Online assessment platform for electronics circuit design

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ABSTRACT
With the growing demand for practical skills in electronics circuit design, an effective and automated assessment system is crucial for educators and learners. This paper presents an Intelligent Agent System for Electronics Circuit Design to evaluate students' circuit diagrams efficiently and accurately. The platform leverages a web-based interface where students can submit their circuit designs, which are then analyzed using an intelligent agent-based evaluation system. The system integrates machine learning-based evaluation models, rule-based verification algorithms, and circuit simulation tools to assess submitted designs' correctness, efficiency, and functionality. The platform supports multiple circuit types, including analog, digital, and mixed-signal circuits, and is adaptable to the field of electronics design and engineering education. Automatic evaluation process supported by this platform enhances learning efficiency, reduces manual grading efforts for instructors, and ensures objective and consistent assessment. It also offers real-time analytics and performance tracking to help educators tailor their teaching strategies. The proposed system is a step forward in modernizing electronics education, fostering hands-on learning, and bridging the gap between theoretical knowledge and practical application.
Keywords — E-learning, online teaching, Online Assessment, Electronics Circuit Design, Automated Evaluation, Circuit Simulation, Machine Learning, Rule-Based Verification, Intelligent agent framework, Digital and Analog Circuits, Student Performance Analysis.

I. INTRODUCTION

Analog circuit course plays a very important role in solving real-time engineering problems in electronics engineering. Analog circuits play a crucial role in interfacing with the real world, where most signals are inherently analog in nature. An analog circuit is essential for enhancing and converting analog signals from the physical system. In an analog circuit course, the fundamental problem is designing a circuit with desired components and their interconnection. Analog circuit design involves designing and implementing circuits using active and passive components to process and manipulate analog signals [1] .Basic circuits dealt with in an Analog Circuit Design course include amplifiers, filters, and converters. The design process considers factors like speed, power consumption, gain, accuracy, frequency response, and noise immunity. The design of circuits in an analog circuit course encompasses various challenges and considerations critical for effective learning and application. To design a circuit that meets performance requirements, students must have basic fundamental knowledge of circuits, electronics components, and their interfacing. After designing the circuit, the main key issues include the diagnosis of circuit faults, the complexity of circuit design, and the pedagogical approaches to teaching and learning these concepts. Understanding these aspects is essential for students to develop practical skills in analog circuit design.

Integrating online assessment platforms in electronics education plays a pivotal role in enhancing learning efficiency, improving evaluation accuracy, and fostering hands-on problem-solving skills. Traditional evaluation methods for circuit design are often time-consuming and subjective [2]. Automated assessment platforms enable quick and consistent evaluation, allowing educators to focus on teaching rather than manual grading. Human grading may introduce biases or inconsistencies. It is difficult for a teacher to check all permutations and combinations of the circuit due to time constraints. Online assessment tools use rule-based algorithms and AI-driven evaluation, ensuring fairness and uniformity in grading circuit designs [3]. Online assessments make electronics education more scalable by allowing many students to be evaluated simultaneously. It also provides access to students in remote areas, enabling flexible learning opportunities.

This research proposes an Intelligent Agent System Framework for the evaluation of electronics circuit simulation for student skill identification.

II. INTELLIGENT AGENT SYSTEM FOR CIRCUIT DESIGN EVALUATION (IAS-CDE)

The Intelligent Agent System automats the evaluation process, enabling faculty to manage larger groups of students without compromising the quality of feedback. The system ensures consistent, objective assessments and reduces the administrative burden on instructors, allowing them to focus on more complex teaching tasks and individualized student support.

The architecture of an intelligent agent system (IAS) is shown in Figure 1. [4]

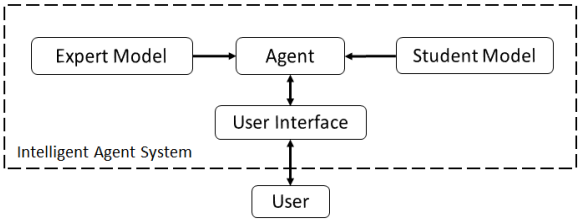


Figure-1: Intelligent Agent Architecture

The Intelligent Agent System for Circuit Design Evaluation (IAS-CDE) includes a student model, an expert model, and an Intelligent Agent. A student model contains the knowledge and skill sets of the student and is continuously updated based on interaction with the system. An expert model contains pedagogical and subject domain knowledge. In this case, the subject domain knowledge is for analog circuit design. The Intelligent Agent makes the decision to either present a learning experience or evaluate the student's performance based on the submitted circuit design. The developed Intelligent Agent System works as an adaptive learning environment for a student and a teaching and evaluation platform for a teacher. An intelligent agent system allows faculty to create basic rules for assessing electronic circuits.

