

# SOFTWARE BASED APPROACH FOR CLASSROOM TEACHING OF ELECTRICAL ENGINEERING COURSES: A CASE STUDY

**Mehar, H. and Nebhnani, N.**

Department of Electrical & Electronics Engineering  
Institute of Engineering & Science,  
IPS Academy  
[meharhemant@yahoo.com](mailto:meharhemant@yahoo.com)

---

## **ABSTRACT**

*Electrical engineering concepts are abstract in nature and difficult to explain using conventional teaching tools. The use of software in teaching holds the potential in providing better learning support as these tools can provide visual representations of complex circuits operation and waveforms for enhanced concept and procedural learning in power electronics. The software packages available for simulation of power electronic circuits include MATLAB, PSPICE and PSIM. In this study the author takes an example of an AC voltage controller to explain the software based teaching approach. The author used two software based simulation tools to explain the AC voltage controller concept and compare the software based approach with the blackboard and power point presentation based technique. Results of different approaches are compared in the last session of this paper, so it's helpful for the faculty of electrical engineering to find the various applications of MATLAB/SIMULINK and PSIM in teaching. Overall students find the simulation approach is helpful for their learning.*

**Keywords:** *teaching, education, AC-AC power conversion, software, engineering.*

---

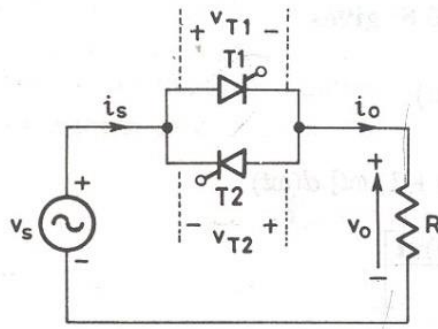
## **1 INTRODUCTION**

Teaching engineering is challenging for educators in higher educational institution. Innovative teaching approach and techniques are required in order to deliver the content effectively, so that students can acquire better and in-depth knowledge of the subject matter. For example, in electrical and electronics engineering, practitioners typically work with complex procedures and processes in planning, designing, simulating, and testing of equipment (Kuo, 2007; Verma, 2008). It has been found that computer aided design (CAD) software is helpful not only in performing the complex work and procedures, but also in teaching engineering students.

Lately, software applications have grown in popularity in education; in fact its usage in the educational field has become important for more and more universities all over the world. CAD for designing and simulation such as MULTISIM, PSCAPE, EAGLE, MATLAB and PSIM and are some of the software adopted in education as they have been shown to provide a suitable platform for better lesson delivery in the classroom (Meher, 2012). In electrical engineering courses where the nature of the subject matter is often abstract and complex, educators often find great difficulty in delivering its content knowledge to students. Students cannot imagine how current flows and how a particular circuit such as AC Voltage controllers works (Rahman, 1994; Cooley, 1991; Abramovitz, 2011; Felder, 2007). However, software like MATLAB and PSIM has the potential to enhance the presentation of content of a large variety of courses, offering teachers the opportunity to develop new educational delivery method. Therefore, a case study was conducted to make a comparison between of Blackboard / PowerPoint and Software simulation based in teaching electrical engineering concepts.

## **2 METHODOLOGY**

A case study was conducted in the year 2013 at the Institute of Engineering & Science, IPS Academy, Indore, India. The subject was Power Electronics Devices & Circuit and Electrical Engineering Simulation Lab. The focus of learning is AC Voltage Controllers (Figure 1). AC Voltage controllers are thyristor based devices which convert fixed alternating voltage directly to variable alternating voltage without a change in the frequency. Some of the main applications of ac voltage controllers are for domestic and industrial heating, transformer tap changing, lighting control, speed control of single phase and three phase ac drives and starting of induction motors. Earlier, the devices used for these applications were auto-transformers, tap-changing transformers, magnetic amplifiers, saturable reactors etc. but these devices are now replaced by thyristor and triacs based ac voltage controllers because controllers are also adaptable for closed loop control systems (Bhimra, 2007; Rashid, 2008; Sen, 2008; Khanchandani, 2008). It is difficult to understand the working of such circuits without the virtual operation, because of the complexity of the operation and the mode of conduction of thyristor. So a better approach is to use a software platform like MATLAB/SIMULINK or PSIM for better understanding.



