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# Operation and Simulation of single phase half wave Uncontrolled Rectifier using MATLAB/SIMULINK

**FADYA FAIZE ALI**

## Abstract:

Rectification is the process of converting alternating current or voltage into direct current or voltage. An uncontrolled rectifier uses only diodes as the rectifying element. The DC output voltage is fixed in magnitude by the amplitude of the AC supply voltage .however, the DC output pure it contains significant AC components called ripple, to eliminate ripple, we must inserted filter after the rectifier. This paper will study single phase uncontrolled rectifiers ranging from simple half wave rectifier using a single diode to more complex full wave bridge rectifier using several diode. This paper is divided into two main part : the first part includes single phase half wave uncontrolled rectifiers circuit which can be implemented in the power electronics laboratory with normal facilities available in the laboratory, Second part contains simulation task which can be carried out in computer lab using matlab\simnlink software.

## الملخص:

التقويم هو عملية تحويل التيار المتردد أو الجهد إلى تيار مباشر أو الجهد. يستخدم مقوم غير المنضبط الثنائيات فقط كعنصر تقويم. يتم تقويم الجهد الناتج في الحجم من قبل السعة من الجهد مصدر المتردد. ونظرا، الإخراج الناتج يحتوي على مكونات مترددة كبيرة تسمى تموج، للقضاء على تموج، يجب علينا إدراج مرشح بعد المقوم. هذه الورقة سوف تدرس مقوم احادي الطور غير المنضبط تتراوح بين مقوم نصف موجة باستخدام الصمام الثنائي واحد إلى أكثر تعقيدا مقوم موجة كاملة باستخدام عدة ديود. تنقسم هذه الورقة إلى قسمين رئيسيين: الجزء الأول يتضمن احادي الطور نصف موجة غير قابلة للتحكم في دوائر المقومات التي يمكن تنفيذها في مختبر الإلكترونيات الكهربائية بالمرافق العادية المتوفرة في المختبر، الجزء الثاني يحتوي على مهمة محاكاة يمكن تنفيذها في مختبر الحاسوب باستخدام ماتلاب /برنامج سيمنلينك.

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**Introduction:**

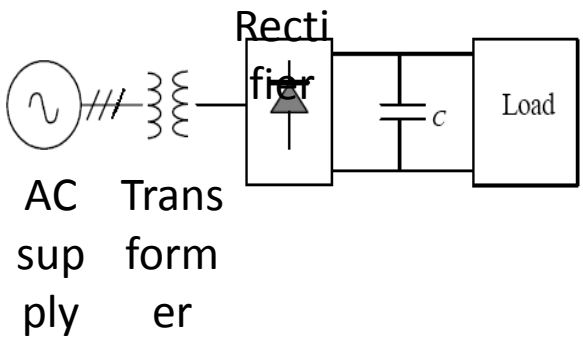
One of the first and most widely used application of power electronics devices have been in rectification. Rectification refers to the process of converting an ac voltage or current source to dc voltage and current. Rectifiers specially refer to power electronic converters where the electrical power flows from the ac side to the dc side [1].

Rectifiers can be classified as:

- Half wave rectifier HWR

- Full wave rectifier FWR

These can further be classified depending upon the rectifying element being used. If using diode, are called uncontrolled rectifiers. Whereas if using Thyristor, are called controlled rectifiers [2]. In this lesion the working principle and analysis of half wave uncontrolled rectifier circuits supplying different types of loads (resistive, inductive) will be presented.




**Block diagram of an uncontrolled diode rectifier circuit**

**Points of interest in the analysis will be**

- Wave form and characteristics values (average, RMS) of the rectified voltage and current
- Influence of the load type on the rectified voltage and current.

