Higher Institute of Technological Studies of Nabeul

Electrical Engineering Department

Field:

Industrial Electricity

Project Graduation

Host organization: GINOR

Variable frequency drive for three-phase asynchronous motor

Realized by: Supervised by:

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DEDICATED

To

$\mathcal{W}$ith great pleasure I dedicate this project.

$\mathcal{T}$o those who helped and encouraged me.

$\mathcal{T}$o my parents **KHAZRI Mohsen** and **Fadhila** who supported me and

sponsored the practical realization of the variable speed drive.

$\mathcal{T}$o my little brother **Dhafrallah** whom I adore, I wish him joy and success
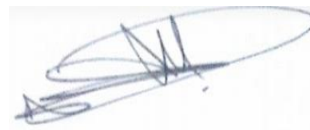
in his studies.

$\mathcal{T}$o my cousin **Nouri** and my aunt **Salha** who helped me in displacements

during my practical realization .

$\mathcal{T}$o all my friends who were always present with me.

$\mathcal{T}$o all those who I love and who try to create this environment in which I

live, full of joy and favorable atmosphere.

KHAZRI Ghazi

Isetn, 2018

Special thanks to

$\mathcal{F}$irst, I want to thank **"GOD"** for giving me courage and patience during my studies.

Secondly, I would like to express my gratitude to my supervisor, **Mr. Mongi ANTIT**, a teacher at **ISET NABEUL** for his precious help, his quality supervision and his directives which have been of great help to me in fulfilling my Project Graduation.

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I also wanted to thank **Mr. Moez HAJJI**, director of the electrical engineering department, for allowing this work to be carried out in good conditions.

I did not want to leave this opportunity without expressing my heartfelt thanks to the director of the **H**igher **I**nstitute of **T**echnological **S**tudies of **N**abeul who gave me the chance to discover the companies and improve my information.

$\mathcal{F}$inally, I express my thanks, the most devoted, to **the president of the jury:**

Mr Jamel Ben Salem and **the jury members**: **Mdme Sondes Abdelmouleh**, **Mr Belhaj**

Hassin Riadh for accepting the judgment of my modest end of studies project.

Project specifications

Subject :

Substitution of a 170 kW direct current motor with another alternating current motor controlled by a variable frequency drive.

Institution:

Higher Institute of Technological Studies of Nabeul (ISETN).

Department: Department of Electrical Engineering.

Option: Industrial electricity (EI).

Class: EI 31

Number of students: 01

Supervised by: Mr. Mongi ANTIT (ISETN)

                    Mr. Salem KHAZRI (GINOR)

Period: 4 Months (from February 05 to June 15, 2018).

Work to do :

- Bibliographic studies.

- Theoretical study and calculation.

- Economic study.

- Assembly and tests.

- Technological study.

- Technical realization

- Manufacturing folder

- Report (1 original + 2 copies).

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Glossary

Chapter I :

GINOR : General industry north of Tunis

DC : direct current motor

5W2H : what, who, where , when, how, how much, why

Chapter II :

ABB : sigle d'ASEA Brown Boveri

emf. (V) : electromotive force

Pin   (W) : Active power absorbed by the stator

Pm (W) : Mechanical losses

Pscu   (W) : Joule stator losses

Pout   (W): Useful power

Pc   (W): Iron losses to the stator

Tem (Nm) : Electromagnetic torque

Ptr   (W): Power transmitted from stator to rotor

Tu   (Nm): Useful torque

Prcu   (W): Joule losses at the rotor

Ωs   (rad/s): Vitesse angulaire de synchronisme

Pfr   (W): Pertes fer au rotor

Ω   (rps) : Vitesse angulaire du rotorique

Pem   (W) : Electromagnetic power

Tr   (Nm): resistive torque

Tn   (Nm): nominal torque

Pst   (W) : equivalent average power

IGBT : Insulated Gate Bipolar Transistor

PWM: Pulse Width Modulation

L1, L2, L3 : 3 phases

D1, D2, D3, D4, D5, D6 : Diodes

C : capacitor

L : coil

T : transistor

R : Resistance

M : three-phase asynchronous motor

Chapiter III

Vm (V) :Amplitude of the reference voltage.

PD3 : Three-phase double bridge

AC (A): alternating current

DC (A) : Direct current

LC : electrical circuit formed by a coil and a capacitor

Chapiter IV

PWM : Pulse Width Modulation

USB : Universal Serial Bus

3 ~ : three phase

Gound GND : mass of the control part

AGND : common mass of the power part

LED : Light-Emitting Diode

MOSFET : Metal Oxide Semiconductor Field Effect Transistor

GENERAL INTRODUCTION

Three-phase asynchronous motors represent more than 80% of the electric motor fleet. They are used to transform electrical energy into mechanical energy through electromagnetic phenomena. Today these machines are increasingly replacing DC machines in most applications requiring variable speed drives. [1]

The use of the variable speed drive is widespread in many industrial fields, either to regulate the process or to fix the operating point. It appears to be a means at the service of a productive approach whose objective is to optimize the competitiveness of the products of the factory.

The objective of my project is to solve a problem for the factory "GINOR" which is represented in a DC motor with a power of 170 kW which causes many problems in terms of operation, which in turn causes a break from factory productivity because this engine turns a diffuser and the location of the latter is very sensitive.

My report is structured in **four chapters** which reflect the approach I adopted for the development of this project.

The first chapter "Presentation of the company and problematic", in which I will describe the company as well as its problematic.

In **the second chapter** "Choice of the three-phase asynchronous motor and its variator", I will study the choice of the three-phase asynchronous motor and the suitable variator.

In **the third chapter** "Simulation of the variable speed drive", I will simulate the variable speed drive, then I will compare its performance with two types of control.

In **the fourth chapter** "Realization of a speed variator based on inverter controlled by arduino", I will make the practical realization of a speed variator of a three-phase asynchronous motor.

The project ends with "General conclusion and perspectives" presenting a synthesis of my work, as well as the perspectives allowing to improve this project.

CHAPTER I:

PRESENTATION OF THE COMPANY AND PROBLEMATICS

INTRODUCTION

This chapter will be the subject of a brief presentation of the General Industry of the North "GINOR", and the detailed explanation of the problem of the society to which it seeks the adequate solution.