**Figure 1: Single phase full wave AC Voltage Controller**

## 2.1 Participants

There were total 60 students enrolled, but this study was conducted with the group of 10 – 10 students by making two batches, all students from III year B.E. class. The ratio of male to female is approximately 6:4; the age group is around 18-20 year old.

In the first week, students were taught using blackboard, second week using PPT slides and in the third week using simulations. At the end of each session, students were given a feedback form and a set of a questionnaire to answer. The feedback form based on all used approaches were filled by the student. Feedback forms were designed to elicit students' feedback on the various parameters including firing angle, modification, clarity, communication level, and creativeness. To complement data from the feedback form, short questionnaires were given which comprises of six items regarding approach, explanation level, and understanding of topic, communication, usefulness and creativeness. On the basis of this feedback and questionnaire from students, the level of applicability and effectiveness of the proposed approach were assessed.

## 2.2 Procedures

The case study is done on the topic of AC voltage controller from the power electronics subject under the electrical engineering courses. The teaching materials used to teach the unit based on the different presentation medium i.e., blackboard, ppt slides and software is here discussed.

### (i) Blackboard technique in real classroom

For explaining this topic to our students in the classroom, we need to make the circuit on the blackboard, as shown in the capture figure 2 below.

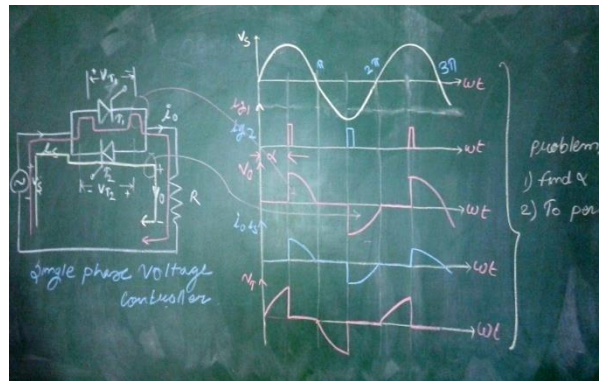


Figure 2: Blackboard captured image from classroom

Here the author drew the circuit on blackboard first and followed by the waves for this particular circuit by taking some imaginary angle  $\alpha$ . In this blackboard the author took the angle at 90 degrees. The author needed a lot of time to construct this circuit and the respective waves and even if change is to be made for the firing angle, it cannot be done was unable to do it at the simultaneously without a messy presentation on the blackboard. Furthermore, when blackboard was used, learning of the operation process of the devices could only be done through imagination. Furthermore, drawing the waves which is the typical way of teaching this unit using blackboard are consuming tasks.

**(ii) PPT slides presentation technique in real classroom**

PPT slides presentation can provide better visuals and save time. However, the materials need to be prepared in advance before the actual teaching. In this study, the author prepared a presentation on AC Voltage controller. The teaching materials are shown in the figure 3.

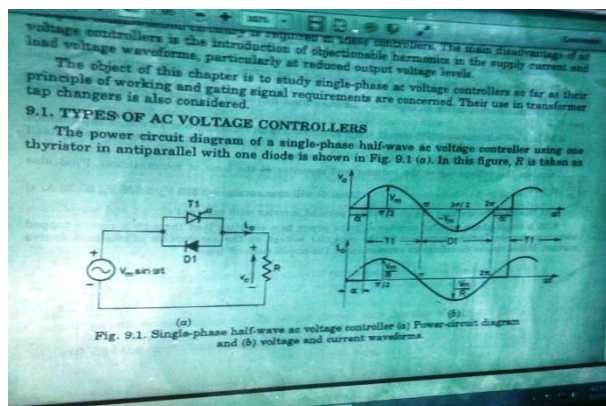
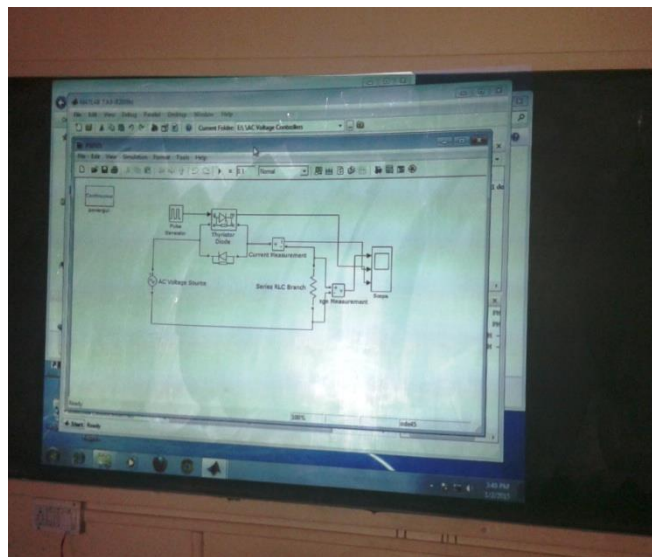


