The Case Study of Simulation of Power Converter Circuits Using Psim Software in Teaching

Hemant Mehar*

Electrical & Electronics Engineering Department IES, IPS Academy, Indore, MP, India
*Corresponding author: meharhemant@yahoo.com

Received April 21, 2013; Revised May 19, 2013; Accepted May 20, 2013

Abstract Involvement of software in teaching is provide a batter support, more clear and visual operation of complex circuits and waveforms to the faculty of power electronics in classroom teaching. The software packages available for simulation of power electronic circuits are MATLAB, PSPICE and PSIM and many more. Use of the software in classroom teaching is provide an additional support to the faculty and its better then the time consuming black board practice. This paper provides a case study of power electronics circuits in PSIM software. Different power electronics converters model are prepared on PSIM software and generate simulation waveforms. This paper is helpful for the faculty of electrical engineering to find the applications of PSIM in teaching.

Keywords: PSIM, simulation, power electronics, electrical, teaching

1. Introduction

In the present trends, Power electronics is one of the most important subjects of electrical engineering. Power electronics technology involved various types of converters. These converters are the application of circuit theory and design techniques, the development of analytical tools toward efficient electronic conversion, control, and conditioning of electric power. The typical undergraduate syllabus will have topics like uncontrolled and controlled rectifiers with R, RL loads; choppers; single-phase and 3-phase inverters; AC voltage controllers, etc. [1]. A simulation practice is providing a platform the student to work efficiently in the present and future design industry because due to the advanced development in technology, simulation process is very useful. Here the simulation of converters is presented using PSIM software.

2. PSIM for Simulation

The basic PSIM process in represented in the Figure 1.1. A circuit is represented in PSIM in four blocks: power circuit, control circuit, sensors, and switch controllers.

Figure 1.1. PSIM Process

The power circuit consists of switching devices, RLC branches, transformers, and coupled inductors. The control circuit is represented in block diagram. Components in s-domain and z domain, logic components (such as logic gates and flip-flops), and non-linear components (such as multipliers and dividers) are used in the control circuit. Sensors are used to measure power circuit quantities and pass them to the control circuit. Gating signal is then generated from the control circuit and sent back to the power circuit through switch controllers to control switches.

3. Simulation in Power Electronics

3.1. Diode Characteristics

Diodes are active devices constructed to allow current to flow in one direction. The diode consists of N-type and P-type materials The N-type material is called the cathode and the P-type material is called the anode. There are two types of biasing that can be applied to a diode. For a diode to be forward biased, a power supply is connected with the positive terminal to the P-type material (anode) and the negative terminal to the N-type material (cathode). The graph below shows the electrical characteristics of a typical diode. When a small voltage is applied to the diode in the forward direction, current flows easily. For a diode to be reversed biased, the power supply leads are set up with the negative terminal attached to the P-type material and the positive terminal attached to the N-type material.
When voltage is applied in the reverse direction through a diode, the diode will have a great resistance to current flow. Different diodes have different characteristics when reverse-biased.

<table>
<thead>
<tr>
<th>V D</th>
<th>I D</th>
<th>I D</th>
<th>I D</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1</td>
<td>0A</td>
<td>18.5uA</td>
<td>0A</td>
</tr>
<tr>
<td>.2</td>
<td>0.2uA</td>
<td>245uA</td>
<td>0A</td>
</tr>
<tr>
<td>.3</td>
<td>1.4uA</td>
<td>1.9mA</td>
<td>0.1uA</td>
</tr>
<tr>
<td>.4</td>
<td>10.4uA</td>
<td>10.6mA</td>
<td>0.2uA</td>
</tr>
<tr>
<td>.5</td>
<td>85uA</td>
<td>39.4mA</td>
<td>1.6uA</td>
</tr>
<tr>
<td>.6</td>
<td>708uA</td>
<td>1113mA</td>
<td>35uA</td>
</tr>
<tr>
<td>.7</td>
<td>6.9mA</td>
<td>1.13mA</td>
<td></td>
</tr>
<tr>
<td>.8</td>
<td>30.5mA</td>
<td>41.7mA</td>
<td></td>
</tr>
</tbody>
</table>

3.2. Diode Rectifiers

Rectifiers are mainly used in power supplies where an AC signal is to be converted to DC. The DC voltage is obtained by passing the rectifier’s output through a filter to remove the ripple (AC components). There are many possible ways to construct rectifier circuits using diodes. The three basic types of rectifier circuits are:

- The Half Wave Rectifier
- The Full Wave Rectifier
- The Bridge Rectifier

In such diode rectifiers, the power flow can be only from the utility ac side to the dc side. A majority of the power electronics applications use such as switching dc power supplies, ac motor drives, dc servo drives and so on use such uncontrolled rectifiers. in this simulation model capacitor filter are used to filtered the ripple content in the output of the rectifier.
3.3. Three Phase Diode Bridge Rectifiers

In industrial applications where three-phase ac voltages are available, it is preferable to use three-phase rectifier circuits, compared to single-phase rectifiers, because of their lower ripple content in the waveforms and a higher power-handling capability. The 3-phase, 6-pulse, full bridge diode rectifier is commonly used circuit arrangement. A filter capacitor is connected at the dc side of the rectifier.

![Simulation modal of Three Phase Uncontrolled Bridge Rectifier](image1)

![Waveforms of Three Phase Uncontrolled Bridge Rectifier](image2)
3.4. Thyristor Converters

For given ac input voltages, the magnitude of the average output voltage in thyristor converters can be controlled by delaying the instants at which the thyristors are allowed to start conduction.

Figure 3.7. Simulation modal of Three Phase controlled Rectifier

3.5. Single Phase Half-Controlled Bridge Rectifier

A single-phase semi converter bridge consists of two diodes and two thyristors. The load is of RLE type. With T1 on, load gets connected to source through T1 and D1. For the period $\omega t=45$ to 180, load current flows through T1 and D1 and output Vo is of same wave shape as Vs. After $\omega t=180$ load voltage tends to reverse as ac voltage changes polarity. There is limited control over the level of dc output voltage.

Figure 3.8. Simulation modal of Three Phase controlled Rectifier
3.6. Single Phase Fully Controlled Bridge Rectifier

A single-phase full converter bridge consists of four SCRs as shown. Thyristor pair T1 and T2 is simultaneously triggered and 180 later, pair T3 and T4 is gated together. Voltage at the output terminals can be controlled by adjusting the firing angle delay of the thyristors. There is a wider control over the level of dc output voltage.

4. Advantages & Limitations

The following advantages derived when using PSIM 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 its user-friendly interface, its simulation speed, its 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 the knowledge of computer and depth knowledge of power electronics subject is necessary to identify the truth results.

5. Conclusion

This case study provides the visual operations of power electronics converters. As power electronic systems are getting more complex today, the simulation used for education is requiring more features. This approach is time saving and some directions in the development of simulation are discussed in this paper, with the help of present model students can simulate the power electronics circuit with various load & conditions.

Reference