1. PRESENTATION OF THE COMPANY

The "GINOR" is an industrial establishment whose mission is to manufacture sugar. It was founded in 1983 by a German company, its share capital amounts to 4.5 million dinars. Based in Ben Bachir (Jendouba North), it houses 160 technicians and managers.
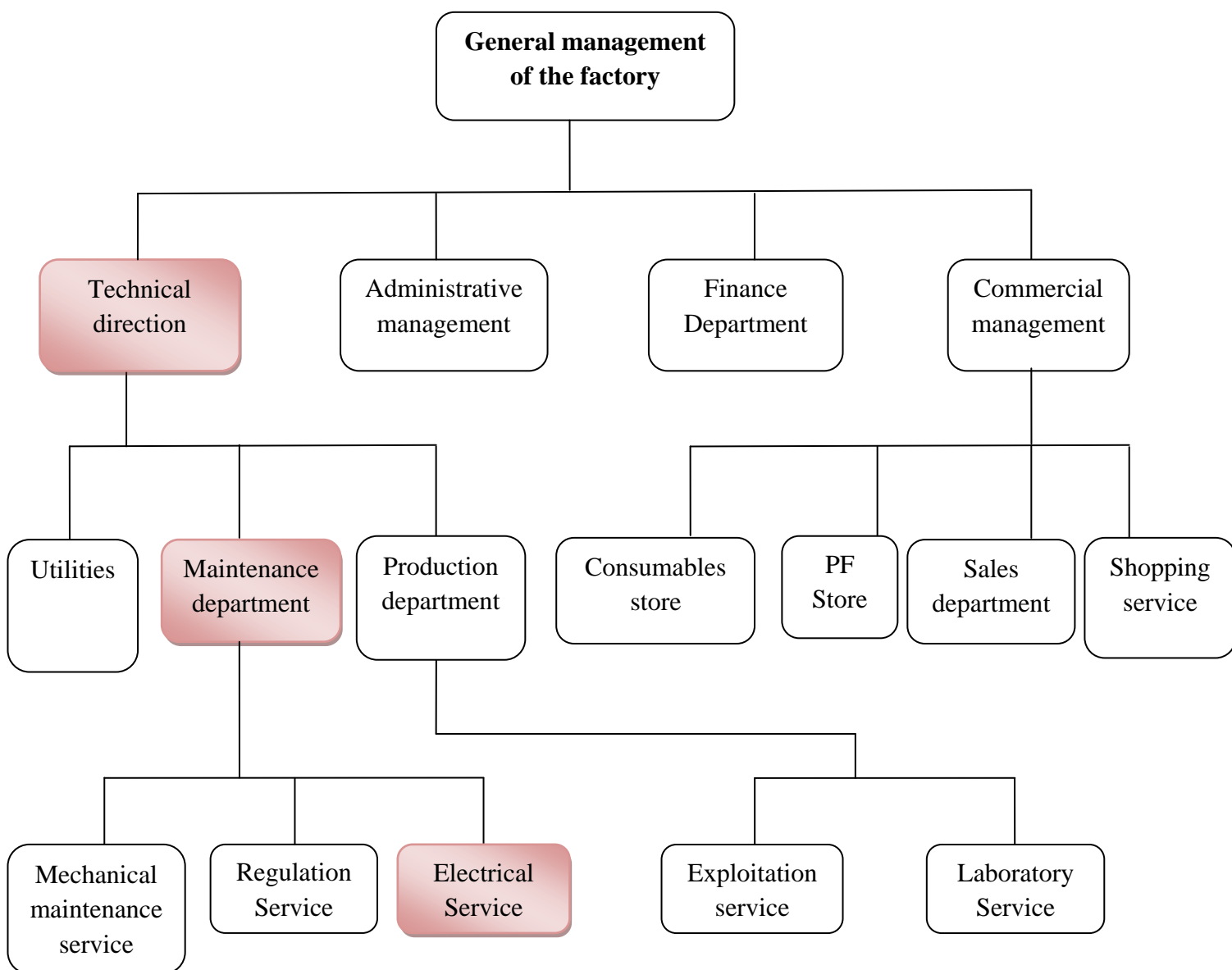
Figure 1: General organization chart

2. PROBLEM

2.1 Diffusion of sugar

The problem lies in the sugar diffusion stage. In this stage sugar pods enter a diffuser. This operation is based on the principle of osmosis: If lukewarm water and these chips are circulated slowly, the sugar contained in them gradually passes into the water in order to obtain a sugar juice. The diffuser of this factory is a huge compartmentalized cylinder driven by a DC motor. It cannot perform the desired performance. It has an interrupted operating cycle which repeats several times due to frequent failures. As a result, the diffuser locks up and no longer rotates, which leads production to being halted until the engine is repaired.

Figure 2 : Diffuser + DC motor

2.2 The 5W2H diagram

The objective of this tool is to ask the 7 key questions (what, who, where , when, how, how much, why), in order to collect all the necessary information in relation to a situation, a system, a problem ... etc. allows to formulate precisely the solution. [2]

Who ?
- Who noticed the problem?
- Mr. KHAZRI Salem engineer and the Manager of the electrical maintenance department of the factory.

What ?
- What is it about ?
- These are problems with the DC motor.

Where ?
- Where does it take place?
- This happens at the diffusion stage.

When ?
- How long has the problem been in existence?
- The problem has existed since the engine was installed in 1981.

How?
- What are its effects ?
- Production stoppage and loss of money.

How much?
- How much money ?
- Buying parts is very expensive.

Why ?
- What purpose ?
- To improve the productivity of the factory.

Figure 3 : The 5W2H diagram

2.3 Diagnostic flowchart

To facilitate the search for the causes of production stoppage, I will use the diagnostic flowchart also called troubleshooting algorithm. [2]

BEGINNING

System malfunction

The engine doesn't start

Checking the voltage at the motor terminals

Checking the voltage across the contactor

Checking the voltage across the source

Voltage present

Voltage present

Voltage present

broken engine

Damaged wiring or relay

Contactor problem

Check the connection of power wires

This is the intended area, all the problems are repeated here with the DC motor.