Figure 3: PPT Presentation captured image from classroom

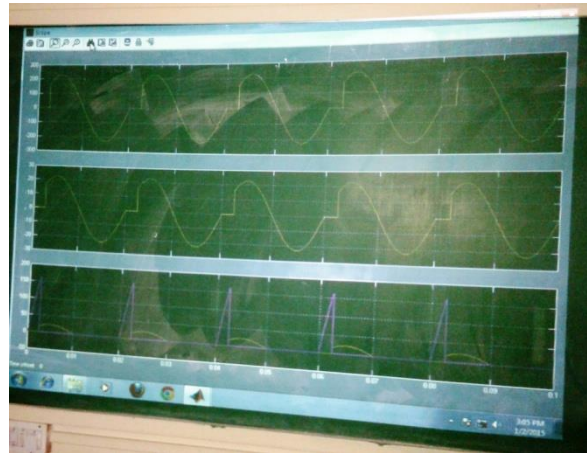
Although using PP slides eliminates drawings while teaching, providing lots of simplicity to explain the working concepts of AC voltage controller, but with medium, students still need to understand the operation of circuits using their imagination.

### (iii) Simulation technique in real classroom

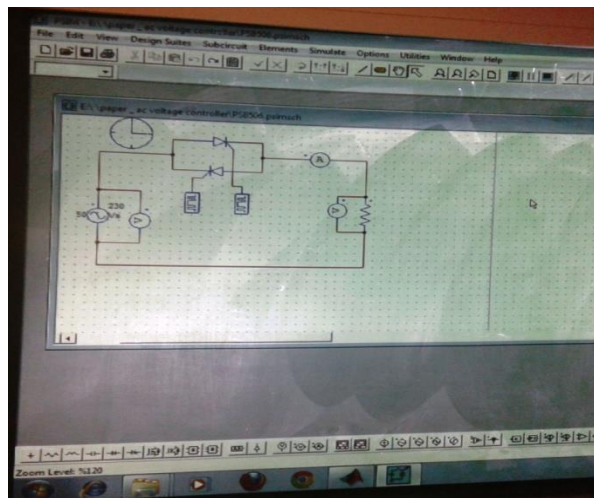
Simulation technique provides solutions to teaching this unit. Figure 4 -7 illustrates the applicability of the simulation method. Here the authors use the two simulation tools for explaining the AC voltage controller, i.e. MATLAB/SIMULINK and PSIM. Here the author could easily explain the operation of these circuits by drawing just in a few seconds or by pre preparing for this circuit and just simulate and run it in front of the student in the classroom. These provide a virtual operation and with the help of the input pulses the author can easily change the shape / performance of the circuit and devices Mehar (2012), Khader (2010).



