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A review of simulink for single-phase rectifier

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ABSTRACT

The current review aimed to i) Simulate the work of electronic transformer; ii) Analyze and design different types of electronic transformer; and iii) Identify the most important joints of the topic in the work of the electronic transformer by evaluating and improving the system components. The number of electronic keys has been approved in terms of representing the number of phases on one side and the type of wave on the other hand such as one-half phase full wave or wave, as well as single-phase, which will be detailed later. The type of electronic keys has also been adopted in terms of the representation of electronic keys in the form of a diode, a transistor, or a thyristor.

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1. INTRODUCTION

Electronic transformer, it had included DC_DC, DC_AC, AC_AC, and AC_DC [1]–[3]. The type of AC_DC is called rectifier [4]–[6]. The rectifier is used when the load is DC and the source was AC [7]–[9]. There are many applications in industrial-like battery chargers, high-voltage direct current (HVDC), and elevators [10]–[13].

There are many types of rectifiers with familiar switches. The familiar switch model includes single-phase uncontrolled, single-phase controlled, three-phase uncontrolled, and three-phase controlled [14]–[16]. These switches required device type nonlinear for examples thyristors like silicon controlled rectifier (SCR), gate turn off thyristors (GTO), and triode for alternating current **(**TRIAC), transistors like insulated gate bipolar transistor (IGBT), and diodes [17]–[19]. The switch type uncontrolled like diode had no control like low power and high power. The number of switches in the rectifier system was one of four at using single-phase but it was three or six at using three phases [20].

Single-phase includes half-wave rectifier (HWR) and full-wave rectifier (FWR). The HWR had a source and one switch using a single phase or three switches at three phases. The FWR had a source and four switches using single-phase or six switches at three phases. Uncontrolled rectifier, there are using diodes that had no control. Controlled rectifier, there are using different switches like metal oxide semiconductor field-effect transistor (MOSFET), IGBT, TRIAC [21]–[23].

This review had simulated many types for rectifier, uncontrolled rectifier HWR and FWR, and controlled rectifier HWR & FWR. In addition, this review had simulated the different loads (R, R_L, and R_C).

2. SIMULATION AND MATHEMATIC MODEL

Electronic transformer (ET), and ET is used to convert an alternating current or voltage into a constant current or voltage, meaning that its input is an alternating current or voltage and the output of a constant current or voltage [24]–[26].

The electronic transformer is composed of electronic switches, which are non-linear devices such as a diode, transistor, and thyristor. Switches for Rectifier, It had classified to the controller like power transistor or thyristor (IGBT, SCR, TRIAC, and GTO), uncontrolled like a diode, bidirectional (TRIAC or two SCR) and unidirectional like (diode, SCR) [27]–[29].

Power electronic transformers (PETs), in this type, by using diode (switches) with 1 phase, one diode in HWR, and four diodes in FWR. Also, with 3 phases, three diodes in HWR and six diodes in FWR. The evaluation, analysis, and improvement of the work of electronic devices depends on their components, their output current, current, voltage, power, and other factors such as i) Root mean square values include output, voltage (V_{rms}) as (1), current (I_{rms}) as (2); ii) Average values include voltage (V_{avg}) as (3), current (I_{avg}) as (4); iii) Input source power (Pac) as (5), output power (Pdc) as (6); iv) Efficiency (η) as (7); and v) Factors include: ripple factor (RF) as (8), form factor (FF) as (9), Harmonic factor (HF) as (10), crest factor (CF) as (11), and power factor (PF) as (12).

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

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

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

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

$$P_{ac} = V_{rms}.I_{rms} \quad (5)$$

$$P_{dc} = V_{avg}.I_{avg} \quad (6)$$

$$\eta = \frac{P_{ac}}{P_{dc}} = \frac{V_{rms}.I_{rms}}{V_{avg}.I_{avg}} \quad (7)$$

$$RF = \frac{V_{ac}}{V_{dc}} \quad (8)$$

$$FF = \frac{V_{rms}}{V_{avg}} \quad (9)$$

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

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

$$PF = {}^{I_{s1}}/_{I_s}\cos\emptyset \quad (12)$$

Simulation, in this part the review includes: i) Single-phase HWR system with different load at R, R_L, and R_C and ii) Single-phase FWR system with different load at R, R_L, and R_C. The simulation results for the single-phase HWR system as shown in Table 2 and simulation results for the single-phase FWR system as shown in Table 3.