In the analysis, following simplifying assumptions will be made

- The internal impedance of the ac source is zero
- Power electronic devices used in rectifier are ideal switches

**Classification of Uncontrolled Rectifiers**

Depending on the type of input source, rectifiers are classified into two main groups:

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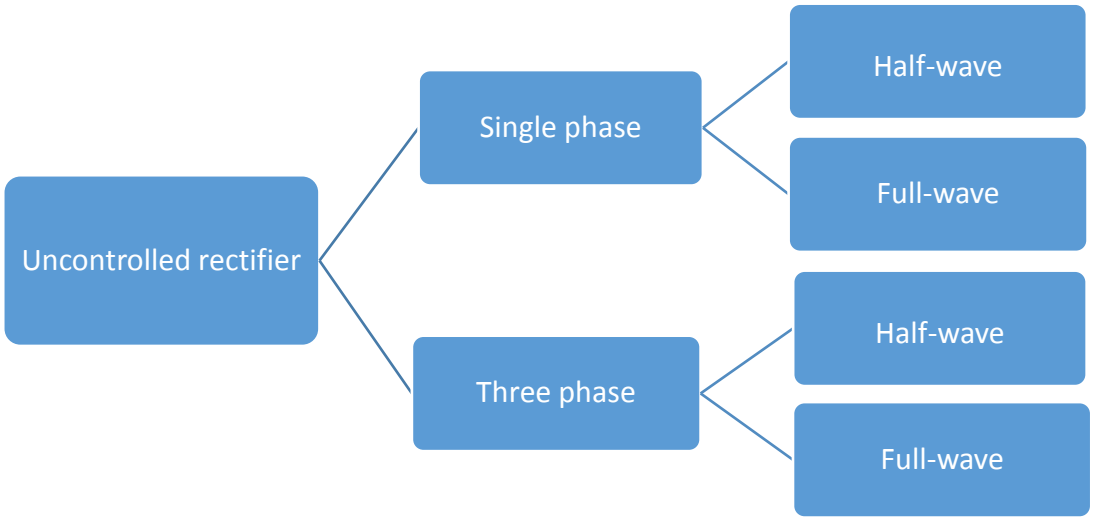


**Single phase uncontrolled half wave rectifier**

The simplest type of uncontrolled rectifiers is HWR is never used industrial applications because of its poor performance. In a single phase, half wave rectifier, for one cycle of supply voltage, there is one-half cycle of output. The load on the output side of rectifier may be resistive load (R), or inductive load (R+L). In this section, operation of this rectifier with resistive, inductive loads will be discussed [2].

**Operation with resistive load**

The circuit diagram and the input and output waveform is shown in Fig (1). At $0<\omega t<\pi$ diode is forward biased and output voltage $V_o$ is source voltage $V_0$. Where $v_0 = \sqrt{2}V_i \sin \omega t$ and load current is $i_o = V_o/R$.

At $\pi<\omega t<2\pi$ diode is reverse biased and output voltage $V_o$ = zero and load current is $i_o = 0$.

For R load the output current waveform same the output voltage waveforms. The average output voltage is $\sqrt{2}\, V_i/\pi$, and RMS value of output voltage is equal to $V_i/\sqrt{2}$. Peak inverse voltage PIV = Vi [4].

