

"Power Electronics Technology" Curriculum Syllabus Based on Professional certification of Engineering education

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Abstract

This paper introduces the syllabus of "Power Electronics Technology" based on engineering education professional certification. According to the graduation requirements, the curriculum teaching objectives have been designed, the theoretical and experimental teaching contents have been revised according to the curriculum objectives, the curriculum objective evaluation standards have been formulated, and the evaluation methods for achieving the curriculum objectives have been specified. The syllabus is oriented towards teaching results and centered on student cultivation, promoting continuous improvement in the teaching of the course "Power Electronics Technology".

Key words

Professional certification, Engineering education, Power Electronics Technology, syllabus, Course objective evaluation

I. Introduction

Many countries have implemented professional certification for engineering education, and it has been proven that professional certification has a great promoting effect on the development of engineering education[1,2,3]. Establishing a professional certification system for higher engineering education is of great significance for improving the international competitiveness of China's higher engineering education and ensuring the quality of engineering education[4, 5].

In 2006, with the approval of the Higher Education Department of the Ministry of Education, a "Pilot Working Group for Certification of Electronic Information and Electrical Engineering" was established to carry out certification work in electrical engineering and automation, electronic information engineering, communication engineering, automation, and other majors[6, 7]. In 2020, the National Engineering Certification Commission approved the certification of the electrical engineering and automation of Yangtze University.

"Power Electronics Technology" is the core course for electrical engineering and automation. In accordance with the requirements for professional certification in engineering education, we have revised the syllabus of Power Electronics Technology. Based on the support of the curriculum for graduation requirements, the curriculum objectives, curriculum content, experimental content, and analysis criteria for achieving the curriculum objectives have been designed. Achievement-oriented, student-centered, and promoting continuous improvement in the teaching of Power Electronics Technology.

II. The nature of the course

"Power Electronics Technology" is a compulsory course for electrical engineering and automation. Power electronics technology is an interdisciplinary technology that utilizes power electronic semiconductor devices to transform and control electrical energy, including the transformation of voltage, current, frequency, and phase. Power electronics technology consists of three parts: power electronic devices, power electronic circuits, power electronic systems and their controls. This course focuses on the basic principles of electric energy conversion circuits. "Power Electronics Technology" is an important professional basic course for electrical engineering and automation.

III. Objectives of the course

1. Familiar with the characteristics, main parameters, driving and protection of power electronic devices, familiar with the composition of single-phase controllable rectification and three-phase controllable rectification circuits, understand their working principles, and understand the types of trigger circuits; Understand the composition of AC voltage regulating circuits and their working principles, and understand the composition of switching power supplies; Familiar with the composition of frequency converters and understand their working principles. (Supporting Graduation Requirements 1.3)

2. Be able to correctly identify and select power electronic devices, establish and debug single transistor trigger circuits and simple DC speed

regulation systems; Be able to inspect and repair switching power supplies, be able to use and maintain frequency converters, and learn to collect, read, and utilize information. (Supporting Graduation Requirements 2.2)

3. Be able to determine the performance indicators of electrical equipment and power systems according to production practice requirements, and design unit module circuits of electrical equipment and power systems that meet user needs. (Supporting Graduation Requirements 3.2)

Table1 Course objectives and graduation requirements

Objectives	Graduation requirements
objectives 1	1.3 Be able to apply relevant knowledge and mathematical model methods to deduce and analyze engineering problems in electrical engineering and automation.
objectives 2	2.2 Be able to correctly express complex engineering problems based on power system theory and mathematical model methods, recognize that there are multiple solutions to engineering problems, and seek the optimal solution through literature research.
objectives 3	3.2 Be able to design each unit module of the system according to the specific performance index requirements of electrical equipment and power system.

IV. Theoretical teaching content

The content of the course covers various power electronic devices, DC/DC, DC/AC, AC/DC, and AC/AC power conversion circuits, auxiliary devices and control systems in power electronic conversion systems, resonant conversion circuits, and application technologies of power electronics technology in power transmission, power control, and power compensation.

During the teaching process, attention should be paid to the connection with the basic knowledge of the prerequisite courses. Through the learning of this course, students are trained to:

1. Understand the development overview, technical trends, and new application fields of power electronics technology.
2. Understand and be familiar with the working mechanism, electrical characteristics, and main parameters of commonly used power electronic devices.
3. Understand and master the basic working principle, circuit structure, electrical performance, waveform analysis methods, and parameter

calculation of power electronic circuits, and be able to conduct preliminary system design.