Electronic circuit simulation tools use a representation framework called 'netlist' to express the schematic diagram and circuit response output in SPICE format.

The proposed Intelligent Agent acquires schematic diagram data in the form of a netlist, and various circuit responses such as frequency response, time response, and power response, in unstructured data like NoSQL.

The following section presents the IAS teacher and student registration process for the student performance evaluation.

III. INTELLIGENT AGENT SYSTEM FOR CIRCUIT DESIGN EVALUATION PROCESS FLOW

A process flow implemented in the proposed Intelligent Agent System for Circuit Design Evaluation (IAS-CDE) is shown in Figure – 2.

There are three major roles in the system 1. Admin, 2. Teacher, and 3. Student. Admin can manage overall system. The processes managed by admin are not shown in the Figure - 2, as these processes are not directly involved in the circuit design evaluation. The teacher can create examination having circuit design problems. He also need to submit the possible solutions related to problem and relevant grade to be given to a student.

A student can take examination online and. The system presents circuit design problem created by teacher and provides a circuit editor space in which student can create circuit design, check various circuit response such as time response, frequency response, etc. On completion student submits the circuit design for a given problem.

The Intelligent Agent System for Circuit Design Evaluation, evaluates the student's design and generate a grade based on teacher's solution and student solution. This grading is not either completely true or false, but based on student's level of understanding and provided solution it can very between considering various circuit performance parameters.

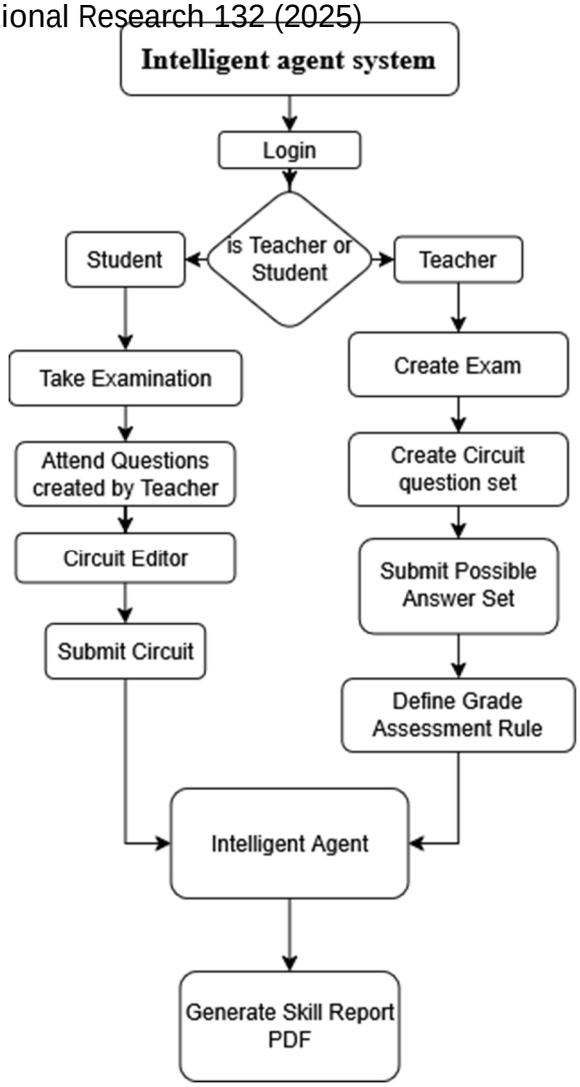


Figure-2: Circuit Design Evaluation Process Flow

The following section presents a case study for a student's performance evaluation for an analog circuit design problem.

IV. ANALOG CIRCUIT DESIGN PROBLEM EVALUATION

In an analog circuit design course, the most common design problem in analog circuits is designing a high-gain amplifier using an operational amplifier (op-amp). In the present case study, a problem is presented to the student: designing an inverting amplifier with a gain of 10 and an input voltage of DC 10 mV. The evaluation criteria considered are as below –

1. Schematic: The correctness of the circuit diagram i.e. interconnection of the various components
2. Circuit design: Selection and use of appropriate components considering their values, rating, and their impact on the performance of the circuit.
3. Output Response: DC output response of the circuit.
4. Power Response: In this case effect of bias current is considered in inverting and non-inverting input. This depends on appropriate value of resistance connected to input and feedback path, and to the non-inverting terminal.