Figure 4 : Diagnostic flowchart

2.4 The disadvantages of the DC motor

The DC motor currently installed has several drawbacks:

1.   The maintenance of this motor and the repair as well as the purchase of parts are very expensive compared to an AC motor.

2.   The higher the speed of rotation, the more the brush pressure must increase in order to remain in contact with the collector, therefore the greater the friction, so the brushes must therefore be replaced very regularly.

3.   The collector imposing contact breaks causes arcs, which quickly wear down the switch and generate electrical parasitics in the supply circuit.

4.   The engine has become obsolete since it has been installed since 1981.

Ventilation motor

Cooling exchanger

Speedometer dynamo

DC motor installed

Rail
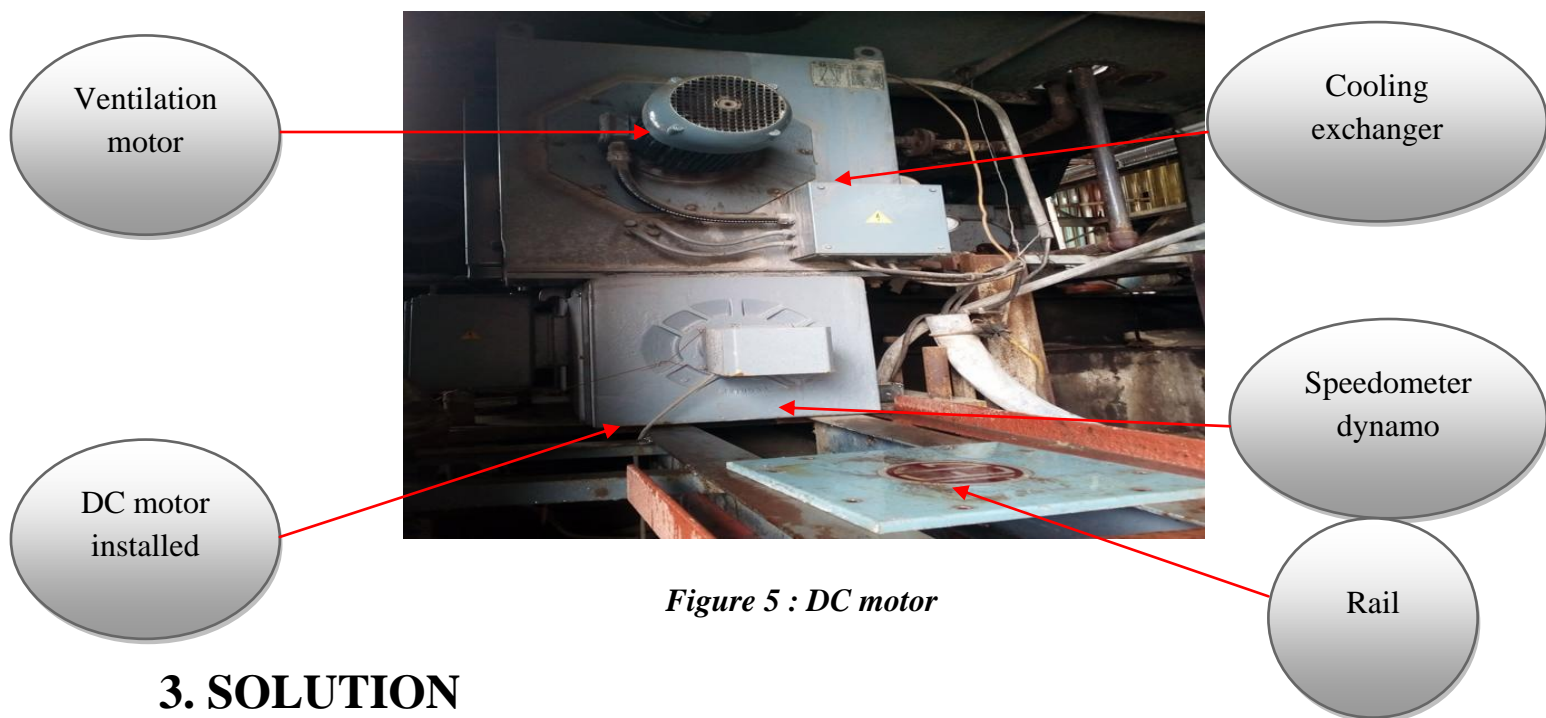
Figure 5 : DC motor

3. SOLUTION

The adequate solution will be a change of the DC motor by another three-phase asynchronous with its control.

4. CONCLUSION

In this chapter I presented the GINOR company, as well as the stage in which the problem is repeated and then the proposed solution. The following chapter will be devoted to a study of the choice of the three-phase asynchronous motor and its variator which will replace the old DC motor.

CHAPTER II:

CHOICE OF THE THREE-PHASE ASYNCHRONOUS MOTOR AND ITS VARIATOR

INTRODUCTION

In this chapter I will study the choice of the new three-phase asynchronous motor of type ABB required by the company which will replace the DC motor while keeping the same power 170 kW and the suitable variator.

1. STUDY OF THE ASYNCHRONOUS THREE-PHASE MOTOR

1.1 Definition

The three-phase asynchronous motor transforms electrical energy into mechanical energy in order to rotate the diffuser, it is extremely robust and more widespread in the industry given its constitution, reliability, low cost, simplicity of construction and reversibility in operation.