4. Have certain ability in power electronic circuit experiments and debugging.

Table2 content, class hours, and course objectives

NO	Teaching content	Hours	Objectives
1	Overview of Power Electronics Technology	2	objectives 1
2	Power electronic semiconductor devices	2	objectives 1
3	Non isolated DC converter circuit	6	objectives 2,3
4	Isolated DC converter circuit	6	objectives 2,3
5	DC/AC inverter circuit	6	objectives 2,3
6	AC/DC conversion circuit	8	objectives 2,3
7	AC/AC conversion circuit	4	objectives 2,3
8	Soft switching technology	4	objectives 1,2
9	control circuit	4	objectives 1,2
amount		42	

Chapter1 Overview of Power Electronics Technology

1. Concept of Power Electronics Technology
2. Main Contents of Power Electronics Technology Research
3. Overview of the Development of Power Electronics Technology
4. Application of Power Electronics Technology

Key points of this chapter:

Understand the concept of power electronics, the main content of research, and the development and application of power electronics technology research.

Ability:

Be able to use the basic concepts and models of power electronics technology to analyze complex engineering problems in power electronics technology.

Chapter2 Power Electronic Devices

1. Overview of Power Electronics
2. Uncontrolled device - power diode
3. Semi-controlled device - thyristor
4. Fully controlled device
5. Power integrated circuit
6. Protection of power electronic devices

Key points of this chapter:

Master the structure of thyristor and understand its working principle;

Familiar with the basic characteristics of power electronics;

Master the main parameters of power electronic devices.

Ability:

Be able to use the basic concepts, models, and main performance indicators of power electronics devices to analyze complex engineering problems in power electronics.

Chapter3 Non Isolated DC Converter Circuits

1. Buck converter

2. Boost converter

3. Buck-Boost converter

Key points of this chapter:

Focus on mastering the structure, working principle, and main quantitative relationships of three basic DC conversion circuits; Master basic waveform analysis, parameter calculation, and basic circuit design methods of DC chopper circuits.

Ability:

Be able to use the basic concepts, models, and main performance indicators of DC/DC converter circuits to analyze complex engineering problems in power electronics technology.

Chapter4 Isolated DC Converter Circuit

1. Forward converter

2. Flyback converter

3. Push-pull converter

4. Half bridge converter

5. Full bridge converter

Key points of this chapter:

Focus on mastering the structure, working principle, and main quantitative relationships of forward converter, flyback converter, and push-pull converter, waveform analysis, parameter calculation, and basic circuit design methods;

Ability:

Be able to use the basic concepts, models, and main performance indicators of isolated DC converter circuits to analyze complex engineering problems in power electronics technology.

Chapter5 DC/AC Conversion Circuit

1. Inverse concept

2. Voltage source inverter circuit

3. Current source inverter circuit

4. Multiple inverter circuit

Key points of this chapter:

Master the working principle, waveform analysis, and basic circuit design methods of voltage source inverter circuits;

Master the working principle of current source inverter circuit.

Ability:

Be able to use the basic concepts, models, and main performance indicators of DC/AC converter circuits to analyze complex engineering problems in power electronics technology.

Chapter6 AC/DC Conversion Circuit

1. Performance index of rectifier

2. Single-phase phase controlled rectifier circuit

3. Three-phase phase controlled rectifier circuit

4. Influence of Transformer Leakage Inductance on Phase Controlled Rectifier Circuit

5. Thyristor trigger circuit of phase controlled rectifier circuit

Key points of this chapter:

Familiar with rectifier performance indicators; Master the working principle, waveform analysis, and basic circuit design methods of single-phase phase controlled rectifier circuits; Master the working principle, waveform analysis, and basic circuit design methods of three-phase phase controlled rectifier circuits; Understand the impact of transformer leakage inductance on phase controlled rectifier circuits, and master their basic calculation methods; Master the working principle of the thyristor trigger circuit of the phase controlled rectifier circuit.

Ability:

Be able to use the basic concepts, models, and main performance indicators of AC/DC converter circuits to analyze complex engineering problems in power electronics technology.

Chapter7 AC/AC Conversion Circuit

1. AC voltage regulating circuit

2. Phase controlled AC/DC frequency conversion circuit

3. Matrix AC/AC frequency conversion circuit

Key points of this chapter:

Master the working principle, waveform analysis, and basic circuit design methods of AC voltage regulating circuits; Understand the working principle of phase controlled AC/AC frequency conversion circuit; Understand the working principle of matrix AC/AC frequency conversion circuit.

