Simulation model of 1-phase pulse-width modulation rectifier by using MATLAB/Simulink

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ABSTRACT

One of the problems that need to be solved is the difference in the type of nutrition from the load. The feeding may be from a constant current source such as batteries and solar cells, and there are alternating current sources such as diesel machines, wind energy, and various power plants. All of these sources need electronic power devices that help convert and regulate the control and control of the type of feeding on the one hand and its amount on the other. From here, we show the size of the challenge occupied by electronic power transformers, as they are considered the solution to many problems of transmission, distribution, and feeding systems for different loads. The current study sheds light on one of the types of electronic power systems, which is unified. Choosing and suggesting a set of single-phase unifying circuits to conduct simulations and come up with results that are analyzed to show the function of the non-electronic modulators. In the current simulation, tests were carried out for a group of circuits that need direct current (DC) power, and their available source of supply is an alternating current source to different departments to access a set of data that enables researchers to conduct appropriate analyzes to perform them, by discussing those results.

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1. INTRODUCTION

Electronic power devices are important in many applications, which is why they are a source of interest for researchers with specialists [1]–[3]. Electronic power devices are of four forms, including changing the type of supply from continuous to alternating and vice versa, and second from a fixed source to a variable [4]–[6]. The first is called the unified, which converts from alternating current to continuous single-phase or three-phase [7]–[9]. The second inverter, which is the opposite of the unified, converts the continuous into alternating [10]–[12]. The third is a constant current transformer and works on obtaining a variable supply from a fixed source [13]–[15]. The fourth is the same as the third, but with a different type of current, it is a constant alternating current (AC) transformer to a variable [16]–[19]. All types can be standardized full waves or unified half waves [20]–[22]. Electronic power devices are important as they are used in various applications such as household and industrial appliances and others that need to be fed a constant current and with an alternating current supply source [23]–[25]. It is necessary for the specialists to see the behavior of the various unified circuits [26]–[28]. Therefore, researchers focused on all types, including single-phase, and there is also another three-phase type [29]–[31].

In the current simulation, verify the possibility of using the computer program to test more types that represent a uniform full wave and half wave. Current simulation using MATLAB/Simulink program for a single-phase modulator that converts alternating current to direct current (DC). It is proposed to simulate this type with a 314 V source and a frequency of 50 Hz. The proposed circuits for simulation are firstly, half wave unified and secondly" full wave unified. Electronic switches and it is called unified uncontrolled using diode again and again unified controller using thyristor. The simulation depends on the unified test in three cases from the load end, resistance load 30 ohm, 40 ohm, and 50 ohm.

The results are in a form. Therefore, it can be said in the cases included in the simulation. First, "a unified half-wave without a controller, the number of which is three, it is a unified half-wave without a controller using an electronic switch, the diode, and the circuit load is (resistance, at 30 ohm, 40 ohm, and 50 ohm). Secondly, a unified half-wave with a controller and its number three is a unified half-wave controlled by a thyristor electronic switch and the circuit load is (resistance, at 30 ohm, 40 ohm, and 50 ohm). Third, a unified full-wave without a controller, and the three number are unified half-wave without a controller using an electronic switch, the diode, and the circuit load is (resistance, at 30 ohm, 40 ohm, and 50 ohm). Fourth, a unified full-wave with a controller, and the three are unified half-wave with a controller using an electronic switch, a thyristor and circuit load are (resistance, at 30 ohm, 40 ohm, and 50 ohm).

2. SIMULATION AND MATHEMATICAL REPRESENTATION

Power electronic devices (PED) are classified into four types in terms of conversion. A transformer is called an inverter, which has a continuous input and an alternating output [32]–[34]. Another has an alternating input and a continuous output called the unified. There are transformers for the same supply and output, both continuous or alternating. All the mentioned types are used using electronic switches such as diode, transistor and thyristor. Some of them are single-phase and three-phase [29], [35], [36]. Their selection depends on the type of supply, type of load, and the required amount of frequency, current and voltage. Electronic transformers are built on two types, including half-wave and full-wave [37]–[40].

