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PRIMENA PROGRAMSKOG PAKETA PSIM U PROUČAVANJA DIODNOG ISPRAVLJAČA
PSIM AS EDUCATIONAL TOOL FOR TEACHING DIODE RECTIFIER

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Sadržaj: *U ovom radu predstavljamo upotrebu PSIM softverskog paketa namenjen za izučavanje osnove diodnih ispravljača. Računarske simulacije su značajne u procesu učenja i dodatna su podrška za bolje razumevanje ne samo ispravljača, već i za razumevanje različitih elektronskih kola. Pripremljena su tri modela celotalasnih ispravljača za simulaciju talasnih formi.*

Abstract: *This paper represents the usage of software packet PSIM in teaching students the basics of diode rectifiers. Computer simulations are important in learning process and can provide additional support in better understanding not just of rectifiers but better understanding of different power electronics circuits. Three models of singe phase full- wave rectifier have been prepared for waveforms simulations.*

1. INTRODUCTION

A rectifier is an electrical device that converts alternating current to direct current through process of rectification. The two basic types of full- wave rectifiers are center- trapped transformer rectifier and the bridge rectifier. The full-wave center- tapped transformer rectifier (Fig. 1) in order to utilize the both cycles of AC voltage supply uses two diodes that create a return path for the current by adding a tap at the center of the secondary winding. During the positive half cycle of the voltage the diode D1 is forward biased and conducts, while diode D2 is reverse biased and does not conducts. In the second half cycle D2 is forward biased and conducts while D1 is reverse biased. The rectification occurs during the whole period of the voltage. The current through the load is always in the same direction during both half cycles even though the secondary voltage has changed polarity.

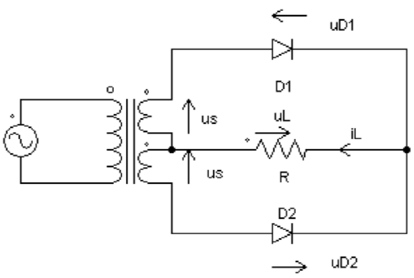

Fig.1 Full-wave center- tapped transformer rectifier

The voltage and current equations, ratio of rectification, form and ripple factor are defined in [1] – [3]. The average value of the load voltage v_L is U_{dc} and is defined as:

$$U_{dc} = \frac{2}{2\pi}\int_0^{\pi} U_m \sin\omega t dt = \frac{2U_m}{\pi} = 0.603 U_m \qquad (1)$$

The root mean square (rms) value of the load voltage v_L is U_L and is defined as:

$$U_L = \sqrt{\frac{1}{\pi}\int_0^{\pi} \left(U_m \sin\omega t dt\right)^2} = \frac{U_m}{\sqrt{2}} = 0.707 U_m \quad (2)$$

The result from equation (2) is expected since the rms value of full- wave rectifier voltage should be equal to the rms value of the input ac voltage.

Having assumed that the load is purely resistive, the average value of load current i_L is I_{dc} and can be calculated as:

$$I_{dc} = \frac{U_{dc}}{R} = \frac{2U_m}{\pi R} = \frac{0.636 U_m}{R} \qquad (3)$$

The root mean square value of the load current i_L is I_L and can be calculated as:

$$I_L = \frac{U_L}{R} = \frac{U_m}{\sqrt{2}R} = \frac{0.707 U_m}{R} \qquad (4)$$

The form factor is ration between root mean square value of the voltage and its average value:

$$FF = \frac{U_L}{U_{dc}} = \frac{\pi}{2\sqrt{2}} = 1.11 \qquad (5)$$

The ripple factor is a ration between the effective (rms) value of the ac component of the load voltage u_L and the average value of the load voltage U_{dc}:

$$RF = \frac{U_{ac}}{U_{dc}} = \sqrt{\frac{U_L^2 - U_{dc}^2}{U_{dc}^2}} = \sqrt{FF^2 - 1} = 0.482 \qquad (6)$$

The rectification ratio is merit for comparing the effectiveness of rectification and can be calculated as:

$$\sigma = \left(\frac{P_{dc}}{P_L}\right)^2 \cdot 100\% = \frac{(0.636 U_m)^2}{(0.707 U_m)^2} \cdot 100\% = 81\% \qquad (7)$$

The transformer utilization factor (TUF) is a measure of the merit of rectifier circuit and is defined as ratio of the dc output power to the transformer volt-ampere rating required by the secondary winding:

$$TUF = \frac{P_{dc}}{V_s I_s} = 0.572 \qquad (8)$$

Where V_s and I_s are the root mean square voltage and current ratings of the transformer secondary. The secondary VA rating $V_s I_s$ is double that one of the half-wave rectifier because the full-wave rectifier with center tapped transformer can be treated as two half-wave rectifiers operating together.