Figure 6 : Three-phase asynchronous motor

1.2 Constitution
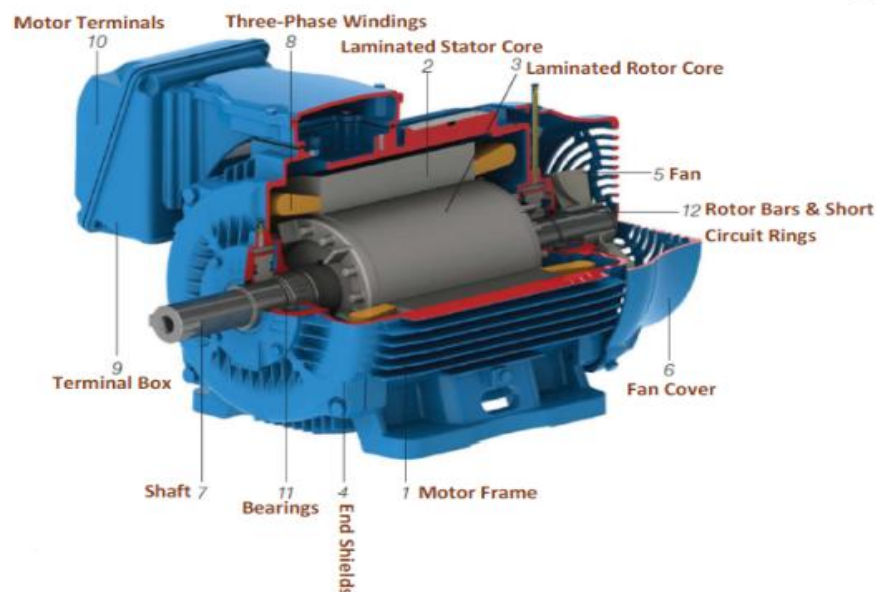
Figure 7 : Constitution of the three-phase asynchronous motor

1.2.1 The stator

It is the fixed part of the motor, it is formed of a ferromagnetic carcass which contains three electric windings each supplied by a voltage phase **U,** and with a frequency **f**. The flow of current through the windings creates a rotating magnetic field $\vec{B}$ inside the stator, its speed of rotation **ns** is called synchronization speed $\boldsymbol{ns = \dfrac{f}{p}}$ or $\boldsymbol{\Omega s = 2.\Pi.ns}$

1. $\boldsymbol{ns}$: The frequency of rotation of the field $\vec{B}$ expressed in **rps**

2. $\boldsymbol{f}$: La fréquence de la tension d'alimentation des bobines en Hertz **Hz**

3. $\boldsymbol{p}$: The number of pairs of rotor poles

4. $\boldsymbol{\Omega s}$: Synchronism speed is expressed in **rad / s**

1.2.2 The rotor

It is the moving part of the asynchronous motor, it rotates slower than the stator rotating field, its speed is **nr <ns**, it carries either a winding accessible by three rings and three brushes, or a squirrel cage not accessible to base of aluminum conductor bars. The relative angular speed of the field relative to the rotor is the angular sliding speed:

$\Omega g = \Omega s - \Omega r$ (rad/s)

$n g = n s - n r$ (rps)

1.3 Operating principle [3]

The rotating magnetic field $\vec{B}$ created by the stator windings sweeps the rotor winding and induces electromotive forces (emf) according to Lenz's law. The rotor winding being in short circuit, these emf produce there induced currents. The action of this field on the induced currents creates the engine torque. The latter tends to reduce the cause which gave rise to the currents, ie the relative rotation of the rotating field relative to the rotor. The rotor will therefore tend to follow this field. The three pulsations found in the engine are:

1. $\omega s = 2\pi. fs$, pulsation of stator
2. $\omega r = 2\pi. fr$, pulsation of rotor

3. $\omega = 2\pi.f$, mechanical pulsation with $\Omega = \dfrac{\omega}{p}$: $\mathbf{\Omega}$ mechanical speed

These three pulsations are linked by the equation:

1. $\omega s = \omega + \omega r$

Slippage is defined by:

2. $g = \dfrac{fs - f}{fs} = \dfrac{\Omega s - \Omega}{\Omega s} = \dfrac{\omega s - \omega}{\omega s} = \dfrac{ns - n}{ns}$

1.4 Power flow diagram

$$P_{in} = \sqrt{3}.U_1.I_1.\cos(\omega)$$

$$P_c = P_{in} - P_{tr} - P_{rcu} \qquad P_{scu} = \frac{3}{2}.R_m.(I_1)^2$$

$$P_{tr} = Tem.\Omega s$$

$$P_m = P_{em} - P_{out} \qquad P_{rcu} = g.P_{tr}$$

$$P_{em} = Tem.\Omega$$

$$P_{out} = Tu.\Omega$$
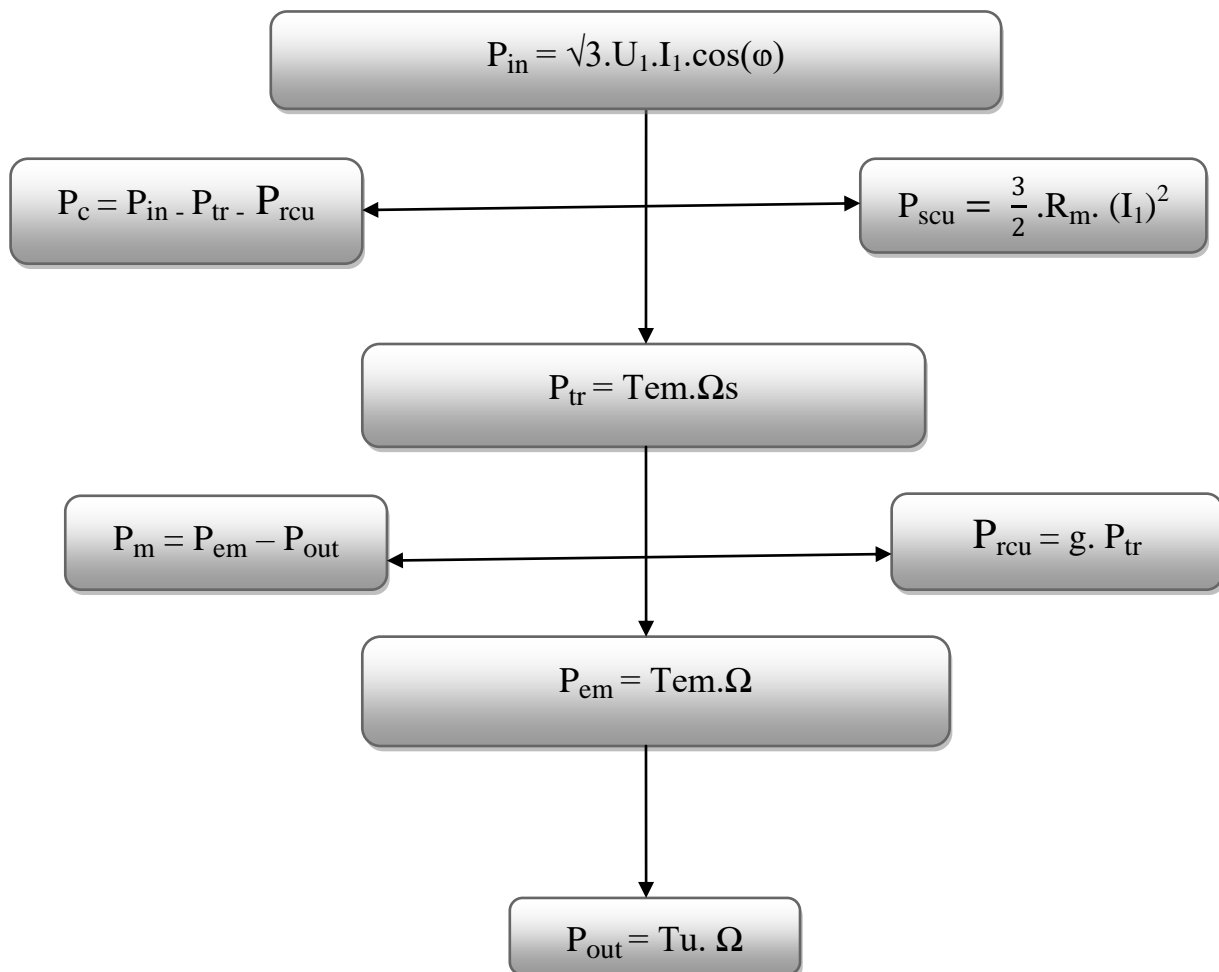
Figure 8 : Power flow diagram