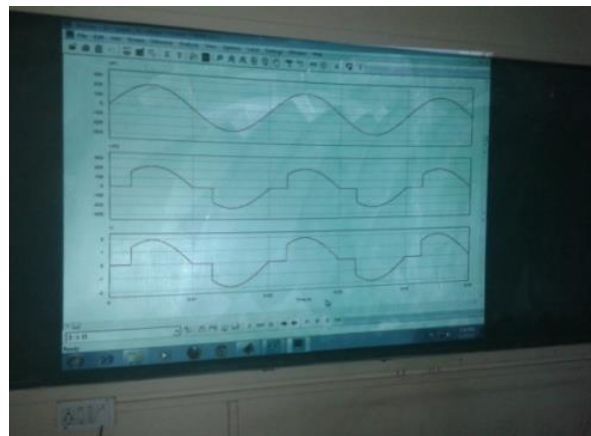
**Figure 4: MATLAB/SIMULINK Software based captured image from classroom**



**Figure 5: MATLAB/SIMULINK Software based captured image from classroom**



**Figure 6: PSIM Software based captured image from classroom**



**Figure 7: PSIM Software based captured image from classroom**

### 3 FINDINGS AND DISCUSSION

The perceptions of students on the different types of teaching medium for AC voltage controller will be presented first followed by detailed explanation on the simulation based approach.

#### 3.1 Students' feedback on the use of the three different teaching mediums

A feedback is taken from the students based on the different parameters, a feedback summary is provided in table 1, as the evidence of this case study.

**Table 1: Comparison between Blackboard, PPT Presentation & Software Approach**

No	parameters	Applied different methodology		
		Blackboard	PPT Presentation	Software
1.	Firing Angle	Fixed	Fixed	Easily Changed
2.	Modification	Not Possible	Not Possible	Easy
3.	Clarity	poor	Average	Higher
4.	Communication Level	Satisfied	Average	Strongly Satisfied
5.	Creative	Average	Below Average	Much Higher

The result from the feedback form indicate that students found that software approach were easily changed in term of firing angle compared to blackboard and PPT presentation, in addition with the circuit and can be easily modified at any time during the delivery of the lecture. This gives a strong and effective communication and showing some creative work.

**Table 2: A questionnaire of Case Study**

No	parameters	Applied different methodology*		
		Blackboard	PPT Presentation	Software
1.	Approach	2	3	5
2.	Explanation Level	3	3	4
3.	Understanding of Topic	4	2	4
4.	Communication	3	4	3
5.	Usefulness	2	3	4
6.	Creative	1	2	5

\*Points given by student based on 1 – poor, 2 – good, 3 – medium, 4 – average, 5 - best

The result from questionnaire indicated that majority students rated software as the best approach, while three of them rated PPT presentation and the remaining two were choosing blackboard. In regards to explanation level, only a little bit different, where four students rated software providing much better explanation, but the usefulness and creative point of view students gives more marks compare to the rest of two approaches.

### 3.2 Using MATLAB/SIMULINK based simulation

MATLAB/SIMULINK based Simulation model for AC voltage controller is shown in figure below. The performance of the devices is represented with the help of waveforms in fig. in this fig the waves for output voltage, current and V & I across the device are shown, for the simplicity of the concept of learning and presentation of proposed method here only a resistive load is considered (Mehar, 2012; Silva, 2013).