Students' performance is evaluated on a scale of 10 based on all the above criteria. Various responses given by a student is presented as follows -

Case 1: Student's design is correct with respect to all the four evaluation criteria

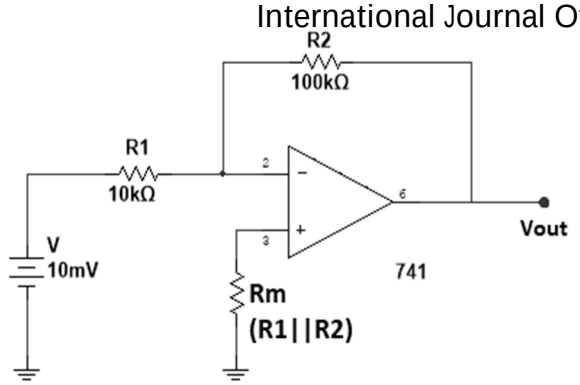
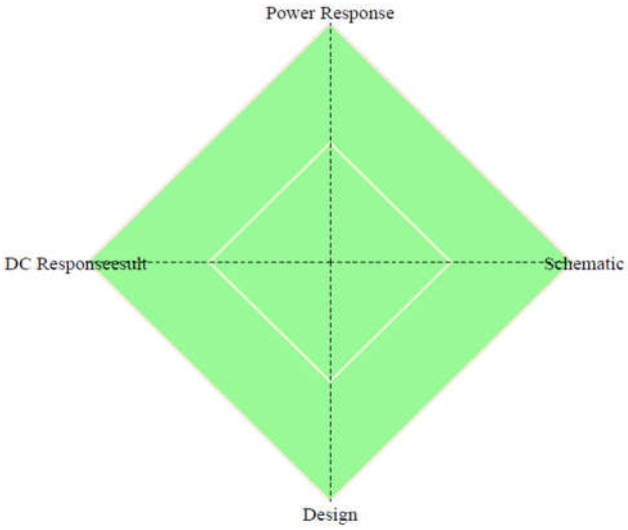


Figure – 3: Circuit Design for Case - 1

The student's submitted circuit design is shown in Figure – 3. Here, student's circuit design in terms of correctness of circuit diagram, selection of components, power response, and DC response is current. The IAS-CDE has generated the evaluation reports in graphical form where the amount correctness in each aspect is represented by the green colored region and also the grading score in the maximum scale of 10.

The system generated evaluation report is given in Figure – 4.



Assessment Score: 10

Figure – 4: Evaluation Report of Case - 1

Case 2: Student's design is incorrect with respect to design criteria (Figure-5):

In this case functional requirement, power response, and DC response are correct. However, to balance the input bias current the resistor to be connected at the non-inverting terminal is not present. Therefore, the system has graded accordingly. The student's performance report is as shown in Figure – 6.

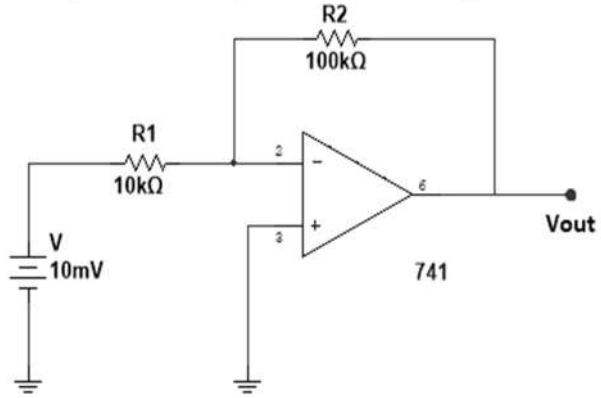
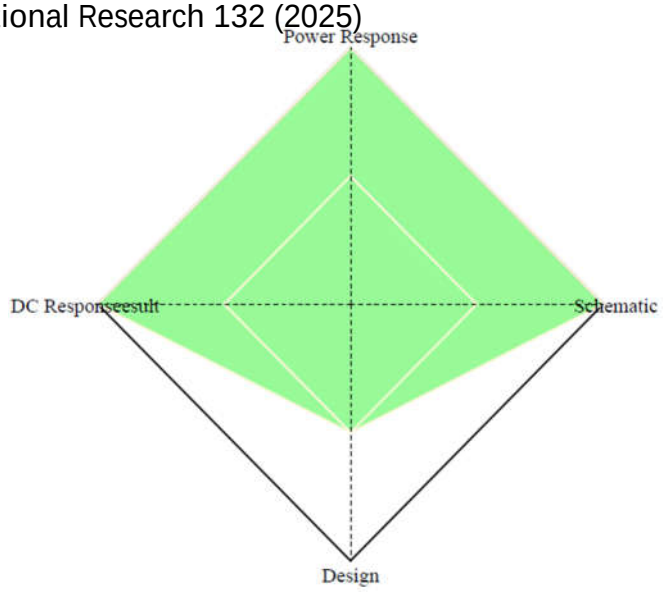