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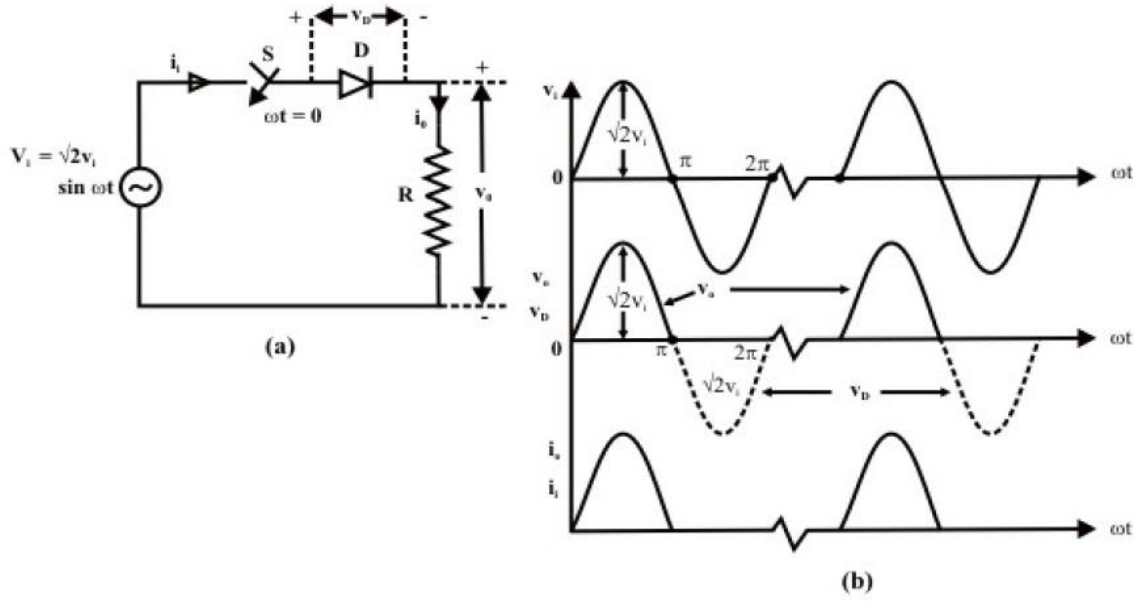


**Single phase uncontrolled half wave rectifier with resistive load. (a) circuit diagram; (b) wave forms.**

**-Operation with inductive load**

The ripple factor of output current can be reduced to same extent by connecting an inductor in series with the load resistance as shown in Fig 2 As in the previous case, the diode D is forward biased when the switch S is turned on. at ωt = 0. However, due to the load inductance $i_0$ increases more slowly. Eventually at ωt = π, $v_0$ becomes zero again. However, $i_0$ is still positive at this point. Therefore, D continues to conduct beyond ωt = π while the negative supply voltage is supported by the inductor till its current becomes zero at ωt = β. Beyond this point, D becomes reverse biased. Both $v_0$ and $i_0$ remains zero till the beginning of the next cycle where upon the same process repeats.

From the preceding discussion

For $0 \le \omega t \le \beta$

$v_D = 0$

$v_0 = v_i$

$i_0 = i_i$

$\beta \le \omega t \le 2\pi$

$v_0 = 0 \quad , i_0 = i_i = 0$

$v_D = v_i - v_0 = v_i$

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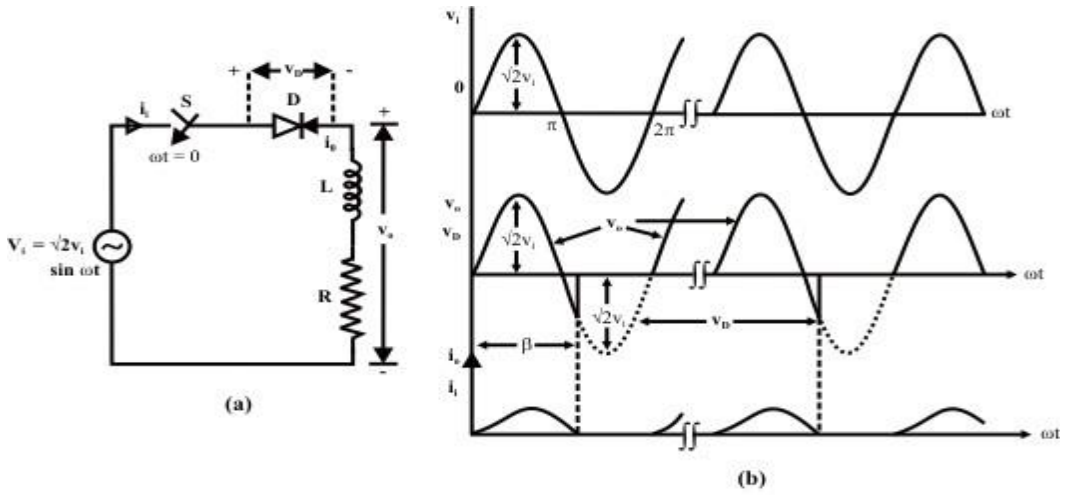


