الجامعة الألمانية الأردنية
German Jordanian University

Electronics 1 Lab (CME 2410)

School of Informatics & Computing
German Jordanian University Laboratory Experiment (2)

Half-Wave , Full-Wave Rectifiers

1. Objective:

To be familiar with the half-wave rectifier, the center-tapped full-wave rectifier and the function of the smoothing capacitor.

2. Theory:

A) Half-wave rectifier

A simple rectifier can be realized starting from the clipper circuit which is able to change a sinusoidal signal into a pulsating wave (see Fig. 3.1.)

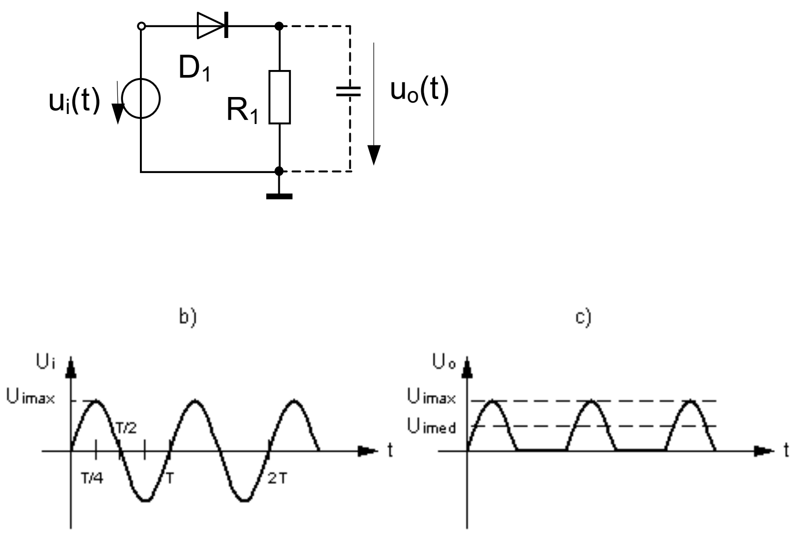


Fig. 3.1 Half-wave rectifier

B) Center-tapped full-wave rectifier:

Consider, for example, the circuit of Fig. 3.2.:

When point 1 finds itself at a positive potential to ground, points 2 finds itself at a negative potential, equal in absolute value.

For positive input voltage $u_i(t) > 0$ the diode D1 is forward biased and the diode D2 is reversed biased: so the current will flow through D1 via the load resistance R1 and ground to point 2 and back to the source. When the polarities changeover, the diode D2 conducts.

As long as $R1\,?\;R$ and $U_{\mathrm{i}}\;?\;U_{threshold}$ the ouput amplitudes is half the input amplitudes $U_{\mathrm{o\,max}} \approx \frac{1}{2} U_{\mathrm{i\,max}}$. In almost all applications the voltage divider R-R is replaced by the secondary of a centered-tapped transformer (like in Fig. 3.8)