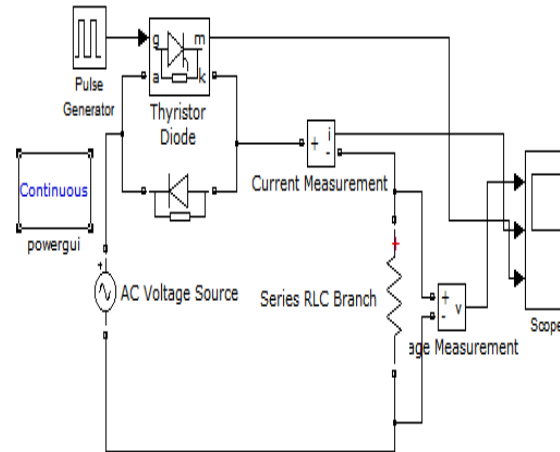


Figure 8: Simulation model of single phase half wave ac voltage controller

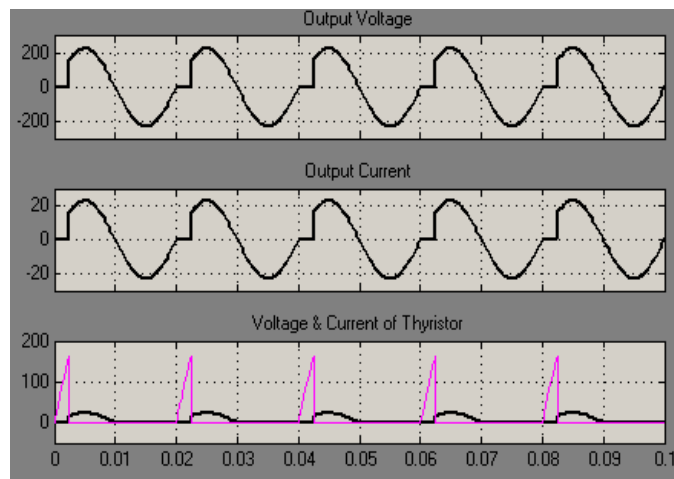
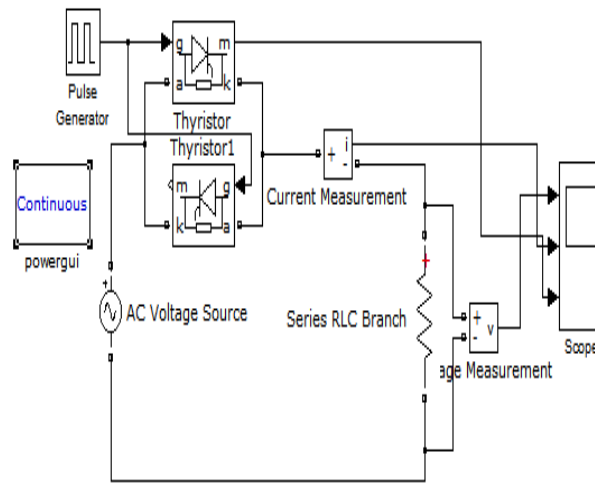


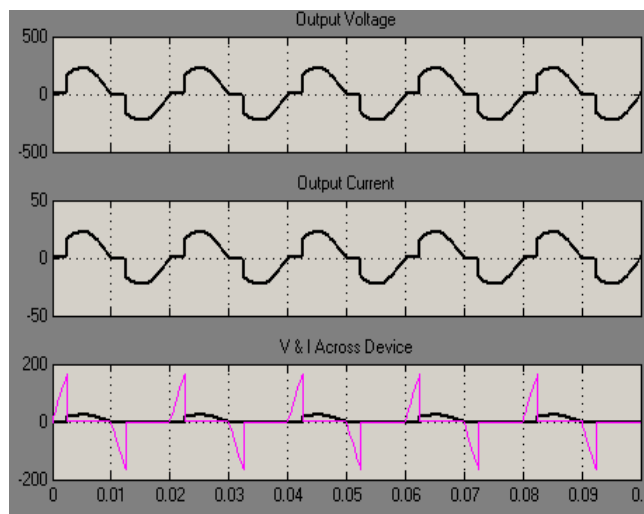
Figure 9: Output results of single phase half wave ac voltage controller





**Figure 10: Simulation model of single phase full wave ac voltage controller**

Here with the change of the setting of the Pulse Generator we can easily change the firing angle of the device. We can also adopt the different firing schemes, but for this particular application the pulse generator is the best suitable option. For the different type of the load we can choose the different types of filtering circuits to improve the operation.



**Figure 11: Output results of single phase full wave ac voltage controller**

### 3.3 PSIM based simulation

A PSIM based Simulation model for AC voltage controller is shown in figure below. The performance of the devices is represented with the help of waveforms in figure in this figure the waves for output voltage, current and V & I across the device are shown. For simplicity of the concept of learning and presentation of proposed method here only a resistive load is considered (Mehar, 2013; Canesin, 2010).

