Design and Development of Electric Locomotive Converter Technology Integrated Experiment Platform

Rui Chen¹, Shudong Wang¹, Chao Liang¹, Shuo Zhao¹ and Yongyong Wu¹

College of Electrical and Information Engineering, Lanzhou University of Technology, Lanzhou, Gansu, 730050, China

*Corresponding author’s e-mail: 1090118371@qq.com

Abstract: Devices for power electronic technology experiment are generally backward and fail to satisfy the need of teaching and technology development nowadays. The design and manufacture of comprehensive experimental platform combined with traditional experiment and advanced electric locomotive converter technology. This platform realized the operation of converter system of electric locomotive. The platform is used for experimental operation of undergraduate and research and innovation of graduate.

1. Introduction

Power electronic technology as a multi-discipline cross discipline, its application field is from traditional roles to more extension exhibition sunrise industry, especially in the field of locomotive traction and rail transit successfully applied as a result, some complex control algorithm is applied to the field of power electronics control, such as nonlinear adaptive fuzzy logic control the use of these complex control algorithm, makes the work performance of power electronic technology to change, is suitable for the development of more fields [1] therefore, for the power electronic technology basic knowledge teaching, more can't be ignored However, at present, the experimental teaching of power and electronic technology course is still in the stage of the teacher's verification of a single knowledge point, which seriously ignores the cultivation of students' hands-on ability and innovation ability and carries out necessary experimental reform to meet the needs of The Times.

2. Problems existing in traditional experiments

The implementation of the experiment needs the support of experimental equipment and experimental platform. The design and development of the experimental platform need to be combined with two aspects. The second is the combination of experiment and practical engineering [2] only in this way can the effects of the experiment be truly brought into play:

1) Traditional power electronic experiment combined with experimental platform for the problem of the traditional power electronic rectifier inverter circuit, not only on books have image display and itself has specific image, easy to remember, easy to be accepted by the students' cognitive, but in practical application process has been basically realize modular encapsulation [3] so the design of the experimental platform, to give attention to two or more things traditional components of the form, and to highlight the application and practice of related modules.

2) How to carry out the power electronic technology experiment, lets the student to master the knowledge of the power electronic technology from the hard and software from the hardware platform, the current experiment is to introduce students to the working process of the circuit, and not able to
make students participate in the circuit device performance analysis of the working process of the main circuit analysis and dynamic analysis, the simulation and the simulation experiment is blank according to the research idea, students should choose their interested in in-depth analysis, thus forming his unique research method, it needs to have a good experimental platform for support.

3) How to integrate the new technology into the experiment the application field of power electronics technology is expanding continuously and the electromagnetic compatibility and energy saving of smart grid are developing rapidly. At the same time, with the development of power devices, power electronics technology has played a role in promoting the development of electric locomotives in view of this situation, the design of the experimental platform should be combined with the current popular practical projects while leaving an interface for upgrading and further expansion.

3. Experimental platform design
In light of the deficiency of the power electronics experiment platform, the research of power electronic technology experiment principle and development trend, on the basis of considering the actual needs of experimental teaching, and with the rapid development of electric locomotive converter technology, the combination of integrative innovation has been designed electric locomotive converter technology experimental platform for electric locomotive converter technology design and development of comprehensive experimental platform mainly includes alternating rectangular transmission system circuit design, platform design and remote monitoring platform design three parts experiment platform diagram is shown in figure 1.

Fig.1 schematic diagram of comprehensive experimental platform for electric locomotive converter technology

3.1. Main circuit design of ac and dc transmission system
The main circuit of the ac/dc transmission system mainly includes four quadrant rectifier intermediate link four quadrant inverter induction motor and five modules of signal acquisition circuit, as shown in figure 2.
1) Four quadrant four quadrant rectifier inverter hardware design with intelligent power module SPM45 series, in order to improve experiment platform should use sex, therefore adopts the modular design method, the four quadrant sorting machine and four quadrant inverter alone made into two independent sandwich plate, and is equipped with convenient connection interface connected with other parts.

2) Acquisition circuit and control circuit design in order to ensure the system can work in two kinds of working condition, traction brake needs of four quadrant the whole flow of the intermediate links, and four quadrant inverter to collect the information of the voltage and current sampling circuit design is very important to the system design process, hall-effect sensor module USES the voltage type and current type of hall sensor module for testing the circuit principle diagram as shown in figure 3 is shown in figure 4.

Figure 4 is the schematic diagram of the current acquisition circuit. The linear current sensor ACS712 based on hall effect is adopted to measure the current. ACS712 both ac and dc can be measured. The output voltage is proportional to the measured ac or dc, and proportional to the chip's power supply voltage, which is convenient for software calculation.

The power module is designed to supply power to each module of the experimental platform. The dc voltage required by the experimental platform is 3.3v, 5v and 15v, among which the dc 5v voltage provides voltage for the intelligent power chip current sensor and the operational amplifier, which is provided by the external switching power module.3.3v power supply for main chip. The intelligent power chip is provided with electric voltage. The voltage is PTN78000W, which converts 5v voltage into 15v dc power module, as shown in figure 5.