The simulation is carried out for a full-wave and half-wave unifier, which can be represented mathematically by (1) to (12), which can be represented in Figures 1-4. Equation (1) is root mean square of output voltage (V_{rms}).

$$V_{rms} = \left\{\frac{1}{T}\int_0^T V^2(t)dt\right\}^{0.5} \tag{1}$$

Equation (2) is root mean square of output current (I_{rms}).

$$I_{rms} = \left\{\frac{1}{T}\int_0^T I^2(t)dt\right\}^{0.5} \tag{2}$$

Equation (3) is average of voltage (V_{avg}).

$$V_{avg} = \frac{1}{T}\int_0^T V(t)dt \tag{3}$$

Equation (4) is average of current (I_{avg}).

$$I_{avg} = \frac{1}{T}\int_0^T I(t)dt \tag{4}$$

Equation (5) is root mean square of input power (P_{ac}).

$$P_{ac} = V_{rms}.I_{rms} \tag{5}$$

Equation (6) is average of output power (P_{dc}).

$$P_{dc} = V_{avg}.I_{avg} \tag{6}$$

Equation (7) is efficiency (η).

$$\eta = \frac{P_{ac}}{P_{dc}} = \frac{V_{rms}\cdot I_{rms}}{V_{avg}\cdot I_{avg}} \tag{7}$$

Equation (8) is ripple factor (RF).

$$RF = \frac{V_{ac}}{V_{dc}} \tag{8}$$

Equation (9) is form factor (FF).

$$FF = \frac{V_{rms}}{V_{avg}} \tag{9}$$

Equation (10) is harmonic factor (HF).

$$HF = \left[\left({}^{I_{s1}}/_{I_s}\right)^2 - 1\right]^{0.5} \tag{10}$$

Equation (11) is crest factor (CF).

$$CF = \frac{I_{s(peak)}}{I_s} \tag{11}$$

Equation (12) is power factor (PF) [41]–[44].

$$PF = {}^{I_{s1}}/_{I_s} \cos\emptyset \tag{12}$$

In Figure 1 show 1-ph of uncontrolled for half wave rectifier (H.W.R) by using one diode with R load. In Figure 2 show 1-ph of controlled for H.W.R by using one thyristor with R load. In Figure 3 show 1-ph of uncontrolled for full wave rectifier (F.W.R) by using four diode with R load. In Figure 4 show 1-ph of controlled for F.W.R by using four thyristor with R load.

