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Exploration of the Reform of the Assessment Mode for "Analog Integrated Circuit Analysis and Design"

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Abstract: The emerging engineering education is the leading force in the construction of a strong education country, which aims to cultivate outstanding engineering innovation talents, the key point of which is to improve the talent cultivation capabilities. This article takes "Analysis and Design of Analog Integrated Circuits" as an example to explore a new mode for engineering education assessment for integrated circuits, under the background of cultivating emerging engineering talents. An assessment mode based on "enhancing engineering capabilities and constructing a multi-dimensional tightly coupled knowledge system" is proposed, which transforms the final assessment at the end of course into a process-oriented "milestone-based" assessment approach. It provides a solution for establishing an new evaluation system that adapts to the training of emerging engineering talents in integrated circuits.

Keywords: Integrated circuit; Reform of assessment mode; Emerging Engineering Education

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1. Introduction

"Analog Integrated Circuit Analysis and Design" is one of the key course for building the knowledge system of integrated circuits, which guarantees the integrity of talent training system. It has the distinct characteristics of strong engineering and close integration of theory and practice, as well as the emphasis on comprehensive application of knowledge points in engineering practice. Due to the fundamental characteristic and extremely challenging nature of analog integrated circuit design, such as compromise design requirements, strong experience dependence, and high sensitivity to process, power supply voltage and temperature, a significant shortage of engineering talents in analog integrated circuits exist. This work takes "Analog Integrated Circuit Analysis and Design" as an example to explore a new mode of assessment for emerging engineering education of integrated circuit major. Our objective is to establish an evaluation system that adapts to the emerging engineering education, and to meet the in-depth and systematic needs of integrated circuit education system in China.

2. Implementation of the proposed assessment mode

Traditional assessment mode takes independent knowledge points as the assessment object, and adopts an closed-book examination mode at the end of class stage. Students only mechanically reinforce independent knowledge points for the purpose of exam preparation[1]. Each knowledge point is independent and presents a flatten feature, moreover, the students cannot organize and summarize knowledge points in a three-dimensional manner due to cram for examination. As a result, it is difficult for the students to construct a multi-dimensional knowledge system for analog integrated circuits. It is even more difficult to obtain the ability to analyze and solve practical engineering problems by a comprehensive utilizing of multidimensional knowledge system.

This article proposes an assessment model based on "enhancing engineering capabilities and constructing a multi-dimensional tightly coupled knowledge system." This model shifts the focus from a single final assessment to a comprehensive process-based assessment throughout the course.

2.1. Assessment contents design

The ultimate goal of this course is to enable students to acquire the ability to analyze and solve engineering problems of analog integrated circuit by comprehensive utilizing of foundational knowledge system. A key manifestation of this ability is is the capability of comprehensively utilizing multidimensional knowledge systems to design analog integrated circuits with specific functions and performance indicators. On the other hand, integrated circuit design heavily relies on EDA design tools, and the most intuitive visual evaluation of also needs to demonstrated design results through EDA tools. Thus, this course selects typical integrated circuit units from industry cases or research projects as the assessment objects. Then, students are guided to build and design the sub-circuit of the assessment objects step by step throughout the learning stage of the course, with the help of EDA tools. Finally, students complete the full circuits design and simulation verification at the end of the course stage[2].

The circuit unit to be assessed must meet following characteristics: a) It has a good engineering background and can actively adapt to industrial development needs and new technologies to ensure the progressiveness, engineering and comprehensiveness of the assessment content; b) can cover most of the knowledge points of this course; c) has a simple structure to reduce design difficulty; d) has complete functions and has the potential for engineering application.

Based on the above considerations, a wireless power harvesting (WPF) chip for self-powered biosensors is proposed as an industry case for assessment. Low dropout regulator (LDO), the core unit of WPF, is selected as the circuit unit to be assessed. WPF has broad application prospects in self-powered biosensors and in the next generation of self-powered IoT wireless sensor networks. The specific assessment content is the full circuit design of LDO, which has complete functions and simple structure. It mainly consists of sub-circuits such as reference source, current mirror, differential amplifier, and feedback circuit, covering the key knowledge points of this course. Each sub-circuit serves as a "main assessment milestone," while the final system-level LDO design and simulation verification at the course end acts as the "final milestone" assessment. This process-based approach helps students reconstruct the course knowledge system and develop the ability to comprehensively analyze and solve practical engineering problems[3].

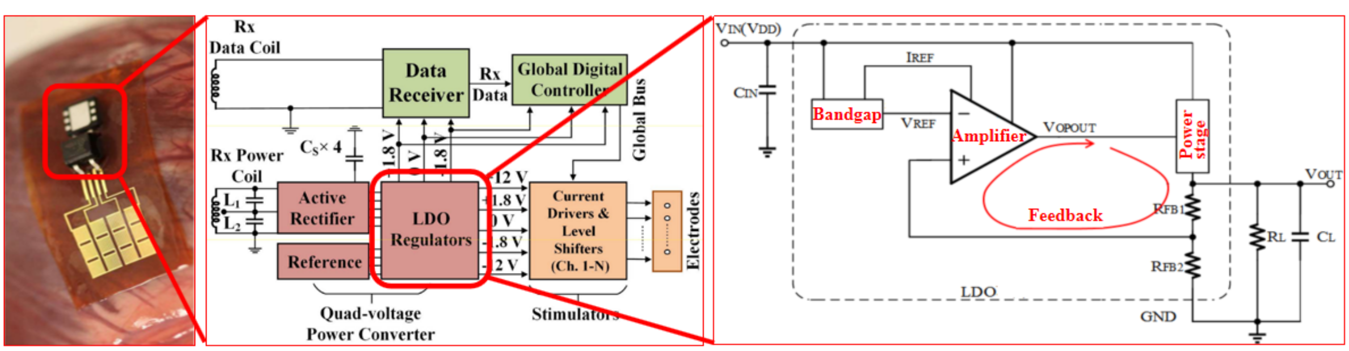

Figure 1. LDO assessment contents design facing to WPF chip for self-powered biosensors

2.2. Synchronized optimization of teaching contents

As the proposed "main site" process based assessment is throughout the entire teaching process, the teaching contents also needs to be optimized. Then, the synchronization of the teaching contents and the assessment contents are guaranteed.