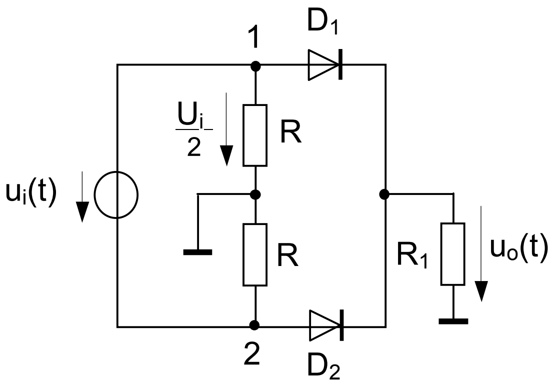


Fig. 3.2 Center-tapped full-wave rectifier

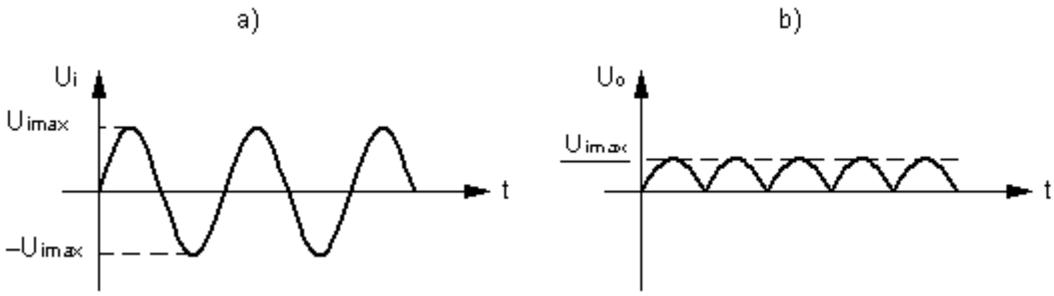


Fig. 3.3

C) Bridge full-wave rectifier:

This is for information only. There are no measurements to do but running the lab you are supposed to answer questions concerning the advantages or disadvantages of the circuits.

Let's consider the circuit of Fig. 3.4. which is called the diode bridge:
When point 1 is at positive potential, the current flows by going through the diode V1, forward biased and the load resistance R1, than goes back to the transformer through the diode V3 (Fig. 3.4)

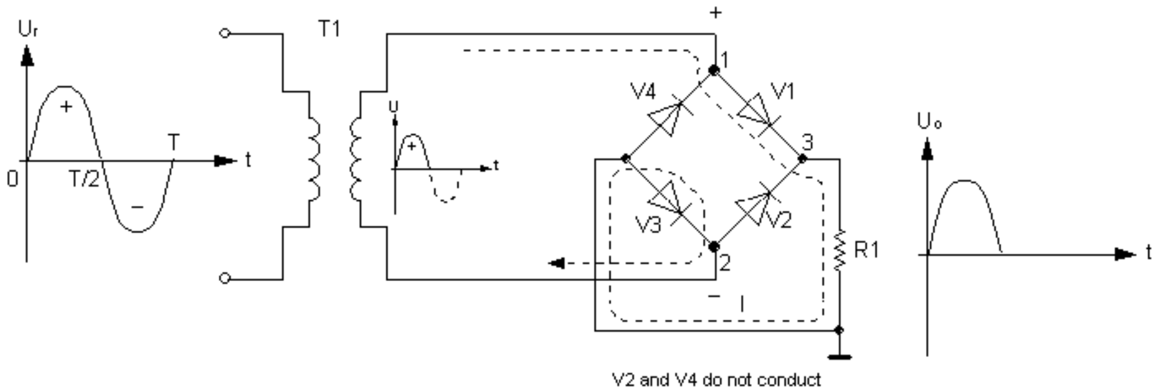


Fig. 3.4 Bridge rectifier, $U_i > 0$

The diodes V2 and V4 do not conduct because they are reversed biased.

For negativ input the point 2 is at positive potential, the current flows through the diode V2, the load resistance R1 and the diode V4 and back to the transformer (Fig. 3.5.).