Single-phase HWR and FWR, in this section, include two parts uncontrolled single-phase HWR and FWR and controlled single-phase HWR and FWR [30], [31].

2.1. Uncontrolled single-phase HWR and FWR

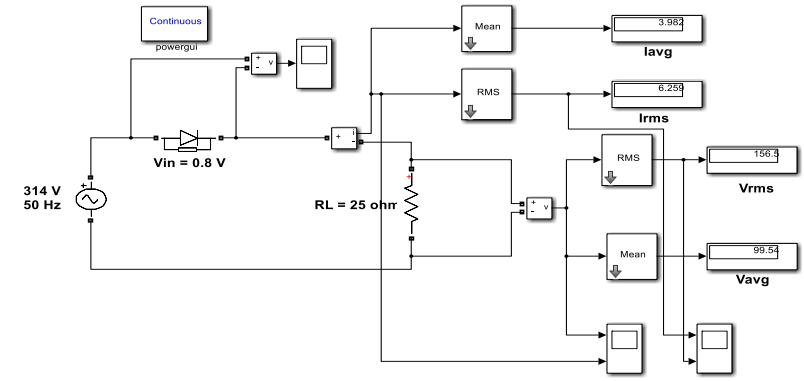
2.1.1. Uncontrolled single-phase HWR

The uncontrolled single-phase HWR by using a diode. Table 1 includes the characteristic of the parameter system and Table 2 include the simulation results for uncontrolled single-phase HWR. Figure 1 shows the simulation model for single-phase HWR, there are three parts: Figure 1(a) is showing at the load

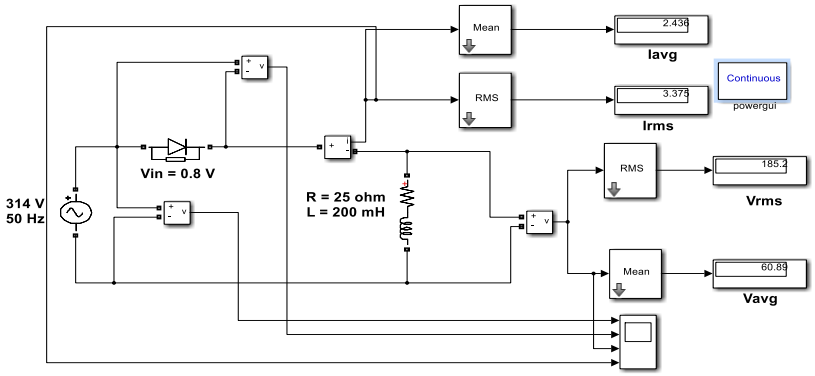
R=25 Ω, Figure 1(b) is showing at load R=25 Ω and L=200 mH, and Figure 1(c) is showing at load R=25 Ω and C=100 µF also the simulation results as shown in Table 1 and Figures 2-4.

2.1.2. Uncontrolled single-phase FWR

The uncontrolled single-phase FWR is using a diode. Table 3 includes the characteristic of the parameter system. Table 4 includes the simulation results for uncontrolled single-phase FWR. Figure 5 shows the simulation model for single-phase FWR. Figure 6 and Figure 7 show the simulation results for single-phase FWR. In Figure 5, there are two parts: Figure 5(a) at the load (R=31.4 Ω) and Figure 5(b) at load (R=31.4 Ω) and (L=30 mH) also the simulation results as shown in Table 4 and Figures 6 and 7.



(a)



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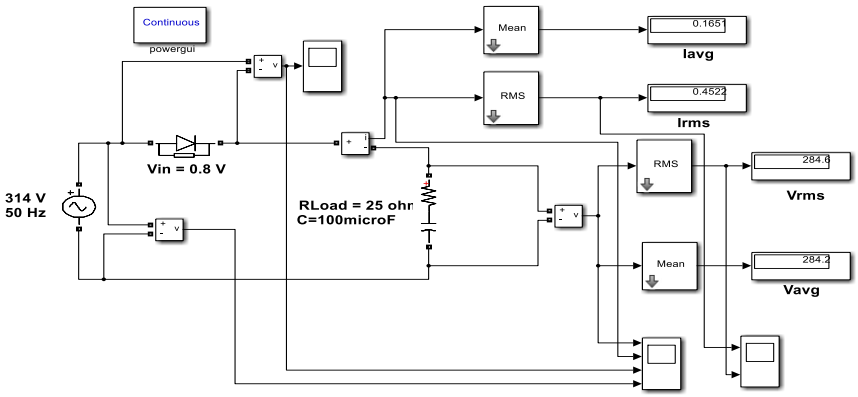