**Fig. 9.3: Single phase uncontrolled half wave rectifier with inductive load. (a) circuit diagram; (b) wave forms.**

The average output voltage is $\sqrt{2}\ V_i/\pi(1-\cos\beta)/2$ and RMS value of output voltage is equal to $V_i/\sqrt{2}\sqrt{2\beta - \sin 2\beta}/2\pi$ [5]

**Simulation results of Single phase uncontrolled half wave rectifiers**

In this part uses the MATLAB-SIMULINK toolboxes to simulate the complete dynamic model of Single phase uncontrolled half wave rectifiers this program is very powerful tool working under MATLAB package of version 7.3 in the Microsoft window environment. This language allows simulating digital, analogs, linear, nonlinear system at the same time through friendly user interactive screens. The SIMULINK screens have a wide range of built in blocks library including analogue and digital operations such as summation, multiplication, differentiation, integration, amplification,

1. **Result with R load**

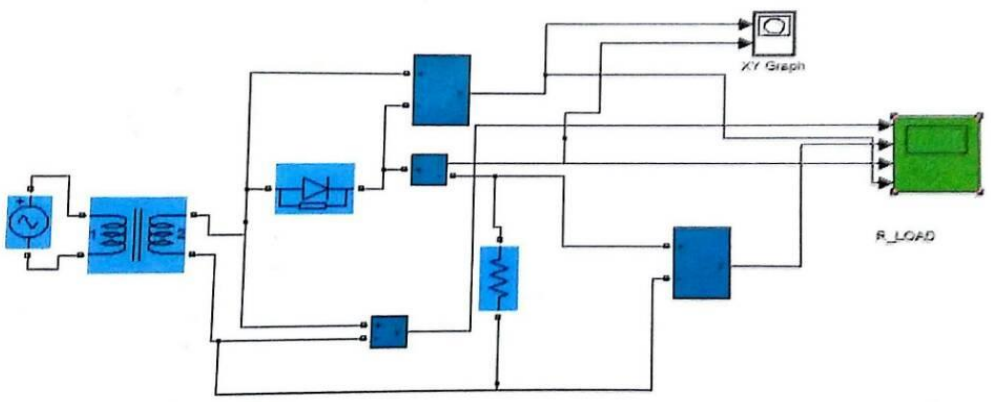


**Figure 3 simulink model of Single phase uncontrolled half wave rectifiers with R load**

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**Simulation results**

The source voltage is sine wave with maximum value V and period T. during the positive half cycle when the voltage at the anode is positive with respect to cathode, the diode turn on to allows current through the load resistor R. Thus, the load voltage follows the positive half sine wave, during the negative half cycle the voltage at the anode becomes negative with respect to the cathode and the diode turns off. Then no current flows though load R. The output voltage as shown in the figure 4 which also shown the load current, the half wave rectifiers thus changes AC power DC.