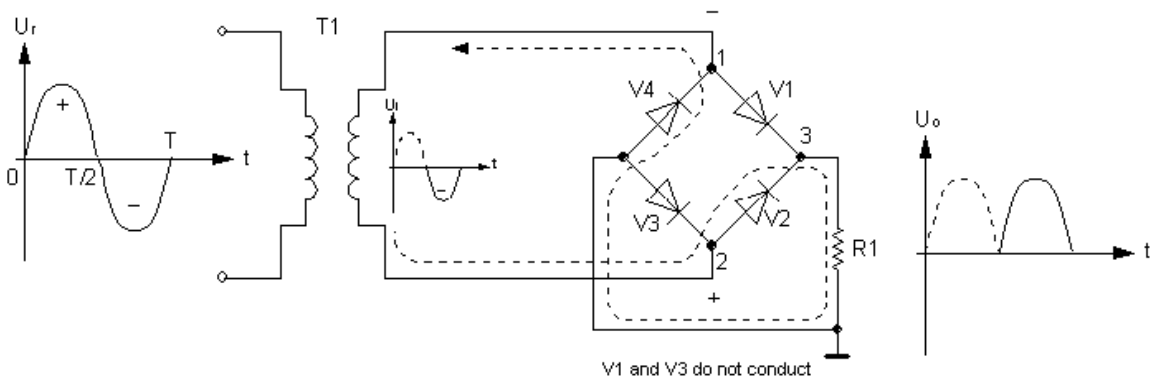


Fig 3.5 Bridge rectifier, $U_i < 0$

As the diodes V1 and V3 are reversed biased they will not conduct. The load resistance R1 is crossed from the current always in the same direction: we obtain a rectified wave that can be made continuous through a smoothing capacitor.

Let's observe on that subject the graphical representation illustrated in Fig. 3.6.

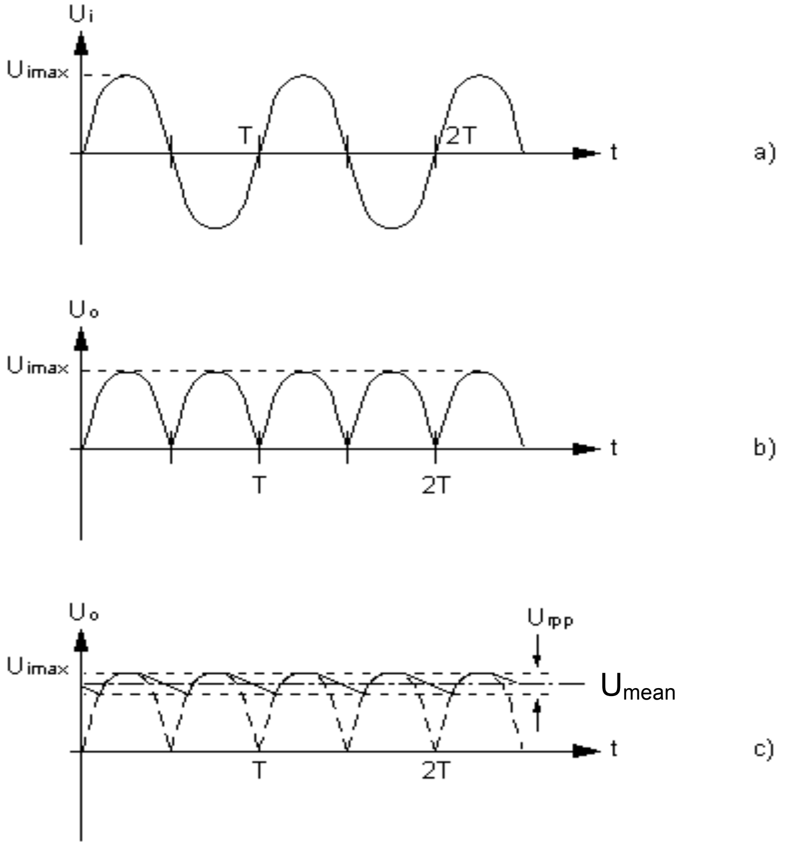


Fig. 3.6

3. *Equipment & Instrument:*

- Module No. : DL 3155E12
- Function Generator
- Oscilloscope

4. *Components List:*

<u>The simple and double half-wave rectifier:</u>

R1 = 10 kΩ - 1/4W - 5%
Vd1 = Silicon diode - 1N4007
Vd2 = Silicon diode - 1N4007

5. Calculation data:

Mean value:

A Digital Multimeter (DMM) in DC-mode will measure the **mean value** of a voltage or even a current**.** Using the IEC standard the mean value of a voltage is written $M(u)$ or $\overline{U}$. Sometimes you simply will find the writing U_{mean}.