Therefore, the assessment contents and its engineering background are distributed throughout the teaching process: a) During the introduction, a special topic on "Advanced Applications of Integrated Circuits" is presented, using the self-powered biosensor WPH chip as a cutting-edge engineering case. The engineering background, working principle, system architecture, and the specific parameter indicators of the LDO within this system are elaborated. Relevant research papers are provided for student reference. The LDO is then decomposed into sub-circuits corresponding to relevant chapters and knowledge points; b) When teaching detail knowledge points in chapters, guided by the system architecture of LDO, the working principles and design methods of decomposed sub-circuits are elaborated. Moreover, the detail performance indicators are provided, the students are then organized for the sub-circuit design and assessment; c) At the final stage of this course, explanation of the combination-test and simulation verification methods of LDO system are carried out. Through the above organization, the sub-circuits of LDO are set as an intermediate assess station during full teaching procedure, while all sub-circuits are polymerized together to build the full LDO system, which helps students constructing the multi-dimensional knowledge system of analog integrated circuits.

2.3. Assessment organization and implementation

The assessment organization and implementation is shown in **Figure 2**. Students are organized as several engineering project teams(EPT) with 3 students in each team. The decomposed LDO sub-circuits are distributed to each EPT. Then, the EPT carries out EDA assisted sub-circuit design and simulation verification. The teacher evaluates EPT based on the EDA simulation results. In this assessment process, each sub-circuit with specific design tasks are issue to EPT according as course progress in chapters, only when the education of the detail working principle, circuit and performance analysis and design method of sub-circuits has been taught. This establishes a "Sequential Milestone-based Engineering Task Distribution" assessment model. Thus, the traditional end-of-course final assessment is transformed into a comprehensive process-based "milestone" assessment.

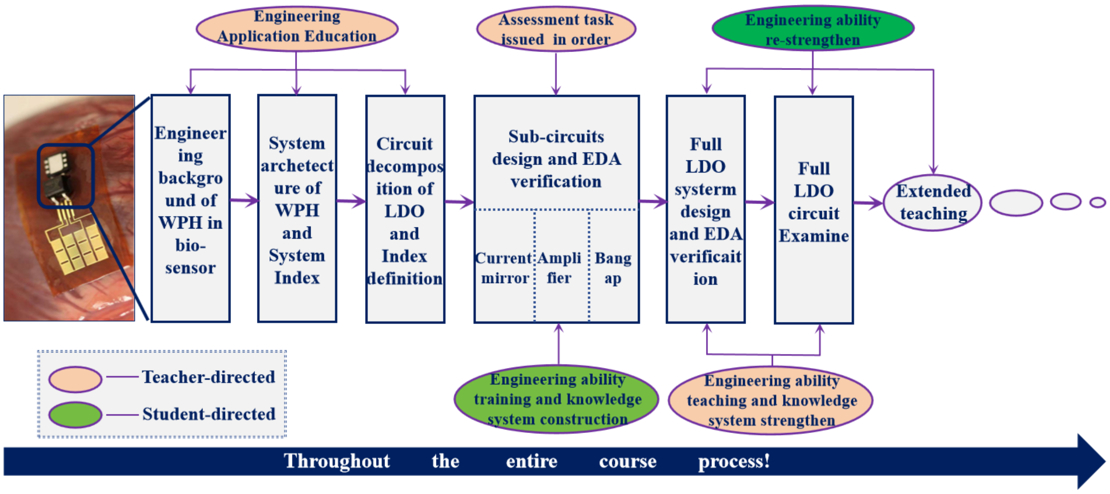

Figure 2. Assessment organization and implementation

During the process-based assessment, the teacher's role evolves from "Engineering Project Manager" to "Systems Engineer" and "Quality Assurance Engineer." The teacher guides students' design thinking, prompts them to actively consider design challenges, reinforces key knowledge points as needed, and assists students in reconstructing the multi-dimensional knowledge system. Following assessments, extended and inspiring teaching methods encourage deeper thinking.

Students assume the roles of "Project Engineer," "Primary Project Executors," "Main Participants in Engineering Capability Training," and "Active Agents in Reconstructing the Multi-dimensional Knowledge System." Stimulated by the engineering project context, student enthusiasm is enhanced, effectively improving the educational outcome regarding comprehensive engineering application capabilities. This assessment model also allows for timely feedback on difficulties encountered with knowledge points and design methods. The instructor can then address these difficulties, reinforce key concepts, and better support students in constructing a multi-dimensional, tightly coupled knowledge system.

3. Conclusion

Adhering to the philosophy of "cultivating engineering application capabilities" and "integrating theory with engineering practice," this work proposes an assessment model based on "enhancing engineering capabilities and constructing a multi-dimensional tightly coupled knowledge system." The principles of emerging engineering education are integrated into each teaching segment, facilitating the organic integration of value shaping, ability cultivation, and knowledge education for students. Ultimately, this approach aims to achieve the fundamental goal of enabling students to acquire a multi-dimensional, tightly coupled professional knowledge system that meets practical engineering requirements, and thereby develop the ability to comprehensively utilize this system to solve practical engineering problems.

Disclosure statement

The author declares no conflict of interest.

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