Figure-5. Circuit Design for Case - 2



Assessment Score: 08

Figure-6. Evaluation Report of Case - 2

Case 3: Student's design is incorrect with respect to power response (Figure-7):

In this case functional requirement, circuit diagram, and DC response are correct. But the power response is poor, as the selected resistors allow high current to be injected to input terminals of the op-amp also high output current will be generated. Student has also shown the resistor at the non-inverting terminal. Therefore, the system has graded accordingly. The student's performance report is as shown in Figure – 8.

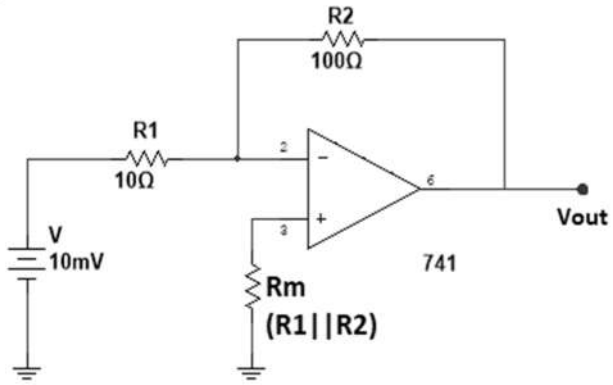
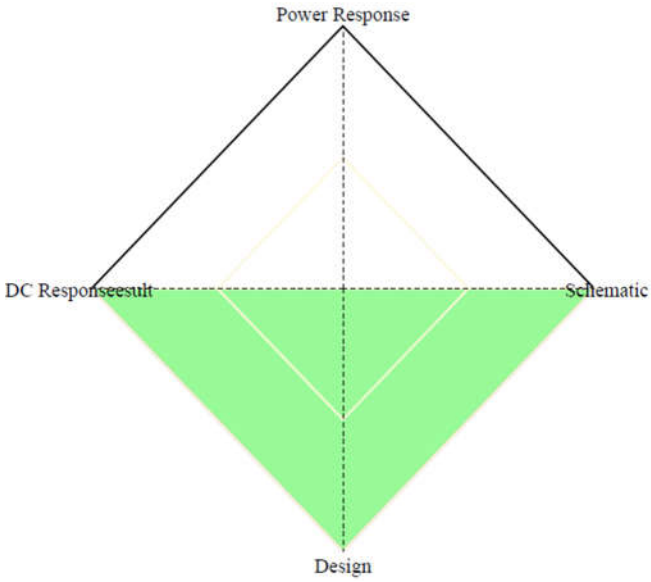


Figure-7. Circuit Design for Case - 3



Assessment Score: 07

Figure-8. Evaluation Report of Case - 3

Case 4: Student's design is correct with respect to circuit diagram, and DC response (Figure-9).

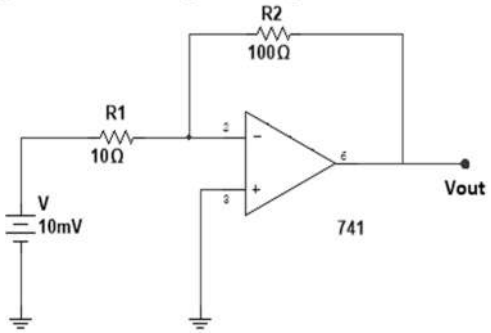
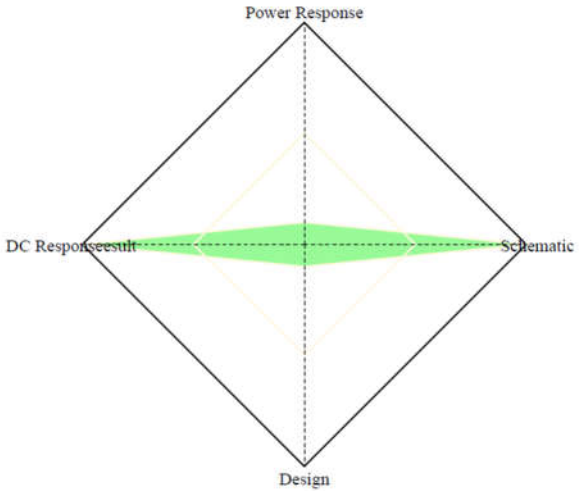