1.5 Choice of motor

1.5.1 Characteristics on the motor shaft [4]

Follow the same clues found on the old nameplate of the DC motor:

1. Rotation speed :   Nominal power :

    n_1=2860 rpm   Pn = 170 kW

2. Supply voltage :   frequency :

    230/400 V   f = 50 Hz

1. Calculation of the rotation speed Ω1:

$$\Omega 1 = \frac{2\times\Pi\times n1}{60} = \frac{2\times\Pi\times 2860}{60} = \boxed{299.49 \text{ rad/s}}$$

2. Calculation of the resistant torque Tr1:

We have $P_{out} = T_{r1}\times\Omega_1 = 170 \text{ kW}$

$$\rightarrow T_{r1} = \frac{P_{out}}{\Omega 1} = \frac{170\times 1000}{299.49} = \boxed{567.63 \text{ Nm}}$$

The nominal torque of the motor must be greater than the resistive torque:

$T_n > T_{r1} \Leftrightarrow T_n > 567.63 \text{ Nm}$

3. Calculation of the number of pairs of poles:

We have **nr** = 2860 rpm so **ns** must be equal to 3000 rpm

$$ns = \frac{60\times f}{P} \qquad \Leftrightarrow \quad P = \frac{60\times f}{ns} = \frac{60\times 50}{3000} = 1$$

Number of pole pairs = 1   ➔   Number of poles = 2×p = $\boxed{\textbf{2 poles}}$

1.5.2 Determining the type of engine [5]

The type of the new three-phase asynchronous motor ABB (see annex 1) according to the previous information is **M3BP 315 MLA 2** its code is 3GBP311410- •• G with a power of 200 kW. (30 kW range)

1. Its nominal torque = 640 N.m respects the torque rule:

 Nominal torque > resistive torque: 640 Nm > 567.63 Nm

2. Insulation class F

3. Heating class B

Insulation class F with heating B corresponds to the most frequent industrial requirements.

Puissance kW	Type de moteur	Code produit	Vitesse tr/min	Rendement CEI 60034-30-1; 2014			Facteur de puissance Cos φ	Courant		Couple			Moment d'inertie J = 1/4 GD²kgm²	Masse kg	Niveau pression sonore L_WA dB
				Pleine charge 100 %	3/4 charge 75 %	1/2 charge 50 %		I_s A	I_s/I_n	C_N Nm	C/C_N	C_v/C_N			
3000 tr/min = 2 pôles				400 V 50 Hz				Conception CENELEC							
200	³ M3BP 315 MLA 2	3GBP311410-••G	2980	95,7	95,7	94,9	0,90	335	7,7	640	2,6	3,0	2,10	1190	78

Figure 9 : Choice of engine

English datasheet: new.abb.com/products/3GBP311410-ADG/m3bp-315mla-2

4. Calculation of the equivalent average power:

The service chosen is the continuous service S1 (appendix 2) with a start-up time of the order of 1s. The calculation of the equivalent average power **Pst** is necessary to verify the sizing of the chosen motor. It is given by the following relation:

$$Pst = \sqrt{\frac{n \times td \times \left[\frac{Id}{In} \times Pn\right]^2 + (3600 - n \times td) \times Pout^2 \times Fdm}{3600}}$$

It is necessary that: Equivalent average power < nominal power

Data in Annex 2:   Data in Annex 1 :

1.   Fdm = 1 $\frac{Id}{In} = \frac{Is}{In} = 7,7\ A$

2.   n ≤ 6 we take n = 6 $P_n = 200\ kW$

3.   td = 1 s $P_{out} = Tr1 \times \Omega1 = 170\ kW$

With :

Fdm : step value to choose   **n** : value of the number of starts

td   : boot time   **Id = Is** : starting current

In : rated current   **Pn** : nominal motor power selected

Digital Application :

$$Pst = \sqrt{\frac{6 \times 1 \times [7,7 \times 200]^2 + (3600 - 6 \times 1) \times 170^2 \times 1}{3600}} = \boxed{181\ kW}$$

Pst = 181 kW < Pn = 200 kW   ➔   The engine chosen is therefore <u>satisfactory.</u>

1.6 Engine location study [5]

Since the changeover of the two motors will be carried out in a cabin which is already built. It is necessary to study the details of the location of the new motor to avoid possible problems during its installation.