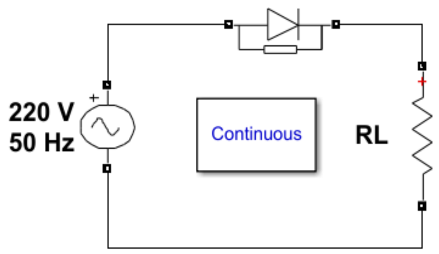


Figure 1. 1-ph of uncontrolled for H.W.R with R load

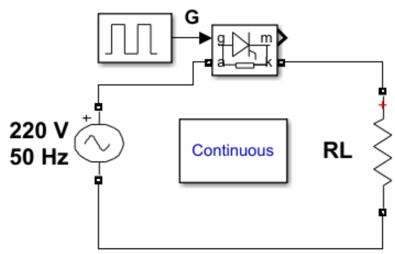


Figure 2. 1-ph of controlled for H.W.R with R load

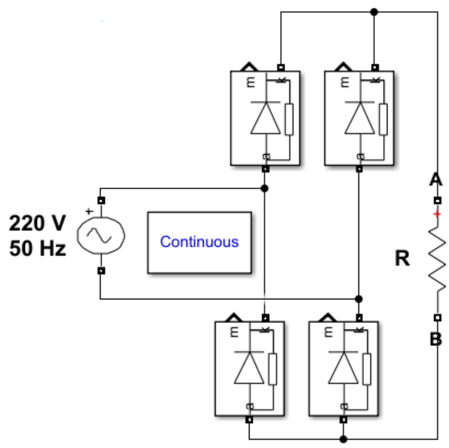


Figure 3. 1-ph of uncontrolled for F.W.R with R load

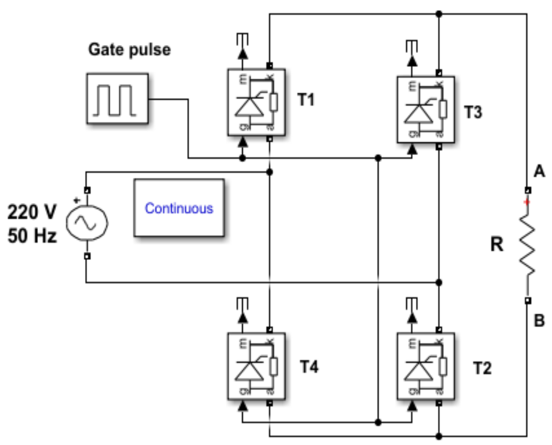


Figure 4. 1-ph of controlled for F.W.R with R load

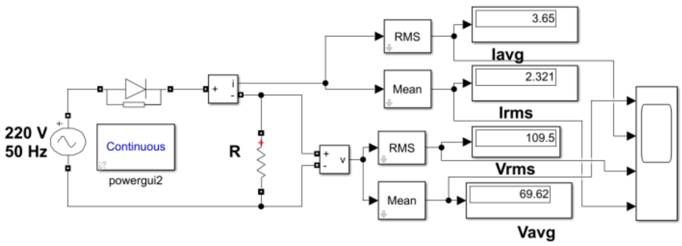
3. MODELLING AND SIMULATION RESULTS

To conduct the simulation, a model was proposed for each circuit representing a unified full wave or a unified half wave with the parameters of the load for each case and the supply source voltage, frequency, and resistance in tables for all cases for which the simulation was proposed. Using the simulation of these types, the results can be shown as in the tables and figures, which shows the possibility of obtaining verification results and shows the work of the rectifier in obtaining a constant current from an alternating current source to feed the load. Simulation results can be documented in tables and figures and under different headings according to the type of rectifier used, as in the following figures and tables. Table 1 shows values for parameter of models.

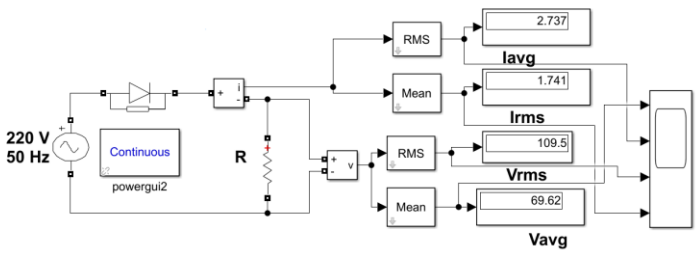
Table 1. Values for parameter of models

Parameter	Sym poles	Values	Units
I/P Voltage	Vin	220	volts
I/P Frequency	Fin	50	Hz
Resistance	R	30, 40, 50	Ω

In Figure 5 show three models for 1-phase uncontrolled H.W.R that use in this simulation, Figures 5(a) at load 30 ohm, 5(b) at load 40 ohm, and 5(c) at load 50 ohm. In Figure 6 show three models for 1-phase controller H.W.R that use in this simulation, Figures 6(a) at load 30 ohm, 6(b) at load 40 ohm, and 6(c) at load 50 ohm. In Figure 7 show three models for 1-phase uncontrolled F.W.R that use in this simulation, Figures 7(a) at load 30 ohm, 7(b) at load 40 ohm, and 7(c) at load 50 ohm. In Figure 8 show three models for 1-phase controller F.W.R that use in this simulation, Figure 8(a) at load 30 ohm, 8(b) at load 40 ohm, and 8(c) at load 50 ohm.



(a)



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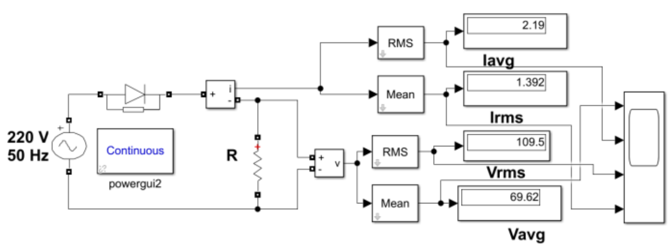
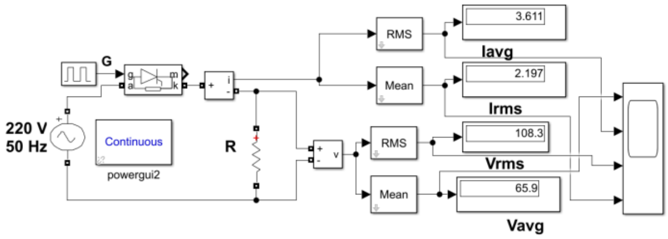
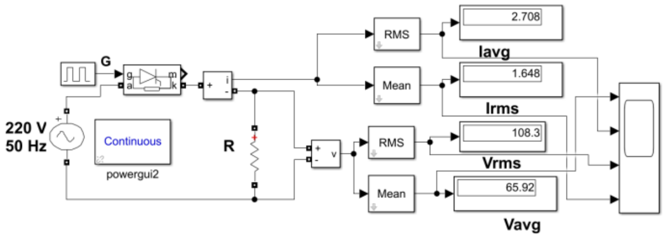


