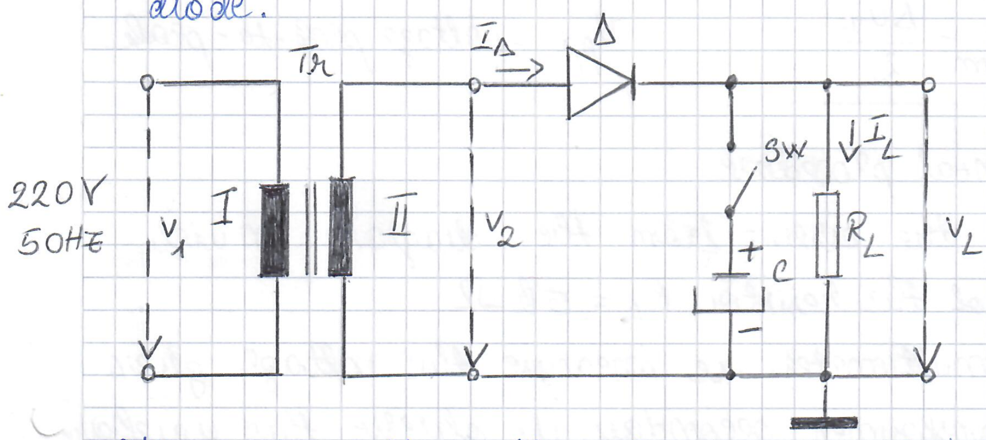
DIODE APPLICATIONS

NILGESE TIMEA
Group 2.2

Experiment : 2.4
Scope of report : The half-wave rectifier

Theory of the report

A half-wave rectifier is a type of rectifier that only allows one half-cycle of an AC voltage waveform to pass blocking the other half-cycle.
Half-wave rectifiers are used to convert AC voltage to DC voltage. This type of rectifier uses a single diode.



Half-wave rectifier circuit diagram

It can be noticed that the circuit contains a transformer denoted by Tr and it is used to reduce the voltage amplitude. Another purpose of it is to isolate the secondary circuit (II) from the primary (I) against high voltages.
The circuit also contains a capacitor C wich can be connected to the circuit by closing the switch. When it's closed we can smoothen the pulsating DC waveform into a constant DC waveform

We will study the output voltage with and without capacitor.

Formulas

• without capacitor:

$$\boxed{u_{L\Delta C} = \frac{U_{2m}}{\pi}}$$

• $U_{2m} = \frac{V_{PP}}{2}$

• $f = \frac{1}{T}$

• with capacitor:

$$\boxed{\Delta u_L \cong \frac{U_{2m}}{C \cdot R_L \cdot f}}$$

$$\boxed{u_{L\Delta C} \cong U_{2m} - \frac{\Delta u_L}{2}}$$

Legend

$u_{L\Delta C}$ - DC component of the output voltage

U_{2m} - amplitude of the input voltage

Δu_L - ripple

V_{PP} - voltage peak-to-peak

Experimental procedure

We analize the circuit from the diagram in wich the value of the resistor $R_L = 5k\Omega$.

Using a multimeter we measure the voltage given by the transformer seconday. We obseve this waveform on the oscilloscope screen and we determine its amplitude and time period. Then we take two cases:

a) case without capacitor: we find the experimental value of $u_{L\Delta C}$ and compare it with the theoretical value. In this case the switch is open.

b) case with capacitor : We perform the same measurements with a $C = 68\mu F$ capacitor.

We compute the theoretical values of the

ripple Δu_L and of the DC component u_{LDC}.
We connect then a second capacitor in parallel and repeat the same procedure.

Experimental measurements

a) case without capacitor (Sw open)

$V_{pp} = 37.2V \Rightarrow U_{2m} \simeq \frac{V_{pp}}{2} = 18.6V$

- experimentally measured: $u_{LDC} = 5.4V$
- theoretically measured: by aplying $u_{LDC} = \frac{U_{2m}}{\pi} \underset{\text{we get}}{=} 5.9V$

We can observe that there is a slight difference between the experimental and theoretical value but they are pretty close.

b) case with capacitor (Sw closed)

$\boxed{\text{1 capacitor}}$ $C = 68\mu F$, $T = \frac{1}{50} = 2ms$, $f = 50Hz$

$V_{pp} = 37V \Rightarrow U_{2m} \simeq \frac{V_{pp}}{2} = 18.5V$

- experimentally measured:

$u_{LDC} = 17V$

$\Delta u_L = 920mV$

- theoretically measured

by applying $\Delta u_L = \frac{U_{2m}}{C \cdot R_L \cdot f} = \frac{18.5}{68 \cdot 10^{-6} \cdot 5000 \cdot 50} = 1080mV$

by applying $u_{LDC} = U_{2m} - \frac{\Delta u_L}{2} = 18.5 - \frac{1.08}{2} = 17.9V$

Nou ue compere the 2 measurements done theoretical vs. experimental

$u_{LSC} = 17.9\,V$ (theory) vs. $u_{LSC} = 17\,V$ (experiment)

$\Delta u_L = 1.08\,V$ (theory) vs. $\Delta u_L = 0.92\,V$ (experiment)

We can conclude that the results from the two methods doesn't differ much.