(c)

Figure 1. Simulation model for single-phase HWR system at (a) load R, (b) load R_L, and (c) load R_C

Table 1. Characteristic of the parameter for single-phase HWR system

Parameters	Values
Supply voltage (V)	314
Supply frequency (Hz)	50
R (Ω)	25
L (mH)	200
C (µF)	100

Table 2. Simulation results for single-phase HWR system

Load values	Vavg (V)	Iavg (A)	Vrms (V)	Irms (A)	Load types
R (Ω) = 25	99.54	3.982	156.5	6.259	R (Ω)
L (mH) = 200	60.89	2.436	185.2	3.375	R (Ω) and L (mH)
C (µF) = 100	284.2	0.1651	284.6	0.4522	R (Ω) and C (µF)

Table 3. Characteristic of the parameter for single-phase FWR system

Parameters	Values
Supply voltage (V)	314
Supply frequency (Hz)	50
R (Ω)	31.4
L (mH)	30

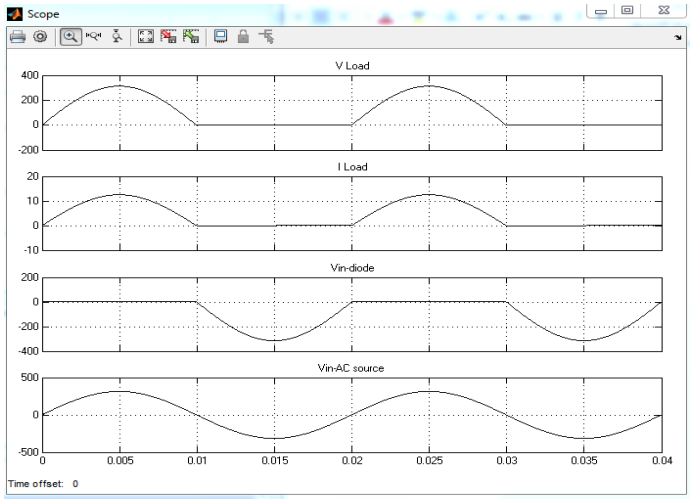


Figure 2. Simulation results for single-phase HWR load (R)

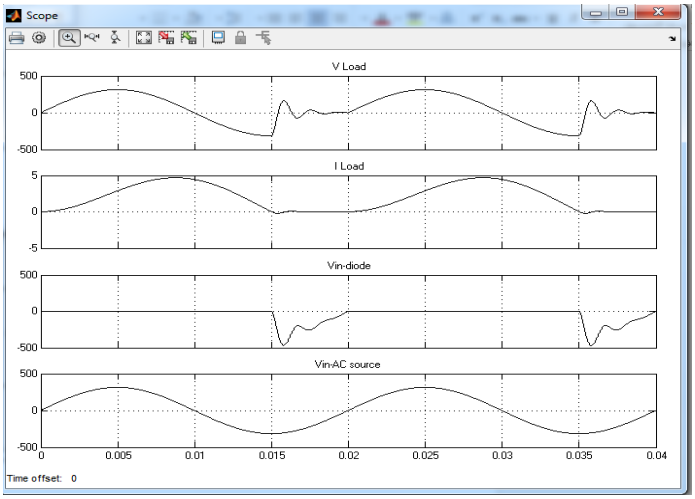


Figure 3. Simulation results for single-phase HWR load (R_L)

