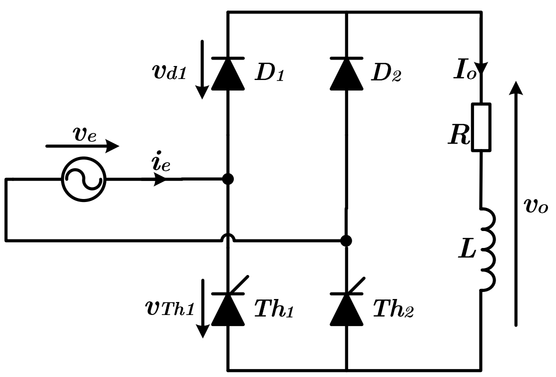
Power Electronics — ***Dr : M. Bouzidi***

L3 Automation — ***Exam*** — ***01/02/2024 Duration :** 1h :30 min*

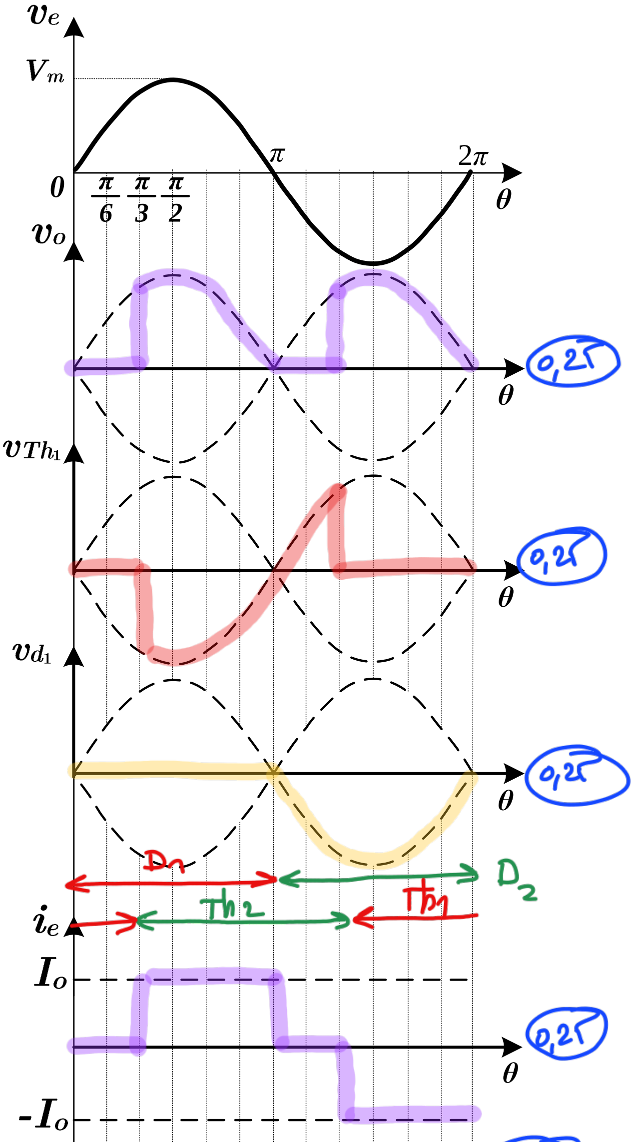
Full name: …………………………………………………. ***Groupe:*** ……….	***Note:*** $\frac{}{20}$ *

***Exercise 1:* (*7 pts*)** The controlled Full-wave rectifier supplies an inductive load R-L. The load current is constant due to the large value of the inductance.

The input voltage RMS is $V_{e,rms} = 220V$. For $\alpha = \frac{\pi}{3}$:



1- Determine the conduction intervals of the power switches.
2- Represent the waveforms of v_o, i_e, v_{Th1}, and v_{d1}.
3- Calculate the average value of the output voltage.
4- Calculate the RMS value of the input current.
5- Calculate the active power, apparent power and the power factor.



v_o	0	Ve	0	−Ve
v_{Th1}	0	−Ve	0	
v_{d1}	0	Ve		
i_e	0	Io	0	−Io

0,25 0,25 0,25 0,25

Figure (1)

Solution

1- Conduction intervals 0,5

- Th_1 ON: $\theta \in$ $[4\pi/3 \quad 2\pi] \cup [0 \quad \pi/3]$
- Th_2 ON: $\theta \in$ $[\pi/3 \quad 4\pi/3]$ 0,5
- D_1 ON: $\theta \in$ $[0 \quad \pi]$ 0,5
- D_2 ON: $\theta \in$ $[\pi \quad 2\pi]$ 0,5

Good luck

2- Waveforms representation:

Complete the table under **Figure (1)** for the variables v_o, i_e, v_{Th1}, v_{d1}.