(c)

Figure 5. 1-ph uncontrolled H.W.R: (a) load 30 ohm, (b) load 40 ohm, and (c) load 50 ohm



(a)



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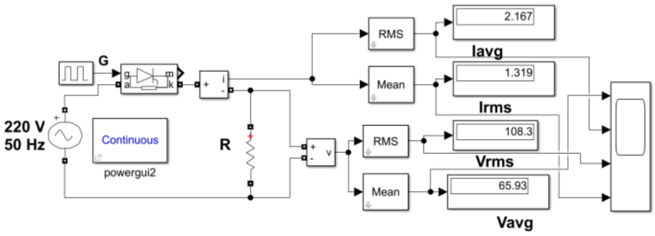
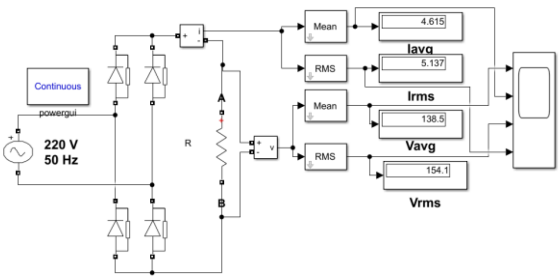
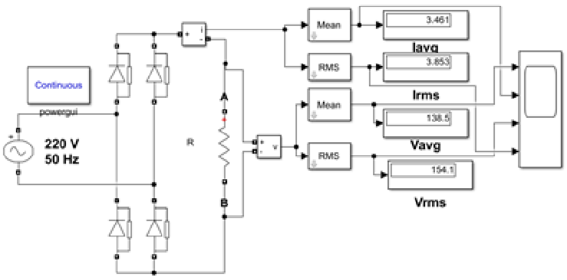


(c)

Figure 6. 1-ph controlled H.W.R: (a) load 30 ohm, (b) load 40 ohm, and (c) load 50 ohm



(a)