In order to smooth the output dc voltage on the load capacitor dc filters are used. The equivalent circuit for capacitor input dc filter is shown in Fig.2. When the instantaneous voltage of the secondary winding u_s is higher than the instantaneous value of capacitor voltage v_L either diode D1 or D2 conducts. When the instantaneous voltage of the secondary winding u_s falls below the instantaneous value of capacitor voltage v_L the diodes D1 and D2 are reversed bias and the capacitor is discharged through the load. The capacitor voltage v_L varies between the maximum value U_m and the minimum value U_m-$U_{r(pp)}$, where $U_{r(pp)}$ is peak to peak ripple voltage. If the voltage $U_{r(pp)}$,[1]-[3], is small it can be approximated with:

$$U_{r(pp)} = \frac{U_m}{f_r RC} \qquad (9)$$

Where f_r is the output ripple frequency of the rectifier.

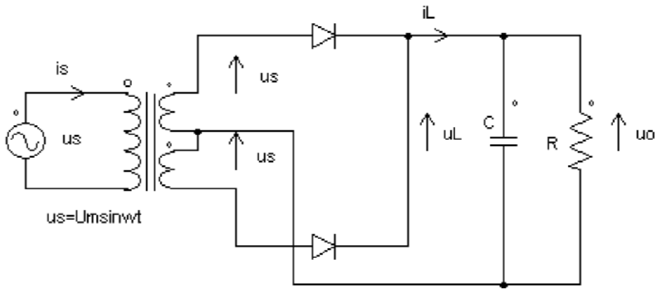

Fig.2. Full-wave center- tapped transformer rectifier with capacitor- input dc filter

The average value of the load output voltage is defined as:

$$U_{dc} = U_m \left(1 - \frac{1}{2 f_r RC}\right) \qquad (10)$$

The root mean square voltage U_L is defined as:

$$U_L = \frac{U_m}{2\sqrt{2} f_r RC} \qquad (11)$$

The ripple factor of full-wave rectifier with capacitor- input dc filter can be calculated as:

$$RF = \frac{1}{\sqrt{2}\left(2 f_r RC - 1\right)} \qquad (12)$$

Bridge rectifier (Fig. 3) in order to provide full- wave rectification uses four diodes instead center- tapped transformer. During the positive half cycle of the transformer secondary voltage, diode D1 and D2 conduct while during the negative half cycle diode D3 and D4 conduct. The voltage and current relationship, as well as form factor and rectification ratio are same as those for full- wave center-tapped transformer rectifier. The bridge TUF factor is higher that the TUF factor of center- tapped transformer rectifier because the currents flowing in primary and secondary windings are continuous sine waves. The TUF factor [1]-[3] of the bridge rectifier can be calculate as:

$$TUF = \frac{0.636^2}{0.707 \cdot 0.707} = 0.81 \qquad (13)$$

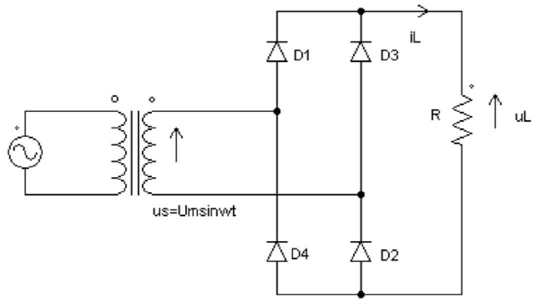

Fig.3. Full-wave bridge rectifier

2. SIMULATIONS IN PSIM

PSIM [4] is a software package designed for simulation of power electronics circuits developed by Powersim Inc. With friendly user interface and fast simulations, PSIM provides powerful simulation environment for power electronics, analog and digital control, magnetics and moor drive system. PISM has interactive simulations capability and allows changing values of parameters and view of voltage and current wave forms in the middle of a simulation. For educational purspose, PSIM has the simplest approach to build electrical circuits and extract results with waveform viewer Simview.

Having the theoretical basis about rectifiers, students are now able to perform simulations in PSIM. The students performed simulation of full- wave center- tapped transformer rectifier with and without capacitor and bridge rectifier. The aim of these laboratory excersises is students to learn how to construct a full- wave rectifier using center- tapped transformer and bridge configuration. Also students learn how to filter rectified waves to generate a dc components from ac source. At the end studets fill lab report and draw the input and output waveforms.

The first exercise [5] is simulation of full-wave center-tapped transformer rectifier as shown in Fig. 4. The input voltage is with sinusoidal waveform with amplitude 220V and frequency 50Hz. The load has resistance of 1Ω. The characteristics of the transformer and diodes are as they are defined in the program. The voltmeter is tied parallel to the input voltage Vi and serves to measure and display the input voltage. The other voltmeter is tied parallel to load R and serves to display the output voltage. The duration of the simulation is 20ms. The waveform of the voltage and the current through the load are shown in Fig. 5.