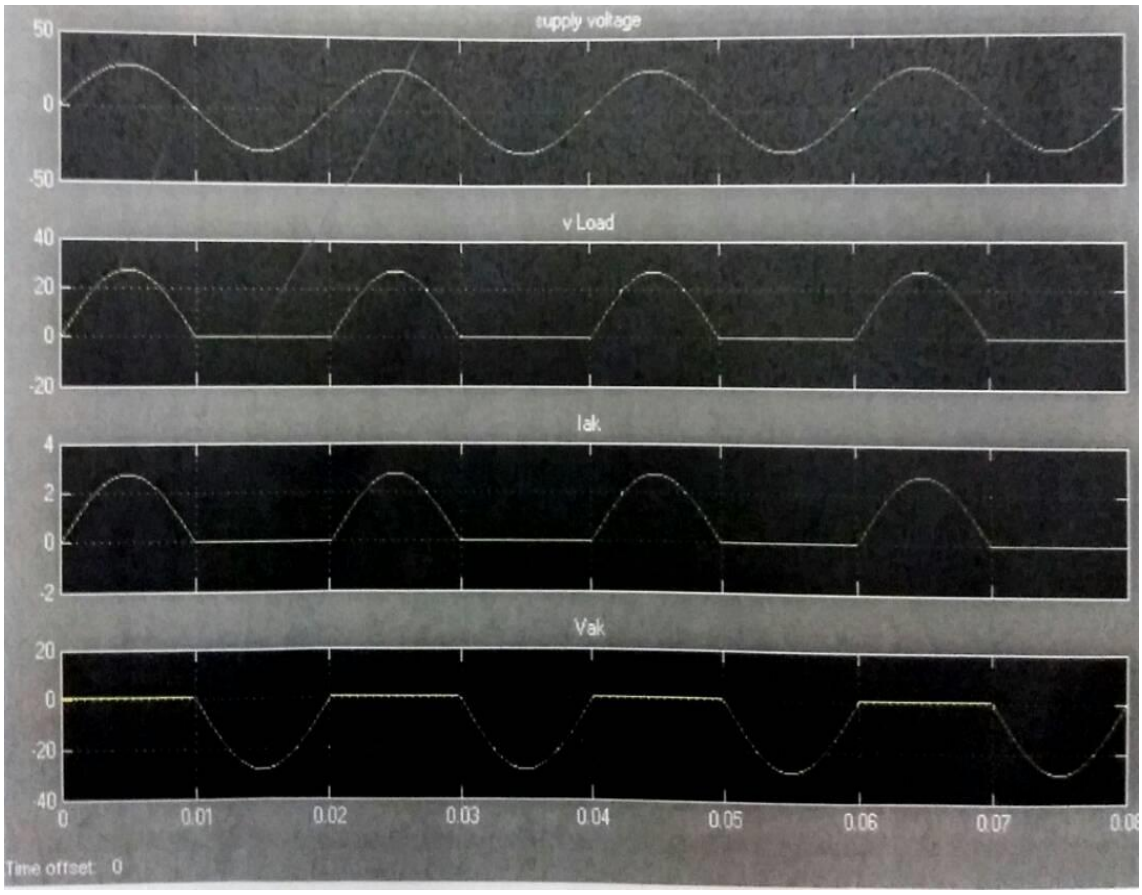


**Figure 4 results of Single phase uncontrolled half wave rectifiers with R load**

Fig 4 shows the waveforms of a single phase uncontrolled half wave rectifier. If the switch S is closed at t=0, the diode becomes forward biased in the interval 0<t<0.01 for t>0.01, vi becomes negative and D becomes reverse biased. So in the interval 0.01<t<0.02 the voltage output$V_0$=0 and current output $I_0$=0