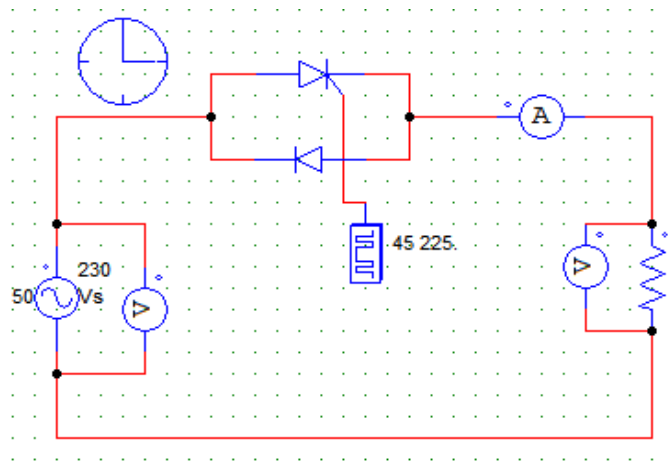


Figure 12: Simulation model of single phase half wave ac voltage controller

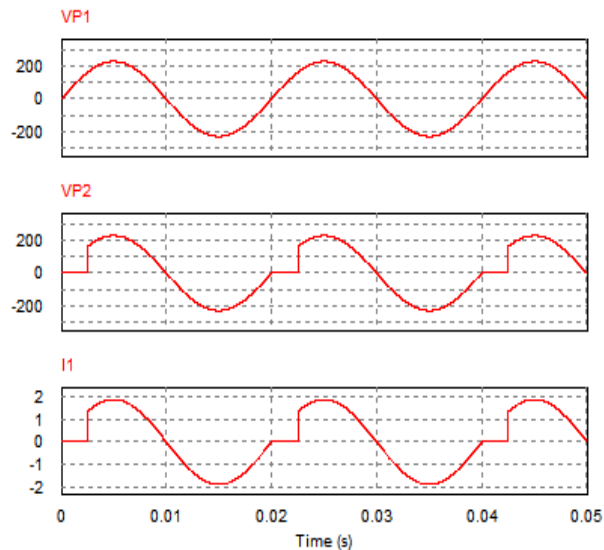
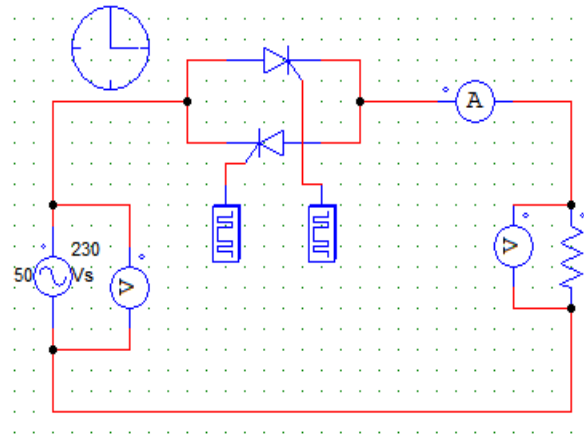
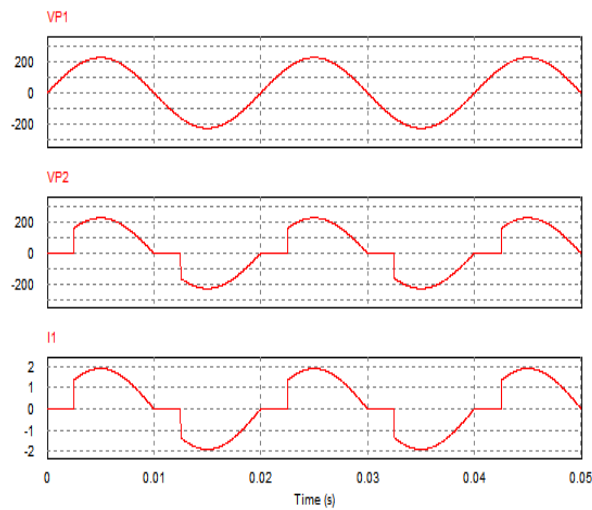


Figure 13: Output results of single phase half wave ac voltage controller



**Figure 14: Simulation model of single phase full wave ac voltage controller**



**Figure 15: Output results of single phase full wave ac voltage controller**

Here with the change of the setting of the Gate Pulse we can easily change the firing angle of the device. We can also adopt the different firing schemes, but for this particular application the pulse generator is the best suitable option. For the different type of the load we can choose the different types of filtering circuits to improve the operation.