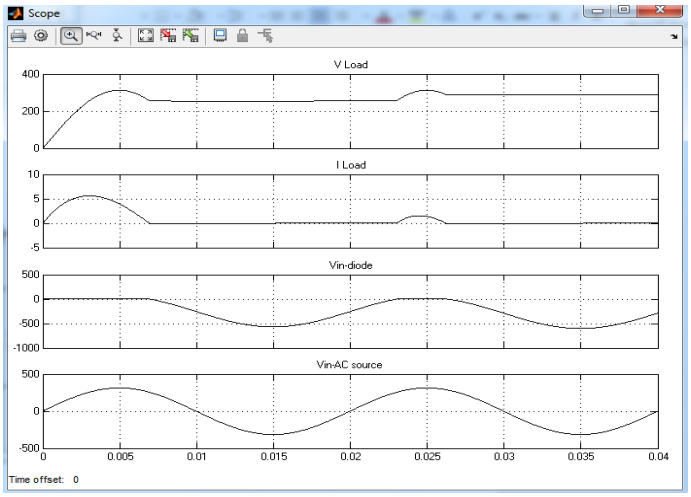
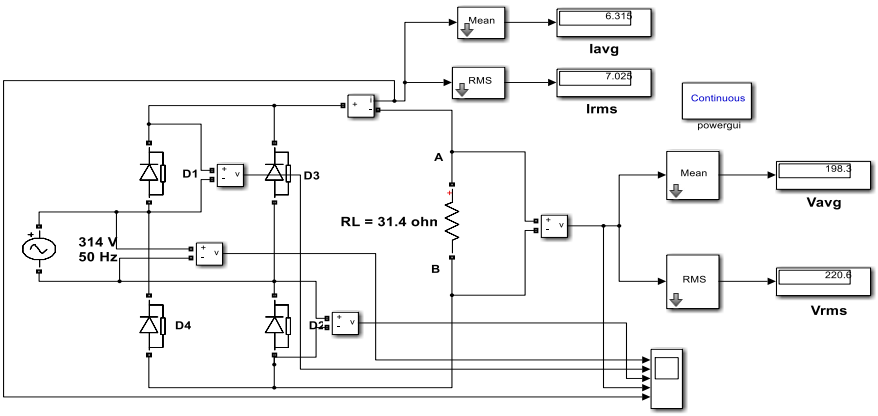


Figure 4. Simulation results for single-phase HWR load (R_C)

Table 4. Simulation results for single-phase FWR system at load (R and R_L)

Load types	Vavg (V)	Iavg (A)	Vrms (V)	Irms (A)
R (Ω)=31.4	198.3	6.315	220.6	7.025
R (Ω) and L (mH)=200	198.3	6.315	220.6	6.831



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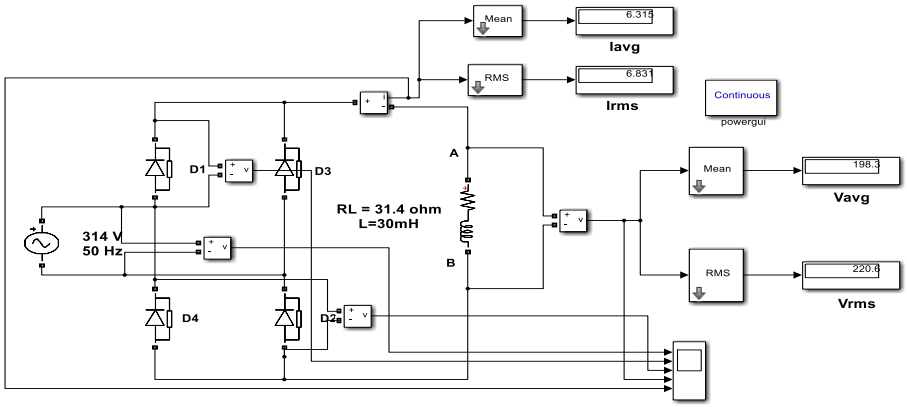


(b)

Figure 5. Simulation model for single-phase FWR system at (a) R and (b) load (R_L)

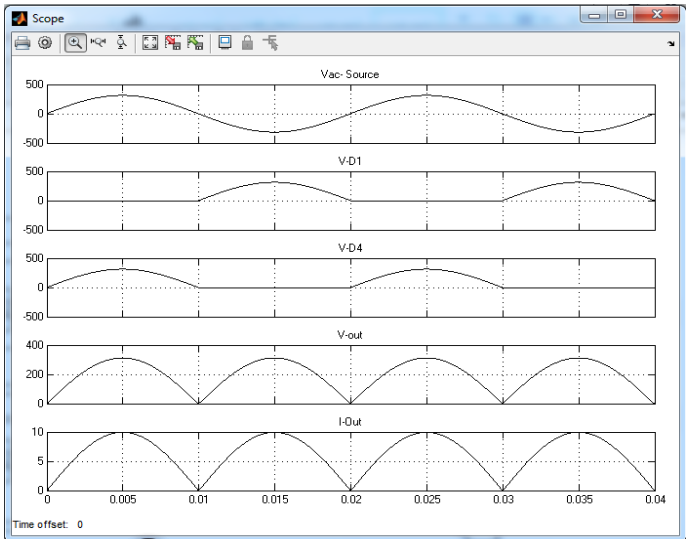


Figure 6. Simulation results for single-phase FWR load (R)