Ability:

Be able to use the basic concepts, models, and main performance indicators of AC/AC converter circuits to analyze complex

engineering problems in power electronics technology.

Chapter8 Soft Switching Technology

1. Quasi resonant converter
2. Zero voltage conversion PWM converter
3. Full bridge LLC resonant converter

Key points of this chapter:

Master the working principle, waveform analysis, and basic circuit design methods of quasi resonant converters and zero voltage conversion PWM converters;

Ability:

Be able to use the basic concepts, models, and main performance indicators of soft switching technology to analyze complex engineering problems in power electronics technology.

Chapter 9 Control Circuit

1. Composition of power electronic converter system
2. Basic composition and working principle of integrated PWM controller
3. Control Methods of Power Electronic Converters

Key points of this chapter:

Master the basic composition and working principle of integrated PWM controller; Control methods for power electronic converters.

Ability:

Be able to use the basic concepts, models, and main performance indicators of control circuits to analyze complex engineering problems in power electronics technology.

V. Experiment and class hour allocation

Table3 Experimental items and types

NO	Experimental items	hours	Experimental types				Supporting course objectives	Supporting Graduation Requirements
			demonstrate	test	comprehensive	design		
1	Three-phase half wave controllable rectifier circuit experiment (optional)	2			√		1, 2	2.2, 1.3
2	Three-phase bridge fully controlled rectifier circuit experiment (required)	2			√		2, 3	2.2, 3.2
3	Sawtooth Wave Synchronous Phase Shift Trigger Circuit and Single Phase Bridge Half Controlled Rectification Experiment (Optional)	2		√			1, 2	2.2, 1.3
4	DC Chopper Circuit Experiment (Required)	2			√		3	3.2
5	Power Transistor (GTR) Characteristics and Driver Circuit Research (Optional)	2		√			3	3.2
6	Study on Characteristics and Drive Circuit of Insulated Gate Bipolar Transistor (IGBT) (Optional)	2		√			3	3.2

The in-class experiment plan has 6 class hours, which need to be selected from 12 class hours of power electronics technology experiments. AC/DC circuits and DC/DC circuits are the two most important aspects of power electronics technology. Therefore, one experiment is selected as a required

experiment, and the other two class hours of experiments are selected by the teacher according to the specific situation of the teaching and laboratory. The experimental items and types are shown in Table 3.

VI. Teaching method

This course is a theoretical and practical basic course. In order to improve teaching quality and enhance students' ability to analyze and solve problems, this course adopts a combination of classroom teaching, homework, experiments, and other teaching methods to achieve the teaching goal of enabling students to master the basic knowledge of power electronics. The main teaching links include classroom teaching, exercise exercises, and self study after class.

1. Classroom teaching and interactive discussion

Classroom teaching is dominated by an "interactive" approach. In this teaching process, students mainly listen to lectures, participate in discussions, and use a combination of multimedia and blackboard writing teaching methods, supplemented by program example demonstrations and teaching, to improve classroom efficiency.

2. After-class homework and self-learning

In class, teachers will propose specific homework requirements. Through homework, the purpose of deepening understanding and enhancing students' ability to see circuits and analyze waveforms is achieved. At the same time, homework analysis is carried out, and the key and difficult points of the homework are carefully selected.

Recommend online teaching resources to students: national quality courses, domestic/international famous school video open classes, allowing students to broaden their horizons, share high-quality teaching resources, and cultivate their awareness and ability to learn independently.

3. Experimental teaching

Power electronics technology is a highly practical course. In order to deepen students' understanding of theoretical teaching content and train students' hands-on ability and observation ability. This course cooperates with theoretical study and is arranged with 6 class hours of experiments. In the experimental class, students are required to be able to independently complete relevant experiments and achieve the expected waveform under the guidance of the teacher.

VII. Examine, Evaluation methods and standards

7.1 Examination standards and score evaluation

The course score includes two parts: daily scores and final exams.

Daily score (100 point system), including homework and experiments.