Definition of the mean value:
For every periodical signal $u(t)$ the mean value $M(u)$ is determined by

$$M(u) = \frac{1}{T}\int_{0}^{T} u(t)\ dt.$$

For a sinusoidal signal $u(t) = U_{\max} \cdot \sin(\omega t)$ the mean value $M(u)$ will get

$$M(u) = \frac{1}{T}\int_{0}^{T} U_{\max} \cdot \sin(\omega t)\ dt.$$

For the half-wave rectifier only one halfwave of the sinusoidal function (s. Fig. 3.1) is used.
As the function $u_o(t) = 0$ for $T/2 < t < T$ we replace the upper limit of the integral by $T/2$. The mean value is

$$M(u_o)_{\text{half-wave}} = \frac{U_{o\ \max}}{T}\int_{0}^{T/2} \sin(\omega t)\ dt$$

$$M(u_o)_{\text{half-wave}} = \frac{U_{o\ \max}}{T \cdot \omega}\left|\cos(\omega t)\right|_{0}^{T/2}$$

$$M(u_o)_{\text{half-wave}} = \frac{U_{o\ \max} \cdot \cancel{T}}{\cancel{T} \cdot 2\pi}(1+1)$$

$$\underline{M(u_o)_{\text{half-wave}} = \frac{U_{o\ \max}}{\pi}} \approx 0.3 \cdot U_{o\ \max}$$

As for the full-wave rectifier both halfwaves of the sinusoidal function (s. Fig. 3.3) are used you have to integrate over a full period T instead of $T/2$. The mean value have to be doubled the value of the half-wave rectifier.

$$M(u_o)_{\text{full-wave}} = 2 \cdot M(u_o)_{\text{half-wave}}$$

$$\underline{M(u_o)_{\text{full-wave}} = \frac{2}{\pi} U_{o\ \max}} \approx 0.6 \cdot U_{o\ \max}$$

6. *Prelab*

1. Simulate the half-wave rectifier circuit of Figure 3.7.
2. Prepare a short report with results of simulation.

7. *Procedure:*

The half-wave and center-tapped full-wave rectifier

3. insert the Module 12 in the console and set the main switch to ON;
4. connect the oscilloscope and the resistor R1 (without the capacitor C) as it is shown in Fig. 3.7.;