4) In the whole process of circuit design, the selection of ac side inductance and dc side capacitance is of vital importance. For ac side inductance, its size will affect the power factor of the whole system,
dc side voltage and other aspects of the output power of the system:

\[
\frac{(2U_{dc} - 3e_m) e_m T_s}{2U_{dc} \Delta i_{max}} \leq I \leq \frac{2U_{dc}}{3i_m \omega} \quad (1)
\]

Where, \( e_m \) is the peak voltage of the power grid; \( T_s \) is the control switching cycle of the rectifier; \( i_m \) is the base wave peak value of the grid side phase current. Maximum allowed \( \Delta i_{max} \) to harmonic current.

Through a large number of experiments and theoretical formula calculation, 2 m h was selected as the experimental platform.

For the dc side capacitance, the choice of its model directly affects the dc side voltage tracking to a given voltage and the stability of the output voltage:

\[
\frac{1}{2 \Delta U_{dc} R_L} \leq C \leq \frac{T_r}{0.74 R_L} \quad (2)
\]

Type, \( \Delta U_{dc} \) to dc voltage maximum dynamic change; \( T_r \) is the time required for the dc side voltage value to determine the steady-state voltage.

Through a large number of experiments, combined with the theoretical formula calculation, the experimental platform to choose 2800 μF.

3.2. Control circuit design of ac and dc drive system

The dynamic control single mining with mesh before into STM32F4 as the core control chip, adopts IFCO indirect field-oriented control method and SVPWM modulation type, output PWM wave, complete control of the hand in rectangular transmission main electrical path and using CAN bus to complete the data transmission control circuit of the hardware system block diagram as shown in figure 6 considering the experiment system of gradation and the characteristics of the secondary development, the modular design of main circuit module, then on System main circuit different parts of the line control.

![Control circuit system diagram](image)

Fig.6 control circuit system diagram

3.3. Remote console design

In order to realize the control of the ac and dc system, it is necessary to carry out real-time monitoring of key parameters in the operation process. If fault is found, the indicator light of fault will turn on in time to facilitate the timely detection and treatment of fault. Meanwhile, the monitoring system has the function of saving data output data. The data in the experimental process are exported to the excel table for further research. The design of this part mainly adopts the Lab VIEW developed by NI company to compile the upper computer interface [5], as shown in figure 7.
4. Advantages of experimental platform

4.1. Application level extensiveness
This experimental platform is not only applicable to major majors of power electronics courses, such as electrical engineering and automation, but also applicable to other non-major majors, such as electronic information engineering. At the same time, it can not only satisfy the outstanding undergraduate students to expand the experiment, but also satisfy the graduate students to innovate in scientific research.

4.2. Extensibility
This experimental platform in the process of design, considering the different levels of the experimenter, in the process of design, will pay the rectangular main circuit part of the drive system has carried on the modular design, it can be divided into four quadrant rectifier part of the inverter and motor control part, and each part has its own core control module, this can be either a separate experiment, and various modules can be connected to a comprehensive experiments at the same time, using programmable devices to design, students can according to the experimental purposes and requirements, to write programs for undergraduate students and graduate students to carry out scientific research innovation.

4.3. Innovativeness
Innovative fills the experiment project and electric locomotive converter technology of combining the blank of this experimental platform, with reference to the locomotive train with typical circuit of current transformer, producing electric locomotive converter circuit model of the power electronic technology curriculum knowledge combined with the actual electric locomotive converter technology, effectively make up for the inadequacy of field practice teaching link, fully arouse the enthusiasm of students learning in the process of experiment, begin to do, want to method was verified by thinking innovation to verify the experimental analysis results of the four process, greatly improve the quality of teaching.

5. Conclusion
Power electronic technology as a multi-discipline cross discipline, is also the foundation knowledge of a variety of new project, so for the electric power electronic technology knowledge teaching quality must be improved, keep up with the forefront of The Times is the only way to improve students' practical ability, solve the students knowledge and the actual project phase out of the question for the design of the electric locomotive comprehensive experiment platform, can greatly improve the quality of teach, effectively will be the mainstream of the electric locomotive converter technology combined with power electronic technology knowledge to students majoring in electrical have a more intuitive
understanding of power electronics technology knowledge, more profound understanding and more practical application.

**Reference**

[1]. Ying Yang. Student-oriented innovation of electronic technology experimental course teaching [J]. Lab research and exploration, 2010, 29 (6) : 80-83.

[2]. Zhidong Wang, Zhuoyong Liang, Gang Wang. Experimental support platform for microcomputer and network communication in electrical engineering [J]. Journal of power systems and automation, 2010, 22 (4) : 151-155.

[3]. Mei Liang. Research and construction of integrated experimental platform for power electronics technology [J]. China modern educational equipment, 2012, 15 (13) : 16-17.

[4]. Jiangtao Zhou. Development of ac-dc integrated transmission test platform [D]. Chengdu: southwest jiaotong university, 2011.

[5]. Rujin Dong. Experimental study on online motor monitoring system based on Lab VIEW [D]. Shanghai: east China university of science and technology, 2011.