Table4 Daily score evaluation criteria

Basic Requirements	Evaluation criterion			
	Excellent (0.9-1)	good (0.7-0.89)	qualified (0.6-0.69)	unqualified (0-0.59)
Familiar with the characteristics, main parameters, driving and protection of power electronic devices, master the basic concepts of power electronic technology, be familiar with the composition of single-phase controllable rectification and three-phase controllable rectification circuits, understand their working principles, and understand the types of trigger circuits; Understand the composition of AC voltage regulating circuits and their working principles, and understand the composition of switching power supplies; Familiar with the composition of frequency converters and understand their working principles, master the basic analysis methods of power electronics technology.	Have a clear understanding of the relevant knowledge of power electronic devices and the working principles of various circuits, and have a thorough understanding of the composition and working principles of switching power supplies and frequency converters. The solution can solve problems with clear ideas and correct calculations. The homework is neat, the answers are correct, the knowledge learned is well applied to solve problems, and the course objectives are well achieved.	Master relevant knowledge of power electronic devices, understand the composition and working principles of switching power supplies and frequency converters. The design idea and calculation process are correct. The homework is neat, the answers have a few small errors, and they can solve problems based on the knowledge they have learned. The course objectives are met and meet the requirements.	Master basic knowledge of power electronic devices and the working principles of various circuits, and have a basic understanding of the composition and working principles of switching power supplies and frequency converters. Plans can still be developed. The homework is neat, there are obvious big mistakes, the ability to apply the knowledge learned to solve problems is acceptable, and the course objectives are generally achieved.	Have not mastered the relevant knowledge of power electronic devices and the working principles of various circuits. Unable to develop a plan. Copying assignments or incomplete assignments. The course objectives were not achieved.

Table5 experiments score evaluation criteria

Basic Requirements	Evaluation criterion			
	Excellent (0.9-1)	good (0.7-0.89)	qualified (0.6-0.69)	unqualified (0-0.59)
Be able to correctly identify and select power electronic devices, and be able to establish and debug trigger circuits and simple DC speed regulation systems. Be able to conduct experiments based on the content of experimental projects, observe experimental phenomena, and analyze experimental results; According to the content of the experimental project, an experimental plan is given, and experiments are conducted to obtain effective experimental results.	Complete all the content of the experiment independently, operate the experiment in a standardized manner, and obtain experimental data with an accuracy rate of over 90%. The experimental report is written neatly and standardized, with detailed and accurate content, and the results are correctly analyzed. The course objectives are well achieved.	Complete all the content of the experiment independently, the experimental operation is relatively standardized, and the accuracy rate of the obtained experimental data is above 80%. The experimental report is written in a standardized manner, with detailed content, and the experimental data is analyzed. The course objectives meet the requirements.	Complete the experiment under the guidance of the teacher. The experimental operation is relatively standardized, and the accuracy rate of the obtained experimental data is above 70%. The experimental report is written in a standardized manner, and the experimental results are appropriately analyzed. The course objectives were generally achieved.	Unable to complete the experiment, or the experimental operation is completely non-standard, or the experimental report is not submitted, or the experimental report is not neat and complete. The course objectives were not achieved.

The final exam (100 point system) is a closed book exam with multiple choice questions, blank filling questions, short answer questions, analysis and calculation questions, etc.

Table6 Assessment content and evaluation criteria for the final exam of the course

objective	Basic Requirements	Evaluation criterion				scale (%)
		Excellent(0.9-1)	good(0.7-0.89)	qualified(0.6-0.69)	unqualified(0-0.59)	
objective 1	Familiar with the characteristics, main parameters, driving and protection of power electronic devices, familiar with the composition of single-phase controllable rectification and three-phase controllable rectification circuits, understand their working principles, and understand the types of trigger circuits; Understand the composition of AC voltage regulating circuits and their working principles, and understand the composition of switching power supplies; Familiar with the composition of frequency converters and understand their working principles.	Have a clear understanding of the relevant knowledge of power electronic devices, the working principles of various circuits, and a thorough understanding of the composition of switching power supplies, frequency converters, and the working principles.	Master relevant knowledge of power electronic devices, working principles of circuits, understand the composition of switching power supplies, the composition of frequency converters, and working principles	Have a basic understanding of the working principles of power electronic devices and various circuits. Have a basic understanding of the composition and working principles of switching power supplies and frequency converters.	Have little knowledge of power electronics, the working principles of various circuits, and the composition and working principles of switching power supplies, as well as frequency converters.	40
objective 2	Be able to correctly identify and select power electronic devices, establish and debug single transistor trigger circuits and simple DC speed regulation systems; Be able to inspect and repair switching power supplies, use and maintain frequency converters, learn to collect, read, and utilize information	Excellent hands-on ability to correctly identify and select power electronic devices.	Have good hands-on ability, and basically correct identification and selection of power electronic devices.	Hands-on ability is average, and there are a few errors in the selection and use of power electronic devices.	Hands-on ability is average, and there are many errors in the selection and use of power electronic devices.	46