3- Average value of the output voltage:

0,25 0,25

$\bar{V}_o = \frac{1}{\pi}\int_{\pi/3}^{\pi} V_m \sin\theta \, d\theta$ 0,25

$\bar{V}_o = \frac{3 V_m}{2\pi}$,

$\bar{V}_o = 148{,}62\ V$

4- RMS value of the input current:

0,25 0,25

$I_{e,rms}^2 = \frac{1}{2\pi}\left[\int_{\pi/3}^{\pi} I_o^2 \, d\theta + \int_{4\pi/3}^{2\pi} (-I_o)^2 \, d\theta\right]$ 0,25

$I_{e,rms} = \sqrt{\frac{2}{3}}\, I_o$,

$I_{e,rms} = 8{,}16\ A$

5- Active power, apparent power, power factor:

0,25 0,25

- $P = \bar{V}_o \cdot I_o$

$P = \frac{3}{2\pi} V_m \cdot I_o$,

$P = 1486{,}2\ W$

0,25 0,25

- $S = V_{e,rms} \cdot I_{e,rms}$

$S = V_{e,rms} \cdot \sqrt{\frac{2}{3}}\, I_o$,

$S = 1795{,}2\ VA$

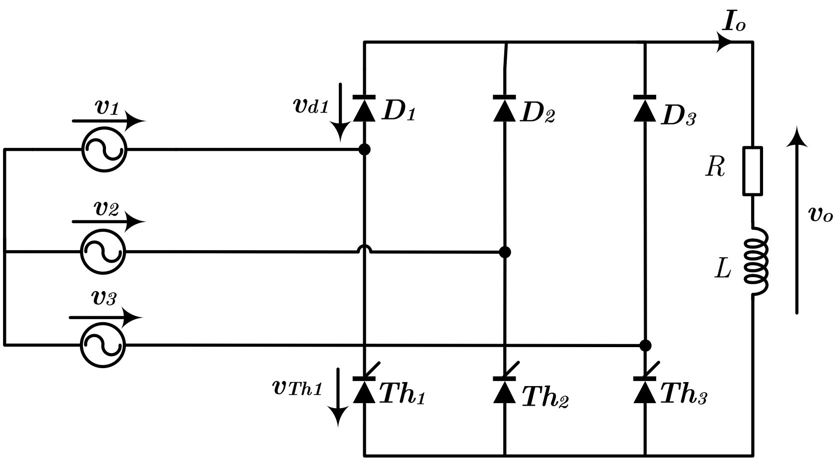
- $PF = \frac{P}{S}$,

$PF = 0{,}82$

0,25 0,25

Exercise 2: (*6pts*)

The controlled three-phase half-wave rectifier supplies an inductive load R-L. The load current is constant due to the large value of the inductance. The input voltage RMS is $V_{e,rms} = 220V$. For $\alpha = \frac{\pi}{6}$.



1- Determine the conduction intervals of the power switches.

2- Represent the waveforms of v_o, v_{Th1} and, v_{d1}.

Solution

1- Conduction intervals

- Th_1 ON: $\theta \in$ $[4\pi/3 \quad 2\pi]$ 0,5
- Th_2 ON: $\theta \in$ $[0 \quad 2\pi/3]$ 0,5
- Th_3 ON: $\theta \in$ $[2\pi/3 \quad 4\pi/3]$ 0,5