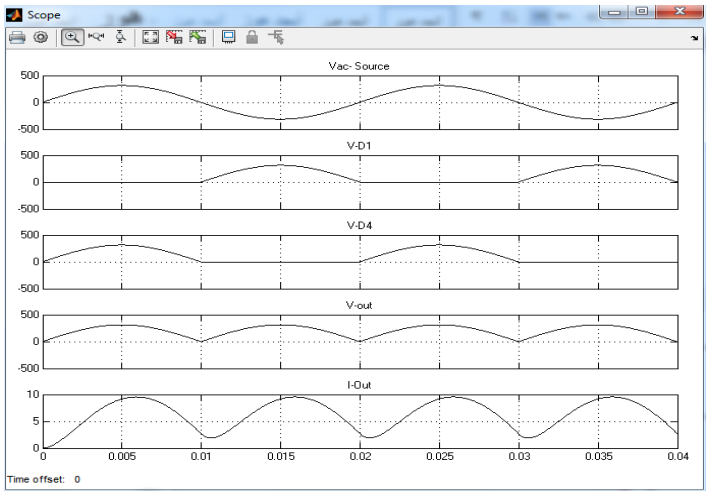


Figure 7. Simulation results for single-phase FWR at load (R_L)

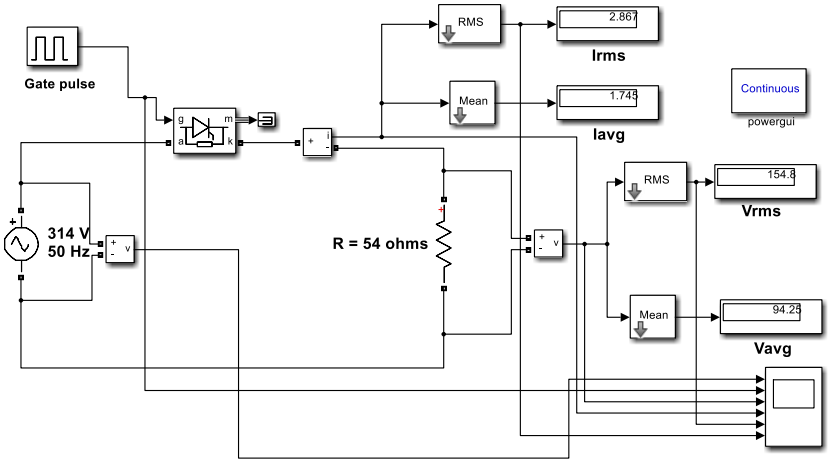
2.2. Controlled single-phase HWR and FWR

2.2.1. Controlled single-phase HWR

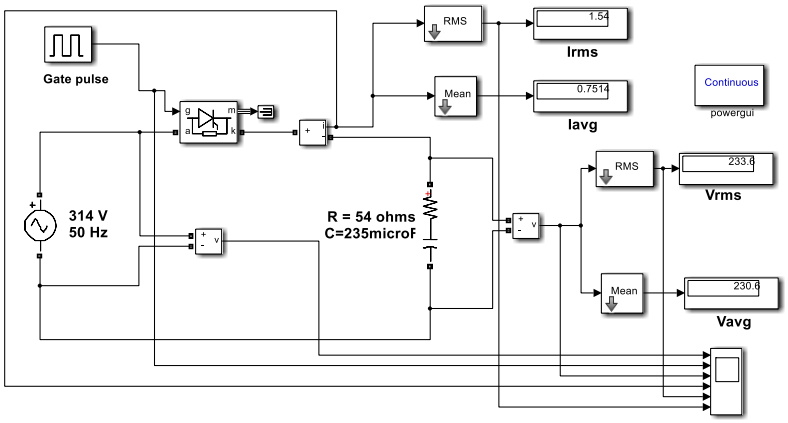
The controlled single-phase HWR by using a diode. Table 5 include the characteristic of the parameter system and Table 6 include the simulation results for controlled single-phase HWR. Figure 8 shows the simulation model for single-phase HWR. Figures 9 and 10 show the simulation results for single-phase HWR. In Figure 8, there are two parts: Figure 8(a) is showing at the load R=54 Ω and Figure 8(b) is showing at load R=54 Ω and C=235 µF also the simulation results as shown in Table 6 and Figures 9 and 10.