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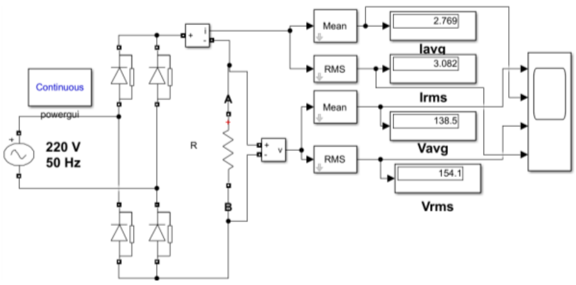
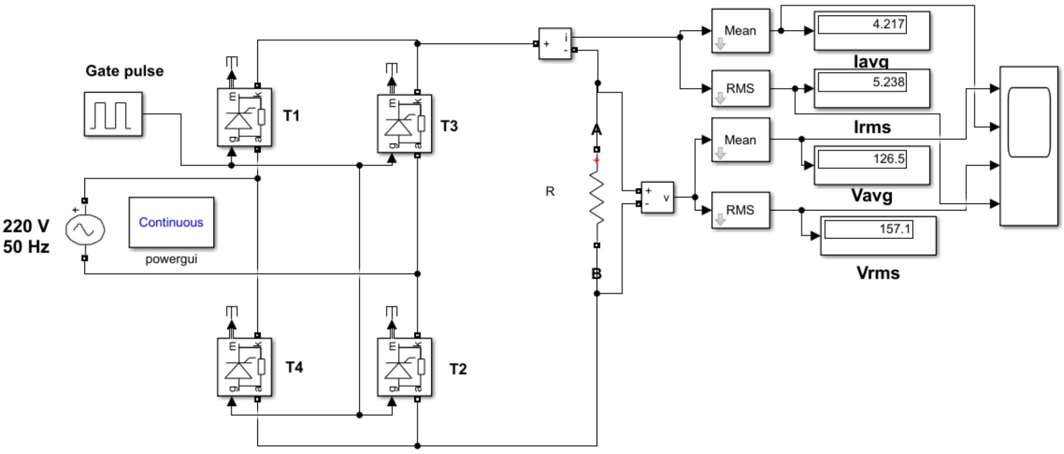
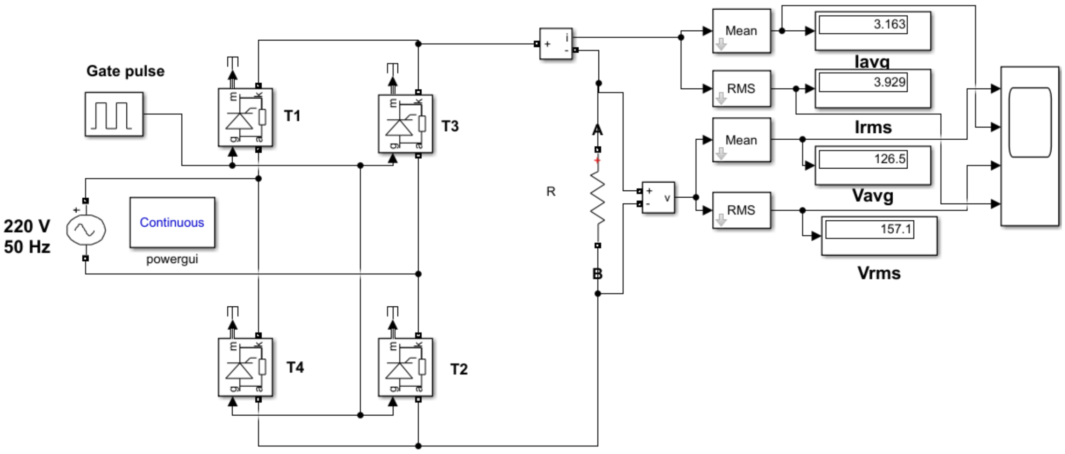


(c)

Figure 7. 1-ph uncontrolled F.W.R: (a) load 30 ohm, (b) load 40 ohm, and (c) load 50 ohm



(a)



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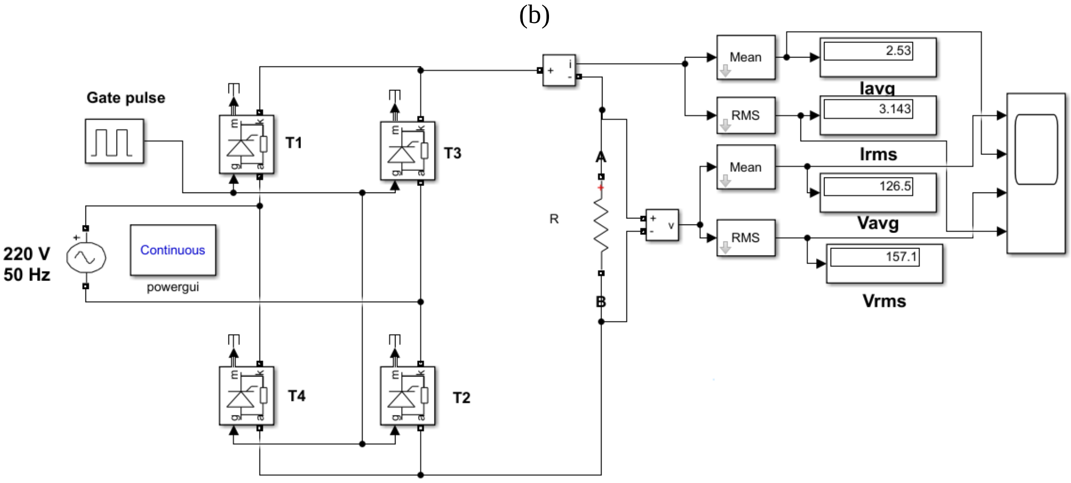
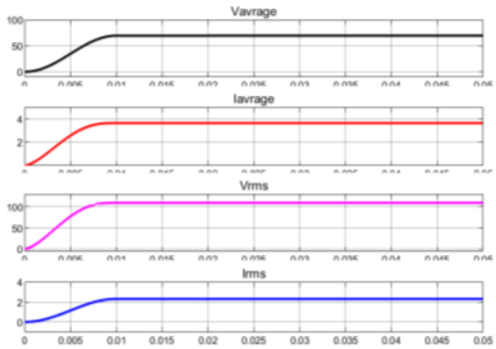