objective	Basic Requirements	Evaluation criterion				scale (%)
		Excellent(0.9-1)	good(0.7-0.89)	qualified(0.6-0.69)	unqualified(0-0.59)	
objective 3	Be able to determine the performance indicators of electrical equipment and power systems according to production practice requirements, and design unit module circuits of electrical equipment and power systems that meet user needs.	Be able to determine the performance indicators of electrical equipment and power systems according to production practice requirements, and well design the unit module circuits of electrical equipment and power systems to meet user needs.	Be able to determine the performance indicators of electrical equipment and power systems according to production practice requirements, and design unit module circuits of electrical equipment and power systems that meet user needs.	Be able to determine the performance indicators of electrical equipment and power systems according to production practice requirements, and design unit module circuits of electrical equipment and power systems that basically meet user needs.	Unable to design unit module circuits for electrical equipment and power systems that meet user needs.	14

Note: The proportion in this table refers to the proportion of final exam scores.
The score is evaluated as: exam score * 70%+average daily score * 30%.

7.2 Course objective achievement evaluation

Table7 "Power Electronics Technology" Course Objective Achievement Evaluation and Analysis Report

1. Basic Course Information					
Course	Power Electronics Technology	nature	Professional Foundation, Compulsory	hours, credits	48/3
Opening Semester	The fifth semester	Professional classes	Electrical Engineering and Automation	Assessment method	Examination, closed book
Teacher: Evaluators: course leader, proposition teacher, and paper marking teacher					
2. Course Objectives Achievement Assessment					
Supporting graduation requirements	Course objectives	Evaluation data source			
		Evaluation basis	Score	average	Achieved value evaluation method
1.3 Be able to apply relevant knowledge and mathematical model methods to deduce and analyze engineering problems in electrical engineering and automation.	1.Familiar with the characteristics, main parameters, driving and protection of power electronic devices, familiar with the composition of single-phase controllable rectification and three-phase controllable rectification circuits, understand their working principles, and understand the types of trigger circuits; Understand the composition of AC voltage regulating circuits and their working principles, and understand the composition of switching power supplies; Familiar with the composition of frequency converters and understand their working principles. (Supporting Graduation Requirements 1.3)	Final exam: Basic knowledge of power electronic devices, working principles of rectifier circuits, working principles of AC voltage regulating circuits, composition of switching power supplies, and frequency converters (40 points)	T10=40	T1=	$\frac{T1}{T10} * 0.7 + \frac{A1}{A10} * 0.3$ =
		Daily score	A10=100	A1=	
2.2 Be able to correctly express complex engineering problems based on power system theory and	2.Be able to correctly identify and select power electronic devices, establish and debug single transistor trigger circuits and simple DC speed regulation systems; Be able to inspect and repair switching power supplies,	Final exam: DC/DC, DC/AC AC/DC, AC/AC Principle and Analysis of Circuit (46 分)	T20=46	T2=	$\frac{T2}{T20} * 0.7 + \frac{A2}{A20} * 0.3$ =

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mathematical model methods, recognize that there are multiple solutions to engineering problems, and seek the optimal solution through literature research.	be able to use and maintain frequency converters, and learn to collect, read, and utilize information. (Supporting Graduation Requirements 2.2)	Daily score	A20=100	A2=	
3.2 Be able to design each unit module of the system according to the specific performance index requirements of electrical equipment and power system.	3.Be able to determine the performance indicators of electrical equipment and power systems according to production practice requirements, and design unit module circuits of electrical equipment and power systems that meet user needs. (Supporting Graduation Requirements 3.2)	Final exam: (14分)	T30=14	T3=	$\frac{T3}{T30} * 0.7 + \frac{A3}{A30} * 0.3$
		Daily score	A30=100	A3=	
3. Course Evaluation and Analysis					
Summary of assessment results					
Continuous improvement methods					

VIII. Conclusion

"Power Electronics Technology", as the core course for electrical engineering and automation majors, plays a strong supporting role in graduation requirements. According to the professional certification standards for engineering education, the assessment standards and evaluation methods for the teaching of power electronics technology courses have been formulated. Guided by teaching results and centered on student cultivation, the continuous improvement of the teaching of power electronics technology courses has been promoted to ensure that the cultivation of engineering and technical talents meets international standards.

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