## 4 RECOMMENDATION

The following advantages derived when using Software in teaching power electronics courses:

1. It provides better visual operation of power electronics converters.
2. Use of software in classroom save the time of the faculty.
3. With user-friendly interface, simulation speed, capability of simulating any type of power converters and control circuits.
4. Students can use this software for their project works.

This paper provides a basic approach to deal with the software. The only limitation with this software approach is that a teacher needs to have computer knowledge and in-depth knowledge of power electronics to assess the accuracy of the results.

## 5 CONCLUSION

This paper provides a comparison between blackboard and PPT slides presentation approach versus software approach for teaching a unit in power electronics. As power electronic systems are getting more complex today, the simulation used for education requires more features. This approach is time saving and some directions in the development of simulation are discussed in this paper, with the help of available model; students can simulate the power electronics circuit with various load and conditions.

## Reference

- Hemant Mehar, (2012) "Software Application In Under Graduate Electrical Engineering Education", *International Journal of Engineering Research & Technology (IJERT)*, Vol. 1 (10).
- Bhimbra, P. S., *Power Electronics*, 4th Ed., Khanna Publication, 2007.
- Muhammad H. Rashid, *Power electronics, circuit devices and application*, 3rd Ed., Pearson education Inc., 2007. P.C.
- Sen, *Power electronics*, Tata McGraw-Hill publishing company, 2008.
- BK khanchandani, *Power electronics*, Tata McGraw-Hill publishing company, 2008.
- Hemant Mehar, (2012) "MATLAB Simulation Techniques in Power Electronics", *IEEE Technology and Engineering Education (ITEE)*, vol. 7 (4), pp. 62.
- Chung Kuo, Jack Hsieh, FiruzZare, (2007), Senior Member IEEE, Gerard Ledwich, Senior Member IEEE "An Interactive Educational Learning Tool for Power Electronics" Conf. Power Engineering, Australasian Universities, AUPEC.
- Rajesh Verma, Ashu Gupta and Kawaljeet Singh, (2008), "Simulation Software Evaluation and Selection: A Comprehensive Framework", *J. Automation & Systems Engineering*, pp. 221-234.
- Sameer Khader, "The Application of PSIM & MATLAB/SIMULINK in power electronics courses", Conf. "Learning Environments and Ecosystems in Engineering Education"; *IEEE Global Engineering Education Conference (EDUCON)* – April 4-6, 2010, Amman, Jordan.
- Kapilevich, B. Shaibon, H. ; Rahman, T.A. "Simulation modeling in electrical engineering: experience of teaching in University Technology of Malaysia", *IEEE First International Conference on Multi-Media Engineering Education Proceedings, 1994.*, pp. 92-98, July 1994.
- Hemant Mehar, (2013), "The Case Study of Simulation of Power Converter Circuits Using Psim Software in Teaching", *American Journal of Educational Research*, , vol. 1 (4), pp. 137-142, May.

- W. W. Cooley, P. Klinkhachorn, R. L. McConnell, and N. T. Middleton, (1991) "Developing professionalism in the electrical engineering classroom," *IEEE Trans. Educ.*, vol. 34, pp. 149–154.
- Euzeli Cipriano dos Santos, Edison Roberto Cabral da Silva, (2013), "Power Block Geometry Applied to the Building of Power Electronics Converters" *IEEE Trans. Educ.*, vol. 56 (2), pp.191–198.
- A. Abramovitz, (2011) "Teaching behavioral modeling and simulation techniques for power electronics courses," *IEEE Trans. Educ.*, vol. 54, no. 4, pp. 523–530,.
- M. Prince and R. Felder, "The many faces of inductive teaching and learning," *J. College Sci. Teaching*, vol. 36, pp. 14–20, Mar. 2007.
- C. A. Canesin, F. A. S. Gonçalves, and L. P. Sampaio, (2010) "Simulation tools for power electronics courses based on Java technologies," *IEEE Trans. Educ.*, vol. 53 (4), pp. 580–586.