.2001. tb0066 2. x.

[10] Yadav, Suneel,Upadhyay,et al.Performance of Three-Phase Analog Network Coding with Relay Selection in Nakagami-m Fading [J].IEEE communications letters, 2013, 17(8):1620-1623. DOI:10.1109/LCOMM.2013.060513.131076.