Table 5. Characteristic of the parameter for single-phase HWR system

Parameters	Values
Supply voltage (V)	314
Supply frequency (Hz)	50
R (Ω)	54
C (µF)	235



(a)



(b)

Figure 8. Simulation model for single-phase HWR system at (a) load R and (b) load R_C

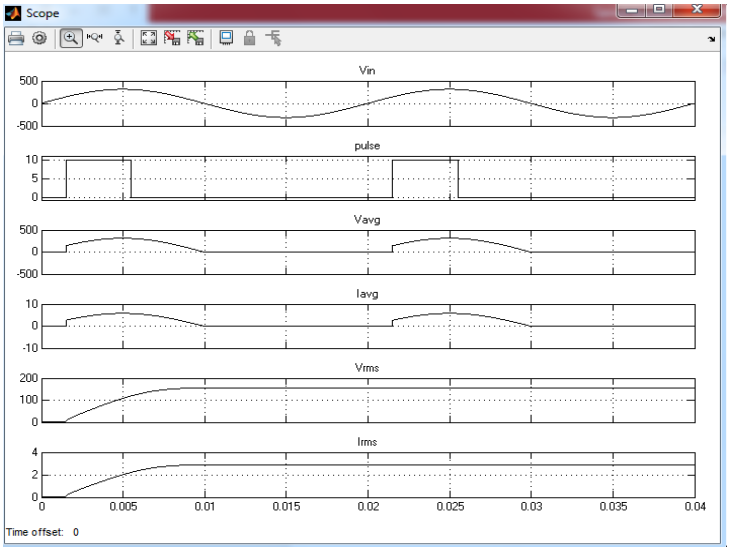


Figure 9. Simulation results for single-phase HWR load R

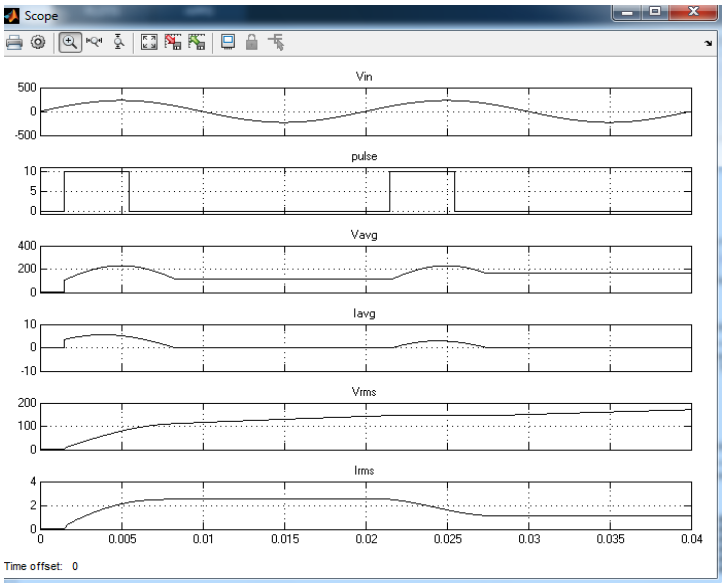


Figure 10. Simulation results for single-phase HWR load R_C

Table 6. Simulation results for single-phase HWR system at load (R and R_C)

Load types	Vavg (V)	Iavg (A)	Vrms (V)	Irms (A)
R (Ω)=54	94.25	1.743	154.8	2.867
C(μF)=235	230.6	0.7514	233.6	1.457

2.2.2. Controlled single-phase FWR

The controlled single-phase FWR by using a diode. Table 7 include the characteristic of the parameter system. Table 8 includes the simulation results for uncontrolled single-phase FWR. Figure 11 shows the simulation model for Single-phase FWR. Figures 12 and 13 show the simulation results for single-phase FWR. Table 8 includes the simulation calculation for characteristic values for HWR and FWR. In Figure 11, there are two parts: Figure 11(a) is showing at the load (R=45 Ω) and Figure 11(b) at load (R=45 Ω) and (L=30 mH) also the simulation results as shown in Table 9 and Figures 12 and 13.