1.6.1 Motor size 315 ML
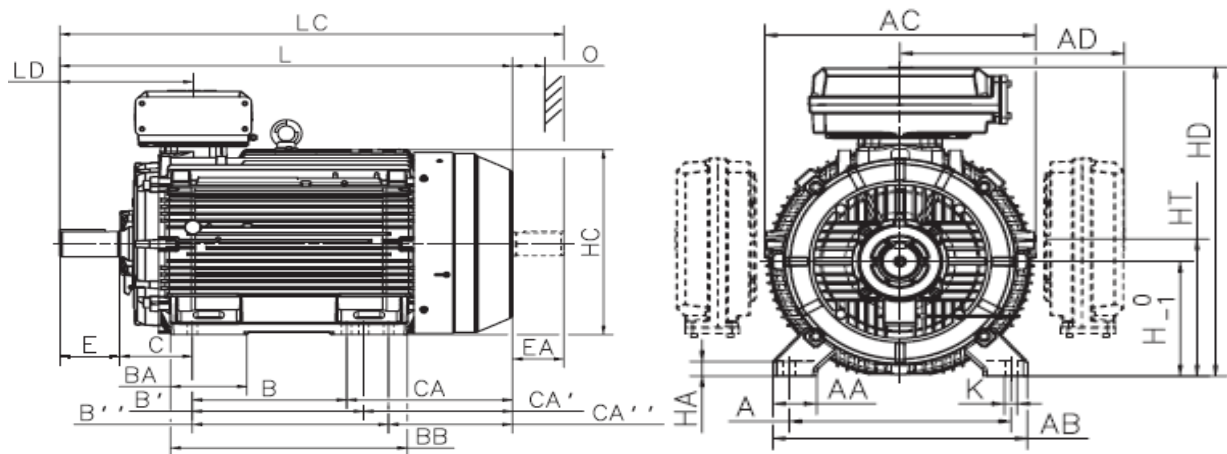
Figure 10 : Motor size 315 ML

1. The motor chosen in legged cast iron, its size is 280 - 315 (appendix 3).

2. Overall LC length: 1433 mm

3. Overall HD height: 852 mm

4. Overall width AC: 654 mm

1.6.2 Engine accessories 315 ML

Parts	Reference	Appendix
Terminal box	370	4
Optional adapter	293	4
Junction box	278	4
Anti-noise carcass	sizes 280 – 450	5
Glissière	tailles 280 - 315	5

Table 1 : Engine accessories

2. SPEED VARIATOR STUDY

2.1 Introduction

The increasing use of variable speed drives in the industrial environment is preferable in order to protect existing installations against electrical disturbances. For this, it is useful to study the drive, its constitutions and its choice so that we can properly control the motor chosen previously.

2.2 Basic principle of the variable speed drive [6]

The variable speed drive makes it possible to control the motor speed above and below the nominal speed by changing the frequency of the supply voltage going from (f = 0 Hz) to the nominal motor speed (f = 50 Hz).

It is composed of: (see figure 11)

1. a **rectifier** which is connected to a three-phase power supply which generates a DC voltage with residual ripple (the signal is not perfectly continuous). The rectifier can be of the controlled type or not.

2. an **intermediate circuit** acting mainly on the "smoothing" of the output voltage of the rectifier (improves the DC component). It can also serve as an energy dissipator when the engine becomes a generator, it is composed of a "low pass" smoothing coil (low frequency filtering), and a "high pass" capacitor (high frequency filtering) to reduce residual ripple.

3. an **inverter** which generates the power signal at variable voltage and / or frequency.
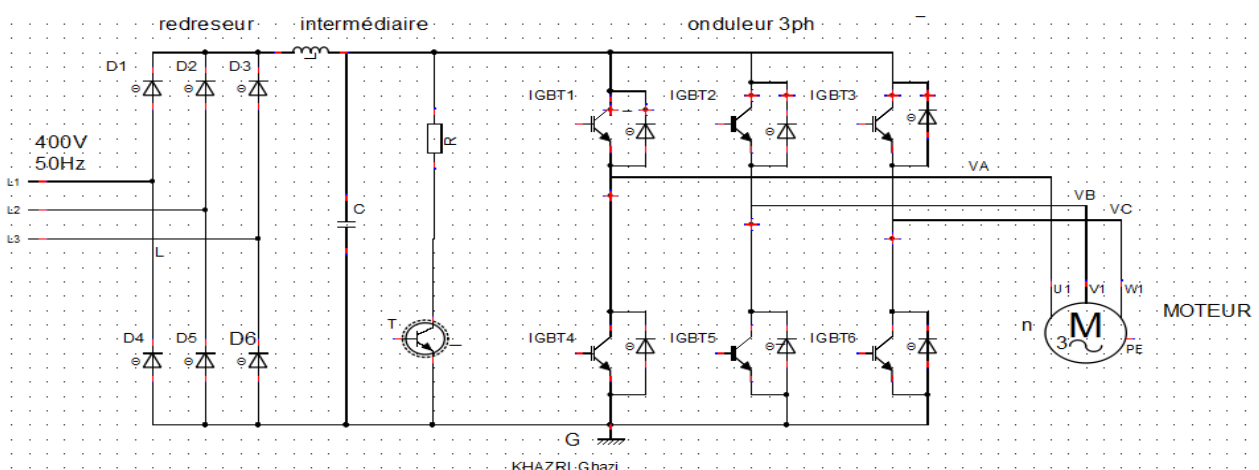
Figure 11 : Speed variator schematic

English schematic : www.inverters.cn/what-is-a-frequency-inverter-810450.html

2.2.1 The rectifier

It is a converter intended to supply a load which needs to be it by a voltage or a direct current starting from an alternative source. Power is most of the time a generator of voltage. This is done by using:

• Either from a diode bridge, the rectifier is "not controlled"

• Either from a thyristor bridge, then the rectifier is "controlled"
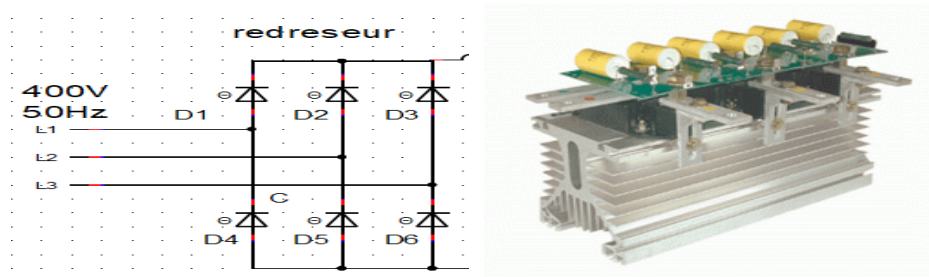
Figure 12 : Rectifier schematic