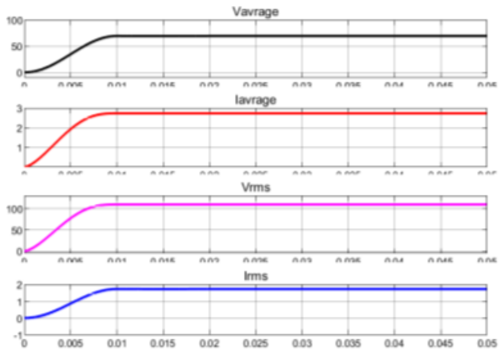
(c)

Figure 8. 1-ph controlled F.W.R: (a) load 30 ohm, (b) load 40 ohm, and (c) load 50 ohm

In Figure 9 show three states for response of 1-phase uncontrolled H.W.R that use in this simulation, Figures 9(a) at load 30 ohm, 9(b) at load 40 ohm, and 9(c) at load 50 ohm. In Figure 10 show three states for response of 1-phase controller H.W.R that use in this simulation, Figures 10(a) at load 30 ohm, 10(b) at load 40 ohm, and 10(c) at load 50 ohm. In Figure 11 show three states for response of 1-phase uncontrolled F.W.R that use in this simulation, Figures 11(a) at load 30 ohm, 11(b) at load 40 ohm, and 11(c) at load 50 ohm. In Figure 12 show three states for response of 1-phase controller F.W.R that use in this simulation, Figures 12(a) at load 30 ohm, 12(b) at load 40 ohm, and 12(c) at load 50 ohm.



(a)



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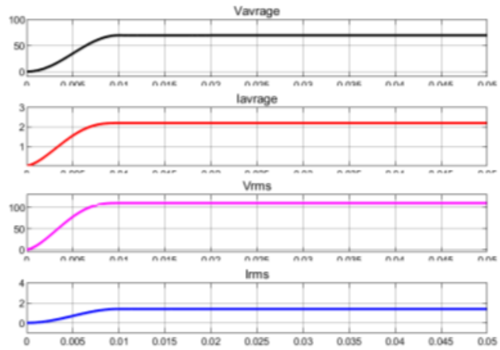
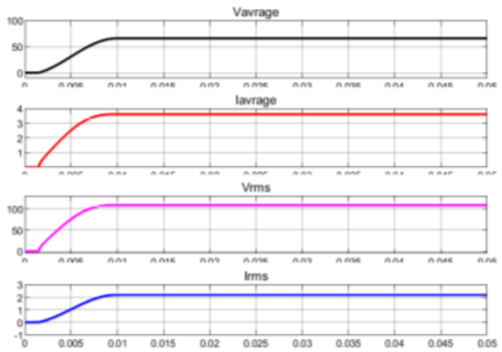
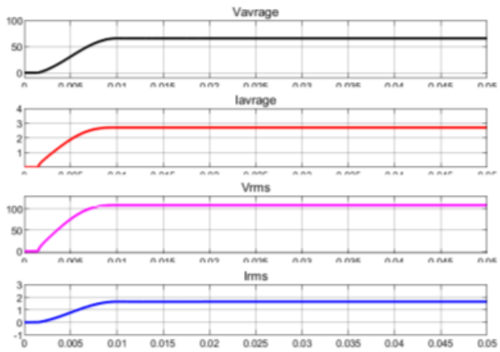


(c)

Figure 9. MATLAB/Simulink response of 1-phase uncontrolled H.W.R with R load: (a) load 30 ohm, (b) load 40 ohm, and (c) load 50 ohm



(a)