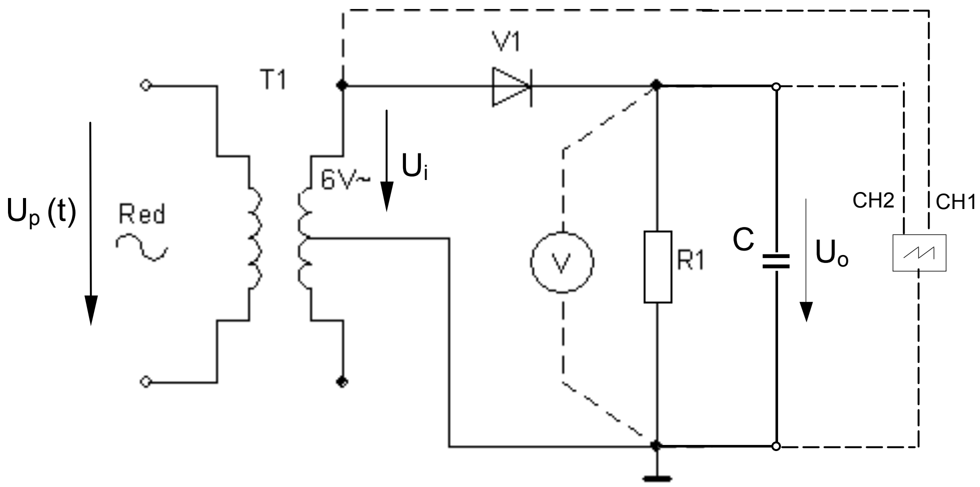


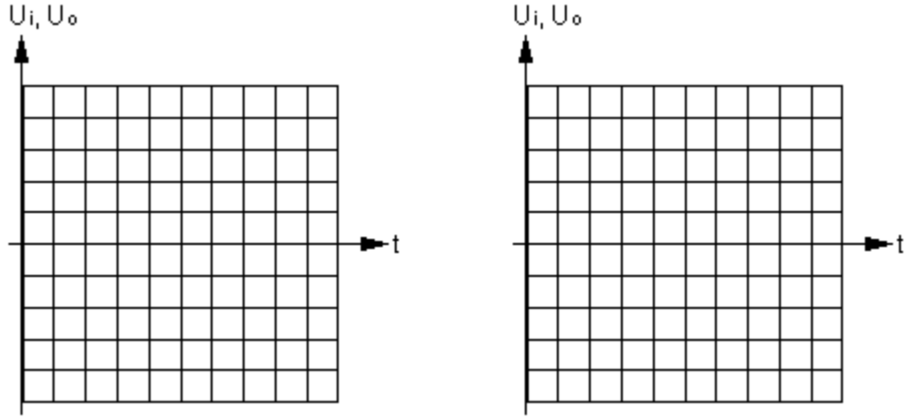
Fig. 3.7 Half-wave rectifier

5. adjust the oscilloscope in the following way:
   CH1 and CH2 = 5V/DIV,
   SWEEP = 5ms/DIV,
   COUPLING = DC;
6. without supplying the signal generator display the lines of channel 1 and channel 2;
7. set the switches S1 to ON and S2 to OFF (half-wave rectifier);
8. supply the circuit by connecting the jacks 1, 2 and ground to the the transformer (6-0-6VAC) (Fig. 3.7) but without the capacitor C;
9. observe the displayed output signal: when the sinusoidal wave is applied to the input, the negative half-wave has been cut and the value of the peak half-wave of the output positive half-wave doesn't coincide with the input one, because of the diode voltage drop;
10. draw in the signals displayed on the oscilloscope (Fig. 3.8-a);
11. measure the peak voltages on the secondary of the transformer ($U_{i\ max}$) and at the resistor R1 ($U_{0\ max}$) and write the values in Tab. 3.1;

12. measure the frequencies on the secondary of the transformer (f_i) and on the resistor R1 (f_0) and write the results in Tab.3.1;
13. with a digital multimeter in DC-mode, measure the value of the DC-component ($\overline{U}_0$) at the resistor R1 and write the values in Tab. 3.1; compare the measured value with the calculated one;
14. connect the capacitor C in parallel to the resistor R1 and draw in the signals displayed on the oscilloscope (Fig. 3.8-a);
15. again measure the value of the DC-component ($\overline{U}_{C0}$) at $R1 \| C$ and write the values in Tab. 3.1;
    disconnect the capacitor C and set the switches S1 and S2 to ON (center tapped full-wave rectifier);
16. observe the displayed output signal: the negative half-wave of the sinusoidal wave applied to the input is not cut any longer but it is "turned over";
17. repeat the procedures of points 8, 9, 10, 11, 12, 13 by drawing in the signals displayed on the oscilloscope (Fig. 3.10.-b);
18. compare the results of the half-wave rectifier with the ones of the full-wave rectifier and describe the differences.

8. *Results:*

A) <u>The half-wave and center-tapped full-wave rectifier</u>



a) b)

Fig. 3.8 : a) half-wave rectifier b) full-wave rectifier

	(a) **Half-wave rectifier**	**(b)** **Full -wave rectifier**
$U_{i\ \max}$ / V		
$U_{0\ \max}$ / V		
f_i / Hz		
f_o / Hz		
$\overline{U}_0$ measured / V		
$\overline{U}_0$ calculated / V		
$\overline{U}_{C0}$ measured / V		

Tab. 3.1

9. *Design:*

A. Design a power supply circuit (without a regulator) where the input is 240V rms AC signal (50 Hz) and the output is a rectified and filtered signal. The output voltage should be 9V with a ripple factor less than 5% when the load is 10kΩ**.**

B. Build and test the circuit. (Do not use a transformer. Take a stepped-down signal directly from the function generator)