Figure-9. Circuit Design for Case - 4

In this case functional requirement (schematic diagram), and DC response are correct. But the power response is poor, as the selected resistors allow high current to be injected to input terminals of the op-amp also high output current will be generated. Student has not connected resistor to non-inverting terminal. Therefore, the system has graded accordingly. The student's performance report is as shown in Figure – 8.



Assessment Score: 05

Figure-10. Evaluation Report of Case - 4

Case 5: Student's design is incorrect with respect to all evaluation criteria(Figure-11).

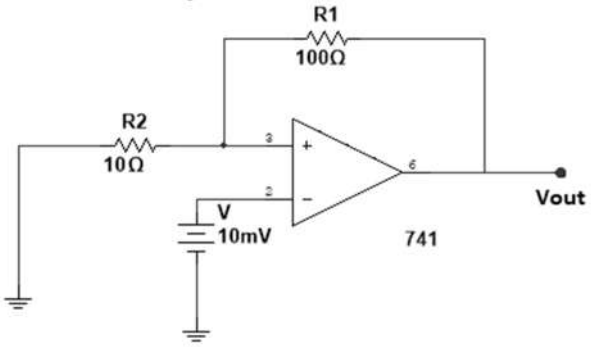
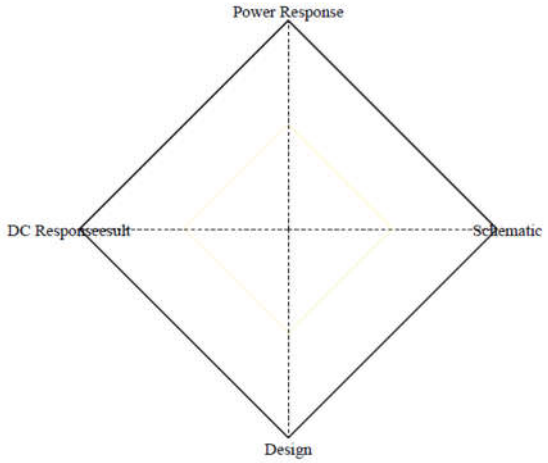


Figure-11. Circuit Design for Case - 5

In this case student has implemented wrong circuit. It is incorrect with respect to all the evaluation criteria and IAS-CDE has generated report accordingly, which is shown in Figure – 12.



Assessment Score: 0

Figure-10. Evaluation Report of Case - 5

V. CONCLUSIONS

IAS-CDE is a web-based system which allows teaching – learning, and evaluation to be done online. It helps automatic evaluation of design problems of analog circuit design course using the Intelligent Agent. It reduces the evaluation time require for the assessment of large number of students, and also reduces the subjectivity in the assessment. This system also helps to student in learning analog circuit design course in practice mode, where student can check his/her own circuit design ability.

REFERENCES

[1] K. K. a. K. Tschulik, "Electronic Circuit Simulations as a Tool to Understand Distorted Signals in Single-Entity Electrochemistry," *The Journal of Physical Chemistry Letters,* vol. 13, no. 43, p. 10120–10125, 2022.

[2] C. B. Bhatt. Chirag B. Panchal, "Comparative Analysis of Electronics Circuit Simulation software (EDA tools) for E-learning and Assessment," *International Journal of Computer Science Trends and Technology (IJCST),* vol. 12, no. 5, 2024.

[3] C. B. Bhatt , N. J. Rao, "SCORM Metadata in the Context of Bloom-Vincenti Taxonomy and Intelligent Tutoring System," *ICWE,* vol. 6, no. 7, pp. 11-14, 2006.

[4] C. B. Bhatt, "Knowledge Representation Framework for a Web-based Intelligent Tutoring System for Engineering Courses, PhD Thesis," July 2008.