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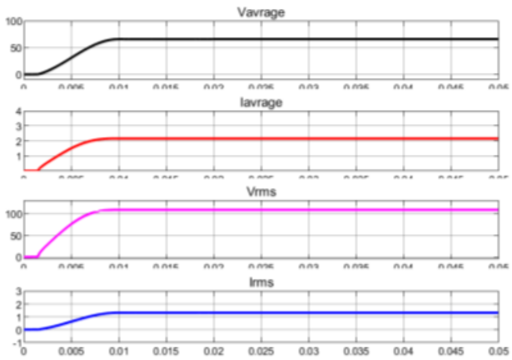

(c)

Figure 10. MATLAB/Simulink response of 1-phase controlled H.W.R with R load: (a) load 30 ohm, (b) load 40 ohm, and (c) load 50 ohm

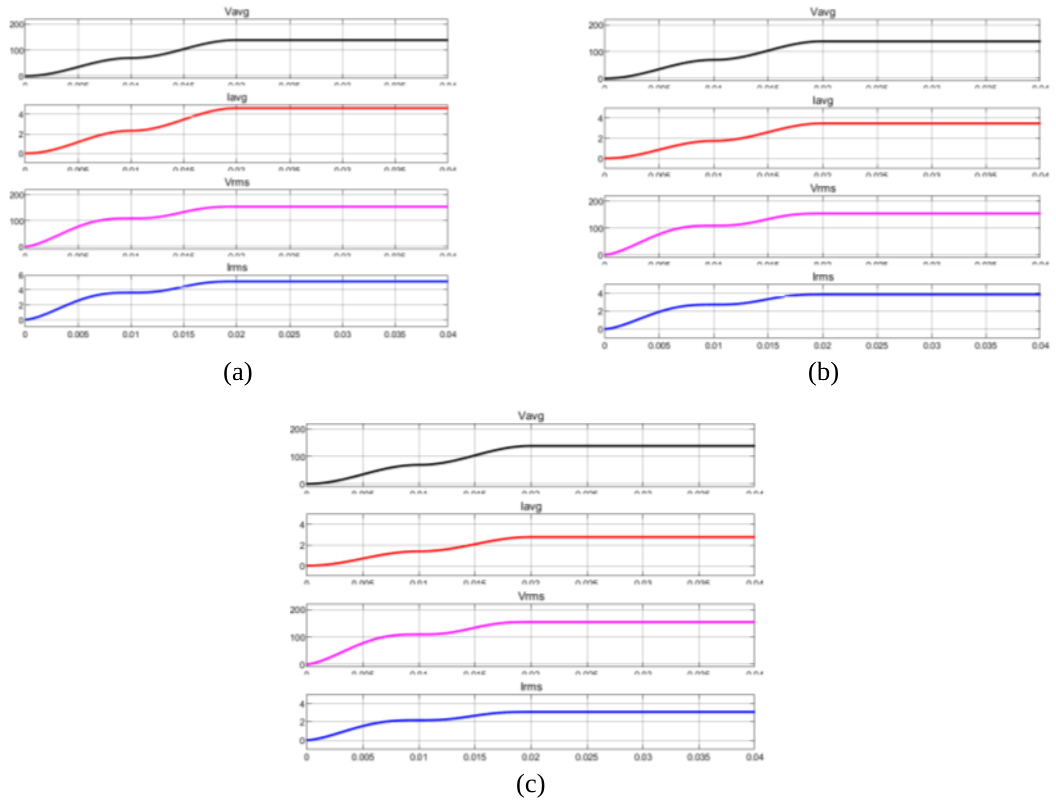

Figure 11. MATLAB/Simulink response of 1-phase uncontrolled F.W.R with R load: (a) load 30 ohm, (b) load 40 ohm, and (c) load 50 ohm