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1. **Result with RL load**

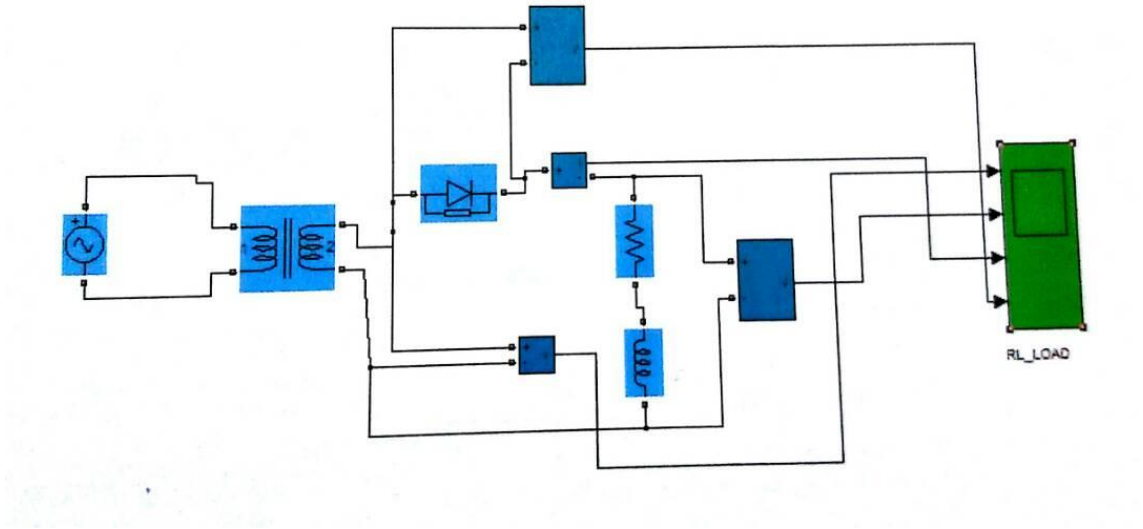


**Figure 5 simulink model of Single phase uncontrolled half wave rectifiers with RL load**

**Simulation results**

The half wave circuit with inductive RL load is shown in figure 5 let analyzes the operation

- As in case of R load the diode is turn on when its anode becomes positive to the cathode the voltage across the load is the same the positive half cycle of AC source
- During this time ,energy transferred from AC source and is stored in the magnetic field surrounding the inductor
- The current though an inductor cannot change instantaneously. therefore the current increase gradually until it reaches its maximum value .note that the current does not reach its peak when the voltage is at its maximum
- When the source voltage decrease the current start decreasing gradually becoming zero when all the energy stored by inductor is released to the circuit .the load current therefore exists for a little more than half the entire period
- At the same time the collapsing magnetic field links with the inductor and inductor voltage that opposes the decrease in the applied voltage
- As soon as the current is zero the diode is reverse biased .the diode then turn off foe rest of negative cycle as shown in the figure 6 [6].

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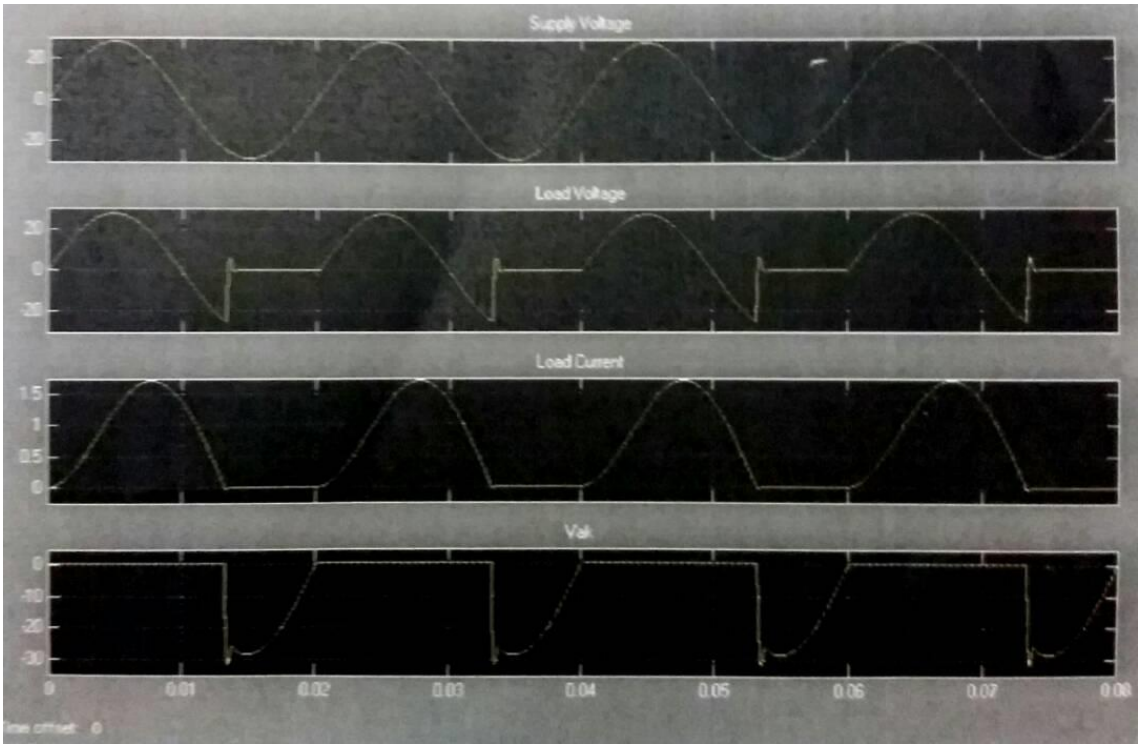