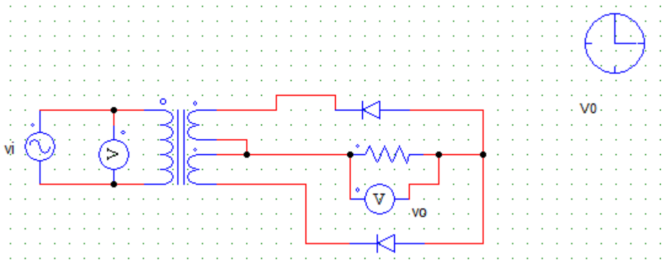

Fig 4. Simulation model of center- tapped transformer rectifier

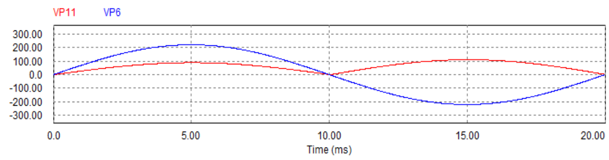

Fig 5. Waveforms of full- wave center- tapper transformer rectifier

The second exercise [5] is simulation of full-wave center-tapped transformer rectifier with capacitor filter as shown in Fig. 6. The source is sinusoidal with amplitude 220V and frequency 50Hz. The load is with resistance 1Ω and the value of the capacitor is adjusted to 0.001F. The characteristics of the transformer and diodes are as they are defined in the program. The other voltmeter is tied parallel to load R and serves to display the output voltage. The duration of the simulation is 20ms. The waveform of the voltage and the current through the load are shown in Fig. 7.

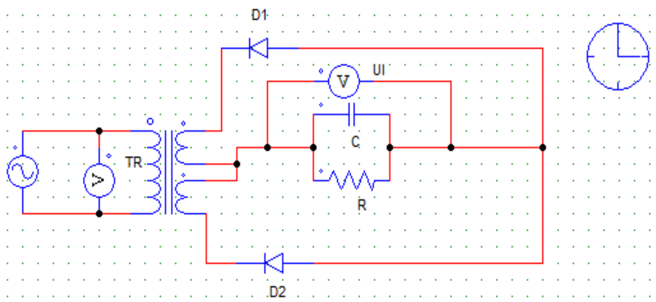

Fig 6. Simulation model of full- wave center- tapped transformer rectifier with capacitor filter

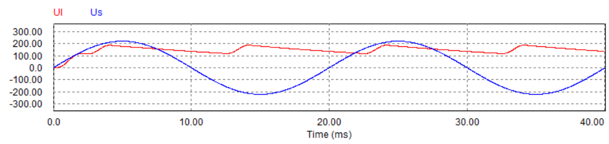

Fig 7. Waveforms of full- wave center- tapper transformer rectifier with capacitor filter

The third exercise is simulation of full-wave bridge rectifier (Fig. 8). The input source is sinusoidal wave with amplitude 220V and frequency 50Hz. The characteristics of the transformer and diodes are as they are defined in the program. Load resistance is 5Ω.

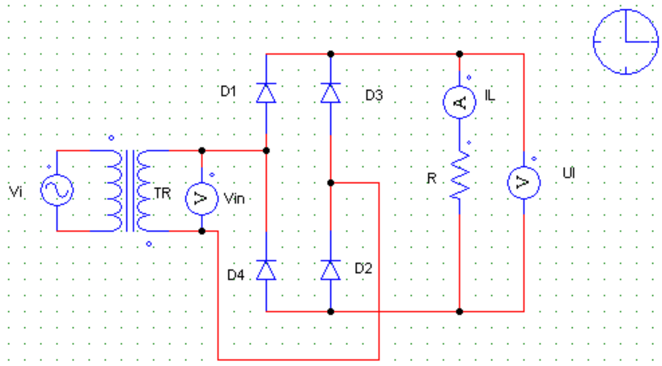

Fig 8. Simulation model of full- wave bridge rectifier

The voltmeter is tied parallel to load R and serves to display the output voltage while the ammeter is tied serial to the load and displays the current through the load. The Duration of the simulation is 40ms. The waveform of the voltage and the current through the load are shown in Fig. 9.

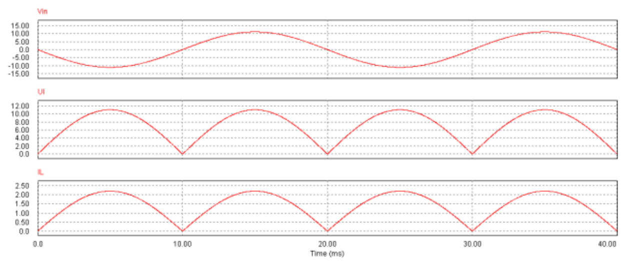

Fig 9. Voltage and current waveforms of bridge rectifier

3. CONCLUSION

A detailed analysis of creating simulation models for diode rectifiers using the software packet PSIM was analyzed in this paper. Trough demonstration of three examples are represented the capabilities of software package PSIM as a complementary tool in learning process that may help students to understand power electronics. The waveforms obtained by the computer simulations are close to theoretically obtained waveforms.

REFERENCES

[1] R. W. Ericson, D. Maksimovic, Fundamentals of Power Electronics, Kluwer, 2002.

[2] W.B. Williams, Principles and Elements of Power Electronics, University of Strathcyde, Glasgow, 2006.

[3] W. Shepherd, Li Zhang, Power Converter Circuits, Marcel Dekker, 2004.

[4] http://powersimtech.com/products/psim/

[5] V. Sarac, Industriska elektronika- Praktikum za kompjuterski vezbi, UGD, Stip 2012.