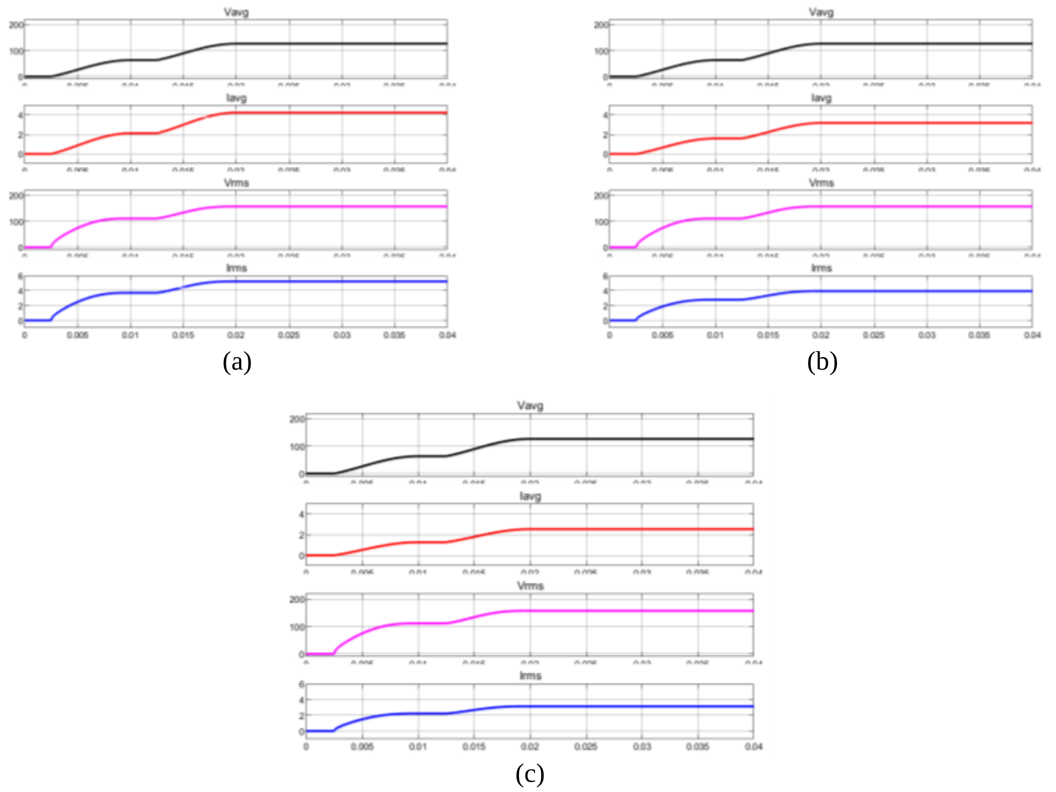

Figure 12. MATLAB/Simulink response of 1-phase controller F.W.R with R load: (a) load 30 ohm, (b) load 40 ohm, and (c) load 50 ohm

In Table 2 show four states uncontrolled H.W.R, controller H.W.R, uncontrolled F.W.R, and controller F.W.R. In all states whenever change load, the voltage is constant but the current was change. Increase the value of load give decrease in current. For example, in first state uncontrolled H.W.R, V_{avrg} was constant at 69.6 V, V_{rms} (V) was constant at 109.5 v with load 30, 40, and 50 ohm. Also, the current was change with load, I_{rms} was 3.5 A at 30 ohm, 2.7 at 40 ohm, and 2.1 at 50 ohm and I_{avrg} was 2.3 A at 30 ohm, 1.7 at 40 ohm, and 1.3 at 50 ohm.

Table 2. Behavior of 1-phase of AC-DC rectifier

Type of AC-DC converter	RL (ohm)	V_{avrg}	I_{avrg}	V_{rms} (V)	I_{rms} (A)
Uncontrolled H.W.R	30	69.6	3.5	109.5	2.3
	40	69.6	2.7	109.5	1.7
	50	69.6	2.1	109.5	1. 3
Controlled H.W.R	30	65.9	3.6	108.3	2.1
	40	65.9	2.7	108.3	1.6
	50	65.9	2.1	108.3	1.3
Uncontrolled F.W.R	30	138.5	4.615	154.1	5.137
	40	138.5	3.461	154.1	3.853
	50	138.5	2.769	154.1	3.082
Controlled F.W.R	30	126.5	4.217	157.1	5.238
	40	126.5	3.163	157.1	3.929
	50	126.5	2.53	157.1	3.143

4. CONCLUSION

After conducting the simulation, a number of conclusions were reached as a result of obtaining results stating that the voltage is stable with the change of load, but the current changes. We suggest the use of pulse width control systems and traditional and expert control systems to adjust the value of the current as future works. Where the results proved the possibility of converting from alternating current to continuous current on the one hand and controlling the current and voltage with the change of load on the other hand, which enabled us to reach how to employ the uniters in different power systems. The simulation also showed the difference in the voltage value according to the type of unifier used. The current study showed, through computer simulation, the possibility of using MATLAB/Simulink to verify the work of electronic circuits in a short time.

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