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Research on the Teaching Content of Power Electronics for the Major of Building Electricity and Intelligence

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Abstract: The present teaching content of the power electronics course is insufficient to cover the power electronics technology used in building electrical engineering. This paper analyzes the relationship between building electrical engineering and power electronics technology, investigates the main power electronics technology used in building electrical engineering, introduces the teaching content of current power electronics course, analyzes the insufficiency of current teaching content related to the practice of electrical engineering, and proposes the principles and directions for the reformation and innovation of the teaching content of the course of power electronics for the major of building electricity and intelligence.

Keywords: Teaching content; Power electronics; Building electricity

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1. Introduction

In recent years, the construction industry in China is facing both challenges and opportunities. By the end of 2023, the urbanization rate of China was close to 66.2% [1]. China's urbanization growth rate will gradually decrease. The construction industry in China will decelerate as well, which is a major challenge for the industry. On the other hand, new opportunities have arisen for the construction industry with the proposal of the carbon peaking and carbon neutrality goals. The carbon emissions generated by the buildings are about 32% of total carbon emissions globally [2]. There are many new technologies to reduce buildings' carbon emissions from the building electricity perspective, such as the renewable energy power generation, the direct current electrical system, and the full electrification of building energy. The major of building electricity and intelligence is a new major emerging with the rapid development of electrical and information technology. It is oriented to the building electrical engineering. Power electronics technology is very important in the building electrical engineering. It is particularly important for improving energy efficiency and reducing

carbon emission.

2. Power electronics and building electrical engineering

2.1. Introduction to power electronics

Power electronics studies the conversion and control of electrical energy using power electronic devices. The power electronic devices such as MOSFET, IGBT and passive components such as power transformers, inductors and capacitors can be used to form the main circuit of a power electronic converter. Additionally, the converter also includes control circuits, drive circuits, detection and protection circuits, etc.

2.2. Application of power electronics technology in building electrical engineering

2.2.1. Building lighting

The light sources in building lighting include gas discharge lamps and light-emitting diodes (LEDs), both of which cannot be directly driven by the AC grid. Electronic ballast, a resonant power inverter, are widely used to drive the gas discharge lamp. LED must be driven by a constant current source power converter. By controlling the output current of the ballast or the constant current source, a wide dimming range can be achieved for the light sources, and its carbon reduction effect is obvious [3].

2.2.2. Reactive power compensation

Reactive power compensation is very important for the building electrical engineering. The conventional reactive power compensation devices used in building electrical engineering are mainly capacitors. New reactive power compensators based on power electronics technology are increasingly used in building electrical engineering, such as static var compensators (SVC) and static var generators (SVG) shown in Figure 1.

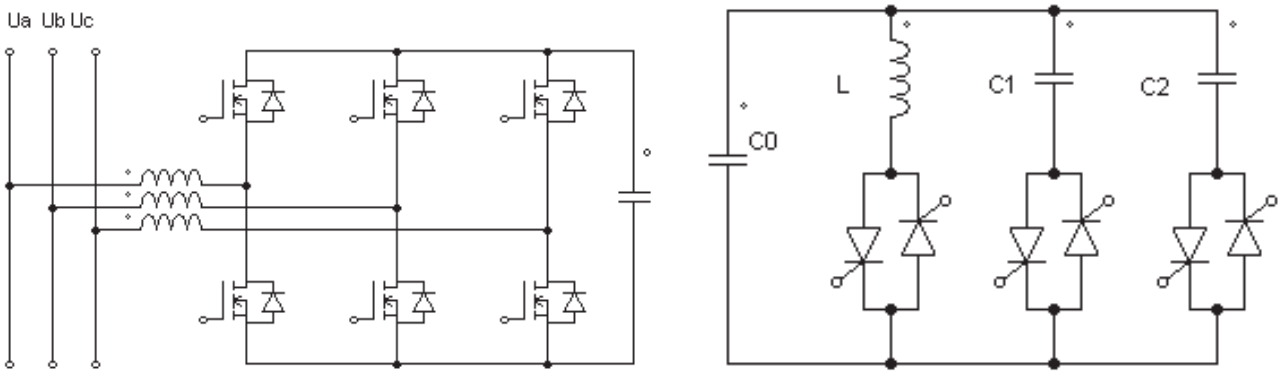

Figure 1. Main circuits of SVC (a) and SVG (b)

2.2.3. Power quality improvements

Improving power quality can boost the operational conditions of the power system load, increase its efficiency, and reduce harmonic losses in lines, trans-formers, and electrical equipment [4]. Therefore, it is of great significance for the implementation of the carbon emission strategy. The commonly used power quality control equipment in building electrical engineering includes active power filter (APF), dynamic voltage

restorer (DVR), etc.

2.2.4. Building PV systems

Photovoltaic power generation directly generates electricity using solar energy. The power generation process is zero carbon emissions and does not consume any fuel. Photovoltaic power generation combined with buildings, such as Building Auxiliary Photovoltaic Power Generation System (BAPV) and Building Integrated Photovoltaic Power Generation System (BIPV) are important forms of photovoltaic power generation [5].