**Figure 4 results of Single phase uncontrolled half wave rectifiers with RL load**

As in the previous case, the diode is forward biased when the switch S is turned on. at t=0. However, due to the load inductance the output current ($i_0$) increases more slowly. Eventually at t=0.01, the output voltage ($v_o$) becomes zero again. However, $i_0$ still positive at this point. Therefore, diode continues to conduct beyond t=0.01 while the negative supply voltage is supported by the inductor till its current zero at t=0.014 beyond this point, diode becomes reverse biased. Both vo and io remains zero till the beginning of the next cycle where upon the process repeats.

For $0<t<0.014$

$V_0=Vi$, $I_0=Ii$

For $0.014<t<0.02$

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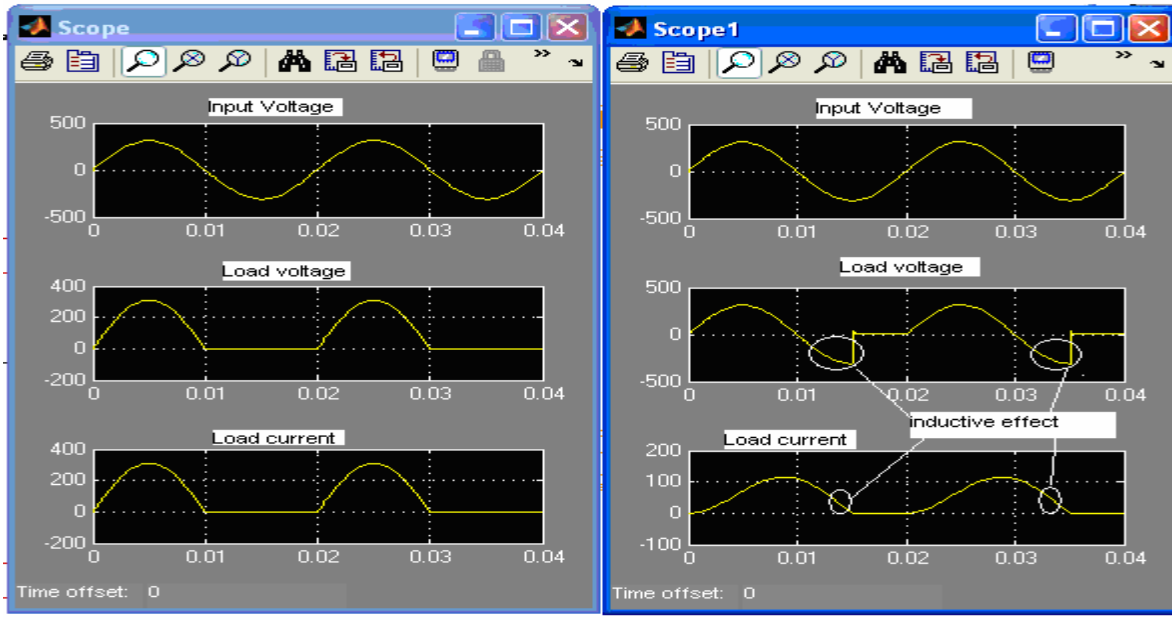
**Simulation Waveform**




## Conclusions

This study introduced substantial analysis and simulation of Single phase uncontrolled half wave rectifiers .developed and simulated by using MATLAB SIMULINK toolboxes.

This simulation results confirm that fast and good response drive systems. The results show that the staring period and steady state values of current and voltage magnitudes are good so that the values in a real lab may be expected.

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5. Tarek EL-Sennawy Alexandria National refining and petrochemicals co.(ANRPC)

   Wady EL-Kamar, EL-Max, Alexandria, zip code:23111,Egypt