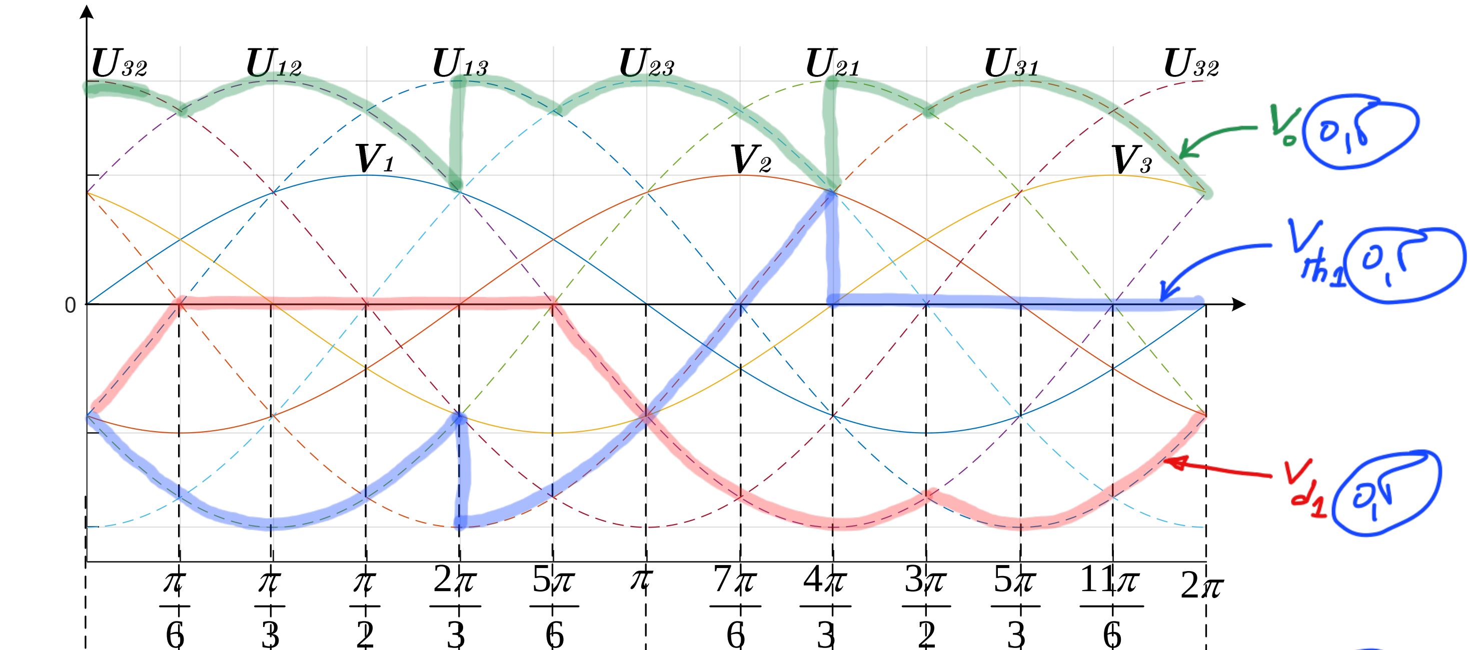
D_1 ON: $\theta \in$ $[\pi/6 \quad 5\pi/6]$ 0,5

D_2 ON: $\theta \in$ $[5\pi/6 \quad 3\pi/2]$ 0,5

D_3 ON: $\theta \in$ $[3\pi/2 \quad 2\pi] \cup [0 \quad \pi/6]$ 0,5

2- Waveforms representation

Complete the table below for the variables v_o, v_{Th1}, v_{d1}.



v_o	U_{32}	U_{12}	U_{13}	U_{23}	U_{21}	U_{31}	0,5
v_{Th1}	U_{21}	U_{31}	0				0,5
v_{d1}	U_{13}	0	U_{12}	U_{13}			0,5

Exercise 3 (*7 pts*)

The DC-DC converter shown below is operated in a continuous conduction mode. The transistor is turned ON over the interval $[0 \;\; DT_s]$, where T_s is the switching period, and D is its duty cycle. The capacitance C is assumed to have a sufficient value to keep the output voltage constant.

1- What is the type of this converter (Buck or Boost).

2- Represent the following waveforms over one period: $i_L(t), v_L(t), v_d(t)$ and $v_H(t)$.

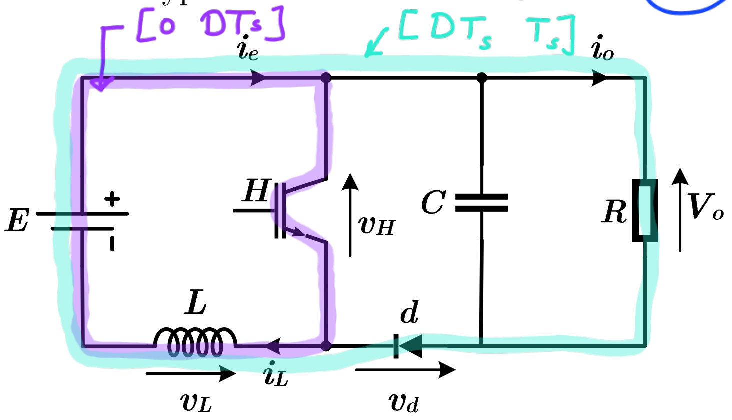
3- Calculate the average value of v_d as a function of E and D.