The power electronic converters used in photovoltaic power generation include photovoltaic controllers, photovoltaic power optimizers, photovoltaic inverters, etc.

3. Course content and analysis of power electronics

Although the contents of the most widely used power electronics textbooks are not identical, there is no significant difference [6–8]. This paper takes reference [7] as an example to analyze the teaching content.

3.1. Content of power electronics textbook

Figure 2 shows the content of reference [7].

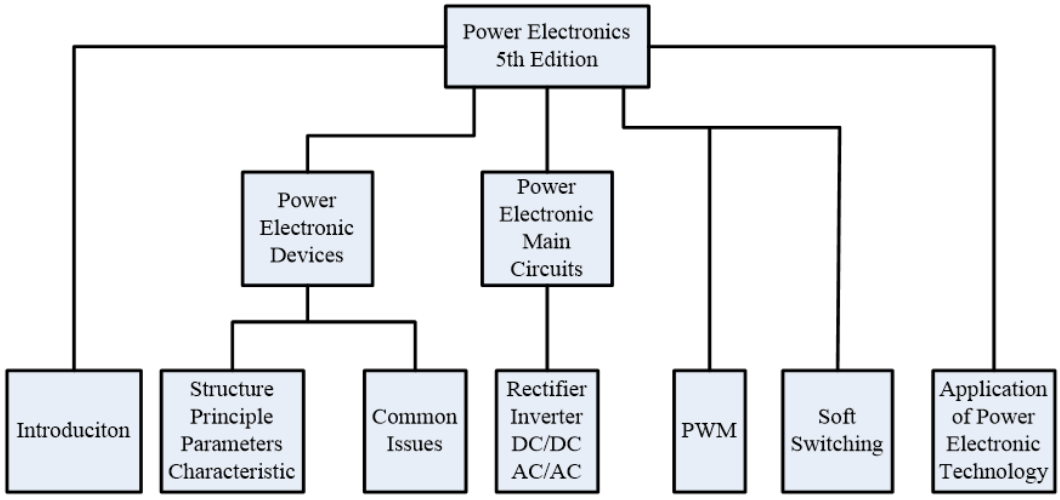

Figure 2. Content of power electronics textbook

The contents of the textbook include power electronic devices, power electronic circuits, PWM and soft switching, and the application of power electronic technology. The proportion for each section is shown in **Table 1**.

Table 1. Proportion of content of power electronics textbook

Content	Introduction	Devices	Main circuit	PWM soft switching	Application
Percent (%)	3.8	13.8	50.2	14.2	18.0

From **Table 1**, it can be seen that power electronic circuits are the core content of the entire course. It

accounts for about half of the total course content. This part is further divided into rectifier, inverter, DC/DC converter, and AC/AC converter. The proportion of these four parts in power electronic circuits is shown in **Table 2**.

Table 2. Proportions of content of power electronics main circuit

Content	Rectifier	Inverter	DC/DC	AC/AC
Percent (%)	45.0	18.3	17.5	19.2

The rectifiers account for 45% of the teaching content of power electronic circuits. In the four parts of power electronic circuits, thyristor-based converter circuits are involved in rectifier circuits, inverter circuits, and AC-AC converter, accounting for about 80% of the power electronic circuit section.

3.2. Analysis of content of power electronics textbook

Based on the analysis above, it can be concluded that there are the following issues with the current teaching content of power electronics course: The teaching content is outdated and fails to reflect the latest developments in power electronics technology. The content of power electronic systems is insufficient. The teaching content of power electronics technology focuses on power electronic devices and power electronic converter circuits, which is incomplete for a power converter. The content is not closely connected to the major of building electricity and intelligence. Most of the power electronics technology used in building electrical engineering investigated in this paper are not covered in the textbook.

4. Innovation and reformation of content of power electronics course

The content of power electronics course should be reformed in the following aspects.

Delete outdated content and incorporate the latest achievements of power electronics. Transfer the teaching content from the thyristors and their converter circuits to controllable switches and their converter circuits.

Add the content related to power electronic systems including driver circuit design, transformer and inductor design, heat dissipation calculation and small signal control model of power electronic converters.

Add the applications of power electronics technology in building electrical engineering investigated in this paper and disperse them to each chapter rather than a concentrated introduction at the end of the course.

5. Conclusion

This paper studies how to innovate the teaching content of power electronics course for the major of building electricity and intelligence to meet the new requirements on building electrical engineers. This paper firstly investigates the application of power electronics technology in the building electrical engineering. Secondly, by analyzing the teaching content in the mainstream textbooks of power electronics, problems of the teaching content were identified. Finally, measures for reforming the teaching content were proposed from several aspects, including updating teaching content, improving textbook structure, strengthening the connection between power electronics theoretical teaching, and building electrical engineering practice.

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Disclosure statement

The author declares no conflict of interest.

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