English schematic : www.electronics-tutorials.ws/power/three-phase-rectification.html

2.2.2 The intermediate circuit

It can also be used to:

1. Uncouple the rectifier from the inverter.

2. Reduce the harmonics.

3. Store energy.

4. Reducing residual ripple

The coil and capacitor work together to provide the load with the most linear voltage possible.
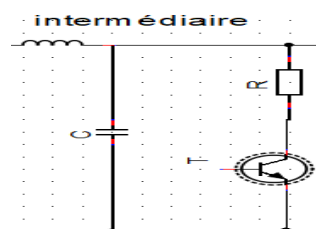
Figure 13 : Intermediate circuit

English schematic : www.powersystemsdesign.com/articles/converter-and-inverter-output-filtering/34/11437

2.2.3 Inverter study

The inverter is the last part of the frequency drive. It is a static DC-to-AC (DC / AC) converter, used to make a source of three AC voltages from a DC voltage source.
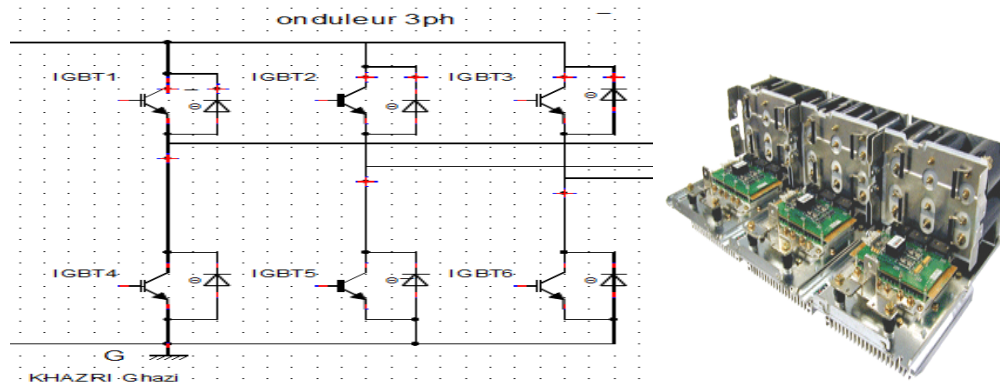
Figure 14 : Schematic of the three-phase inverter

English schematic : www.researchgate.net/figure/Three-phase-inverter-circuit_fig1_4368618

It consists of a DC voltage source and six IGBT bridged switches (Figure 14). The DC voltage is generally obtained by the three-phase diode rectifier followed by filtering by the intermediate circuit.

The inverter is widely used in PWM control for supplying balanced three-phase receivers with variable voltage and frequency. It consists in changing the width of the output voltage pulses with appropriate commands of the semiconductor switches.

The three output voltages is formed by a bistable wave taking the values -E and + E and offset by $\frac{2\pi}{3}$ one over the other.

The following figure explains how a three-phase inverter works:
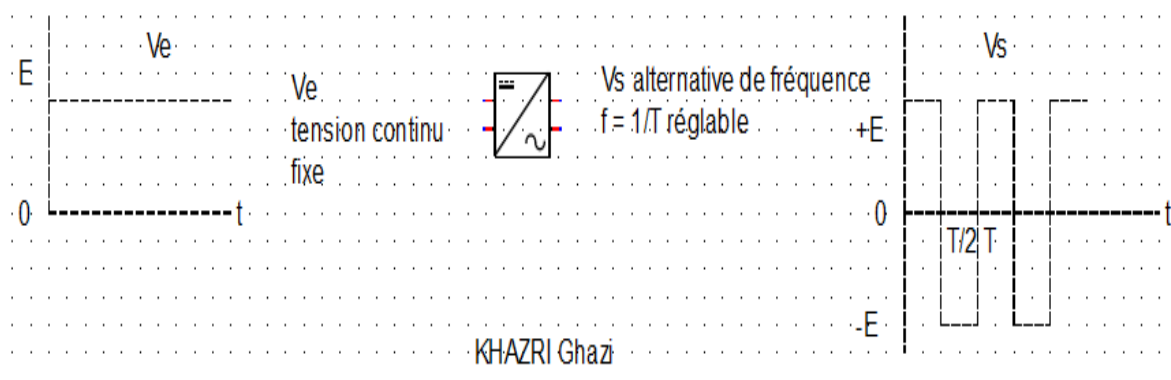
Figure 15 : Operating principle of the three-phase inverter

English schematic : energieplus-lesite.be/techniques/ascenseurs7/variateurs-de-vitesse/

2.3 Modeling of the three-phase inverter
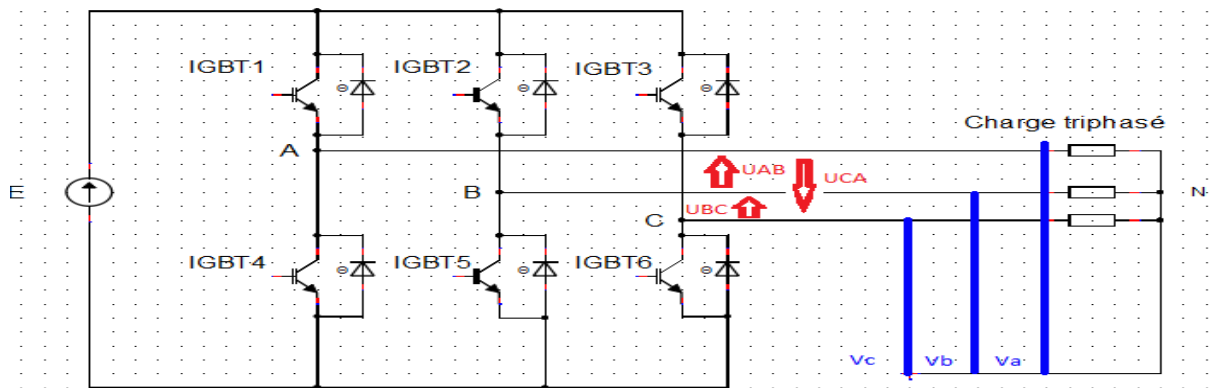
Figure 16 : Modeling of the three-phase inverter

English schematic : energieplus-lesite.be/techniques/ascenseurs7/variateurs-de-vitesse/

In the power circuit of the three-phase inverter in Figure 16, the IGBTs are controlled for a period corresponding to a third of the period.