$\boxed{\text{2 capacitors}}$

In this case we put 2 capacitors with $C = 68\,\mu F$ in parallel so we add them together, therefor the formula will be: $\Delta u_L = \frac{U_{2m}}{2C \cdot R_L \cdot f}$

$V_{pp} = 37\,V \Rightarrow U_{2m} = 18.5\,V$

- experimentally measured:

$\Delta u_L = 460\,mV$

$u_{LSC} = 17.\quad V$

- theoretically measured

by applying $\Delta u_L = \frac{U_{2m}}{2 \cdot C \cdot R_L \cdot f} = \frac{18.5}{2 \cdot 68 \cdot 10^{-6} \cdot 5000 \cdot 50} = 544\,mV = 0.544\,V$

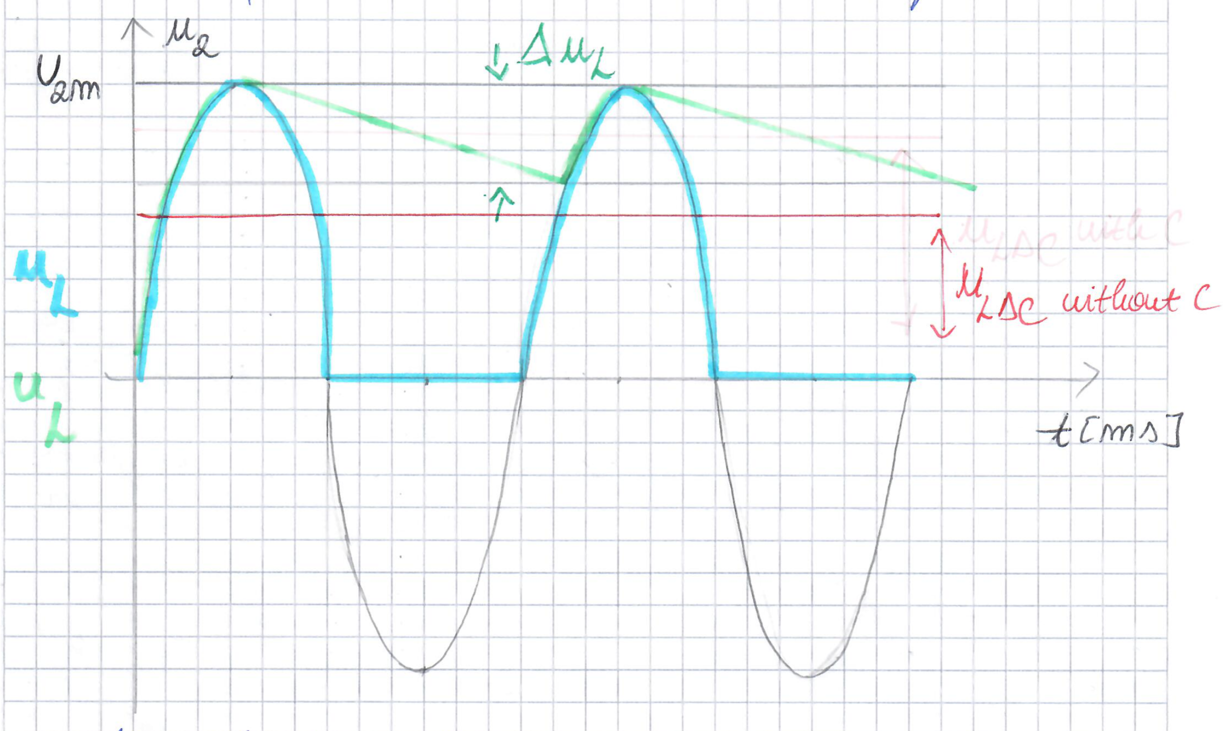
by applying $u_{LSC} = U_{2m} - \frac{\Delta u_L}{2} = 18.5 - 0.272 = 18.2\,V$

The results from the theory formulas are close to the results from the real experiments.

Conclusions

By using a half-wave rectifier without capacitors we get half DC pulses but it can't be actually used in the real world, that's why in reality we use half-wave rectifiers with a capacitor wich is used as a filter.

It can be seen a huge difference in the diagram below of the circuit with and without capacitor.



— u_L without capacitor

— u_L with capacitor

The circuit waveforms using LTspice

Circuit component values:

U_{2m}=18.5V

f=50 Hz

C=68uF

R=5 kΩ