Table 7. Characteristic of the parameter for single-phase FWR system

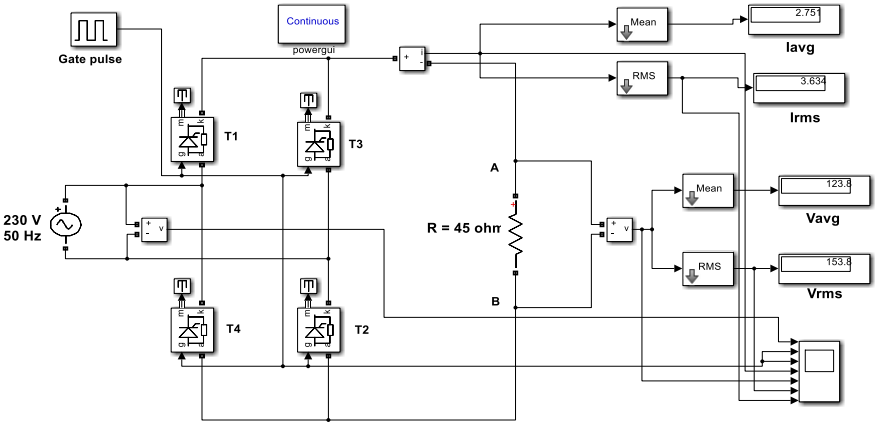
Parameters	Values
Supply voltage (V)	314
Supply frequency (Hz)	50
R (Ω)	45
L (mH)	30

Table 8. Characteristic values for HWR and FWR

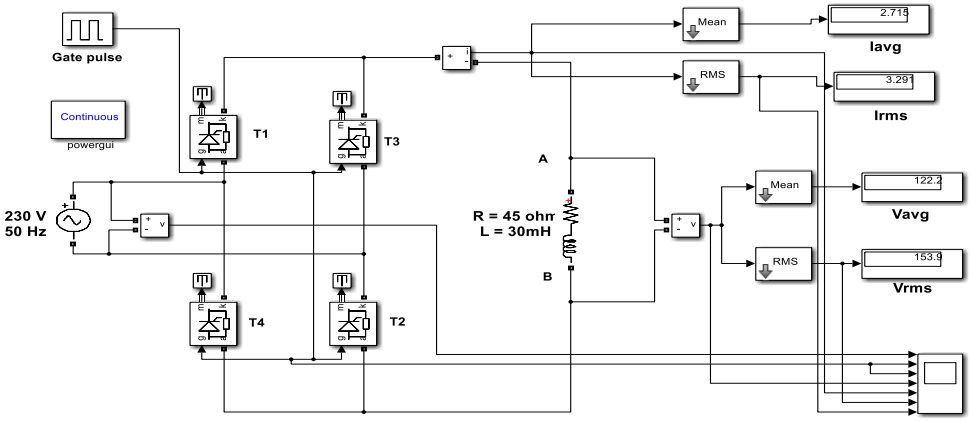
Characteristic type	Characteristic values for HWR	Characteristic values for FWR
P_{dc} (watt)	396.328	1252.32
P_{ac} (watt)	979.69	1549.82
η%	10.45	80.80
FF	1.57	1.11
RF	1.21	0.481

Table 9. Simulation results for single-phase FWR system at load (R and R_L)

Load types	Vavg (V)	Iavg (A)	Vrms (V)	Irms (A)
R (Ω)=31.4	123.8	2.751	153.8	3.634
R (Ω)=30&L(mH)=30	122.2	6.315	153.9	3.291



(a)



(b)

Figure 11. Simulation model for single-phase FWR system at (a) load R and (b) load (R_L)