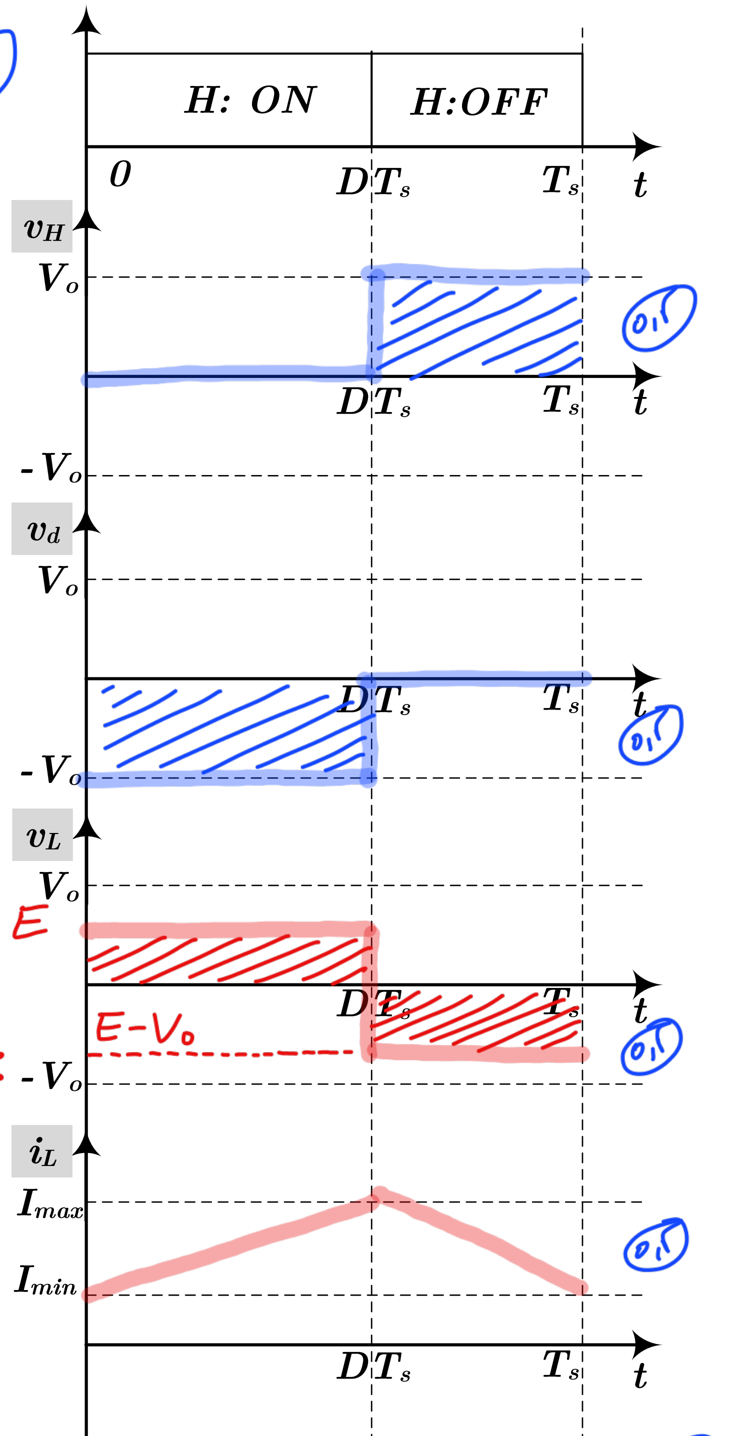
4- Express the output voltage V_o in terms of D and E.

5- Calculate the average value of the input current in terms of E, R, and D.

Solution

1- The type of this converter is: Boost 0,5





2- Waveforms representation:

Complete the table below for variables:

v_H, v_d, v_L, and i_L and represent them.

3- ***Average value of*** v_d

$\bar{V}_d = \frac{1}{T_s}\int_0^{DT_s} -V_o\,dt$

$\boxed{\bar{V}_d = -D \cdot V_o}$ 0,5

4- $V_o = f\,(E,D) = ?$ By applying KVL:

$E - V_o - V_d - V_L = 0$

$\Rightarrow \bar{V}_o = V_o = E - \bar{V}_d$ 0,5

$$\boxed{V_o = \frac{E}{1-D}}$$ 0,5

5- $\bar{I}_e = f\,(E,D) = ?$

$\bar{I}_o = \frac{V_o}{R} = (1-D)\cdot \bar{I}_e$ 0,5

$$\boxed{\bar{I}_e = \frac{E}{R(1-D)^2}}$$ 0,5

v_H	0	V_o
v_d	$-V_o$	0
v_L	E	$E - V_o$
i_L	$\frac{E}{L}.t + I_{min}$	$\frac{E-V_o}{L}(t-DT_s)+I_{max}$

0,5 0,5 0,5 0,5