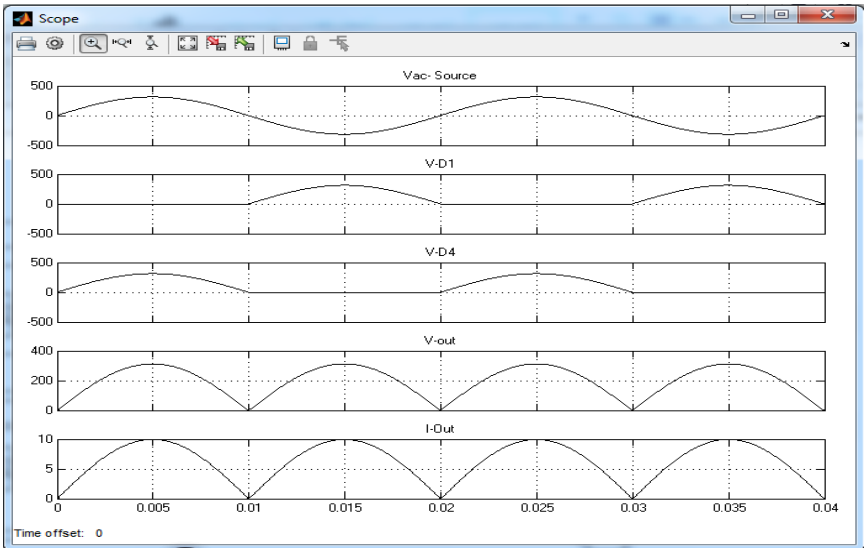


Figure 12. Simulation results for single-phase FWR load (R)

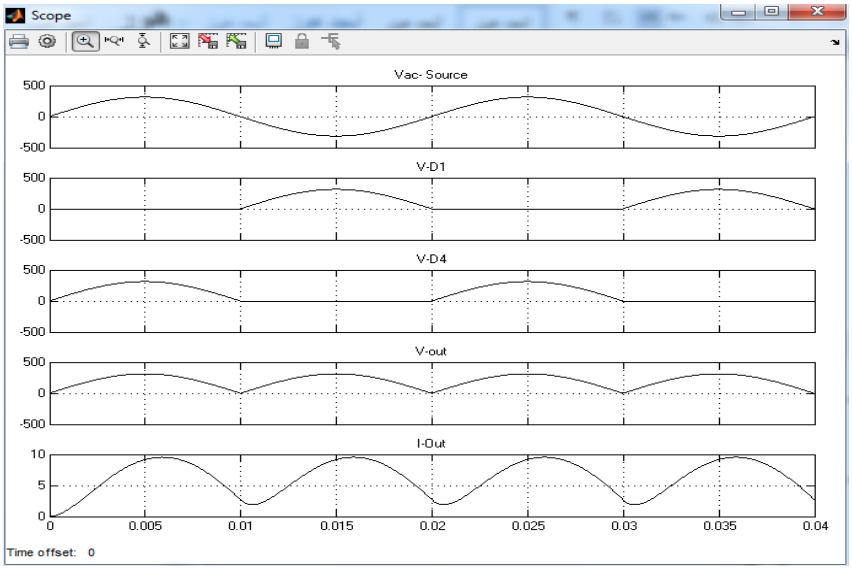


Figure 13. Simulation results for single-phase FWR at load (R_L)

3. SIMULATION RESULTS

The simulation results had four stats in this review include uncontrolled HWR, uncontrolled FWR, controlled HWR, and controlled FWR. The simulation result for uncontrolled HWR is shown in Figures 2 and 4. The simulation result for uncontrolled HWR at Load was (R) as shown in Figure 2, the simulation result for uncontrolled HWR at Load was (R_L) as shown in Figure 3, The simulation result for uncontrolled HWR at load was (R_C) as shown Figure 4. The simulation result for uncontrolled FWR is shown in Figures 6 and 7. The simulation result for uncontrolled FWR at load was (R) as shown in Figure 6, and the simulation result for uncontrolled FWR at load was (R_L) as shown in Figure 7. The simulation result for controlled HWR is shown in Figures 9 and 10. The simulation result for controlled HWR at load was (R) as shown in Figure 9, and the simulation result for controlled HWR at load was (R_C) as shown in Figure 10. The simulation result for controlled FWR is shown in Figures 12 and 13. The simulation result for controlled FWR at load was (R) as shown in Figure 12, and the simulation result for controlled FWR at load was (R_L) as shown in Figure 13.

4. CONCLUSION

Writing any review under any title that requires comprehensive knowledge of the proposed system, parts that represent. The idea is to be expressed in addition to the setting. A goal for it to be working on a realization and can be resorted to a set of goals and to achieve. It works is done with appropriate steps starting from the appropriate. Theoretical study to work on developing a model appropriate to achieve objectives for the proposed idea. In this review, include a single-phase HWR system with different loads at R, R_L, and R_C. Second single-phase FWR system with different load at R, R_L, and R_C.

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