1. Compound voltage:

The voltages v_{AN}, v_{BN}, v_{CN} measured between points A, B, C and the midpoint are then the voltages delivered by the single-phase inverters. We can then determine the shape of the compound voltages taking into account the following relationships:

$$u_{AB} = v_{AN} - v_{BN}$$

$$u_{BC} = v_{BN} - v_{CN}$$

$$u_{CA} = v_{CN} - v_{AN}$$

2. Single voltage:

On the level of the charge we can deduce from it the relations giving the expressions of the single voltages:

$$u_{AB} = v_a - v_b$$

$$u_{BC} = v_b - v_c$$

$$u_{CA} = v_c - v_a$$

By making member-to-member difference between the first and third relationships:

$$u_{AB} - u_{CA} = v_a - v_b - (v_c - v_a)$$

$$u_{AB} - u_{CA} = 2v_a - (v_b - v_c)$$

$$u_{AB} - u_{CA} = 3v_a$$

From where the expression of the first single voltage :

$$v_a = \frac{1}{3} \left(u_{AB} - u_{CA} \right)$$

By carrying out a circular permutation of the indices A, B, C, one establishes the expressions of the two other simple tensions:

$$v_b = \frac{1}{3} \left(u_{BC} - u_{AB} \right)$$

$$v_c = \frac{1}{3} \left(u_{CA} - u_{BC} \right)$$

2.4 The functions of the variable speed drive

1. **Starting:** the motor goes from zero speed to its established speed in a predefined time and avoiding the intensity points.

2. **Speed variation:** modification of the motor rotation frequency by acceleration or deceleration in a given time.

3. **Regulation:** the motor rotation frequency is kept constant whatever the load fluctuations (within certain limits).

4. **Braking:** the engine goes from an established speed to a lower speed (deceleration) or to zero speed (stop) with possible position retention.

5. **Reverse direction** (ie direction of rotation): allows the asynchronous machine to operate in both directions of rotation.

6. **Energy recovery:** when systems are slowed down or braked, they transform mechanical energy into electrical energy.

2.5 Advantages and disadvantages of the variable speed drive

1.   The advantages of the variable speed drive are:

- Soft motor start-up reducing voltage drops in the network and limiting starting currents.

- Increased precision of speed regulation.

- Energy saving: reduction in electricity consumption.

2.   The main drawbacks are:

- Network disturbance (harmonics): IGBTs form a non-linear charge which generates harmonic currents, sources of wave distortion (drop or disturbance of the voltage) in the electrical network.

- More complex wiring

- The high cost

2.6 Variable speed drive choosing factors

2.6.1 Technical factors

Among the main technical factors of choice are:

1. The nominal power and speed of the motor (200 kW - 3000 rpm)

2. The use regime (use in permanent mode)

3. The type of machine driven (inertia, characteristic of torque resistant according to speed).

4. Precision of torque and speed control.

5. The voltage of the three-phase supply network (400 V)

6. Installation constraints (available space, degrees of protection, etc.)

7. The operating domain in the power-speed plane (quadrant1).
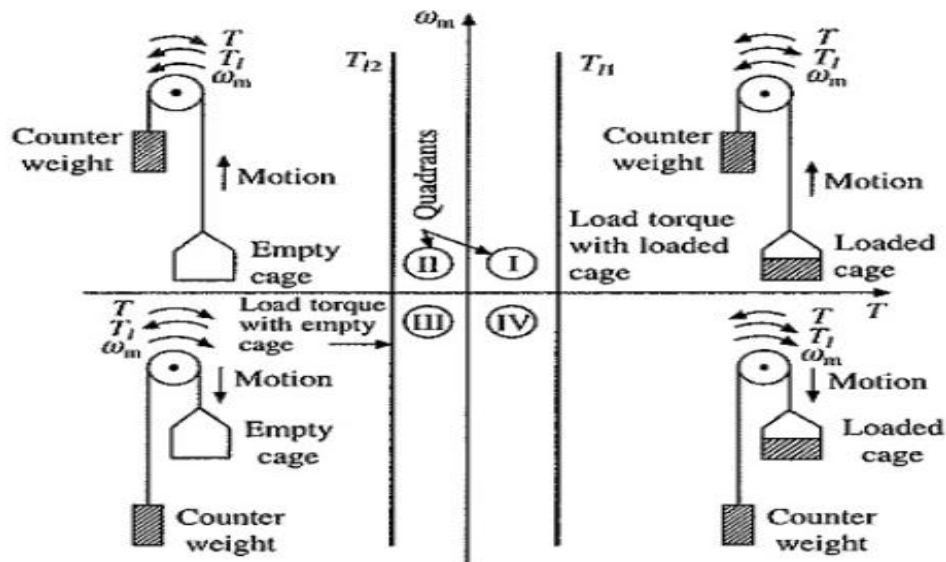
Figure 17 : Operating quadrant of the asynchronous machine

2.6.2 Economic factors

1.   An essential criterion is of course the total investment cost of the drive including the cost of the drive, the motor and their installation.

2.   The operating cost of the drive (maintenance, unavailability cost, energy losses) is an additional economic criterion of choice.

2.7 Choice of frequency drive [5]

The variator chosen is of the ABB industrial drive type (See appendix 6), this type includes frequency variators offering total adaptability to the needs of the factory. Covering a wide range of powers and voltages (up to 690 V). According to the technical factors studied in (2.6) and studies concerning the supplier catalog, the drive that will be chosen is from the ACS800-01 range.

2.7.1 Caractéristiques techniques générales

The ACS800-01 is a complete and compact variator in a wall mounting box covering powers up to 200 kW which is satisfactory for the chosen motor. (See annex 6)

1. Power / voltage: 0.55 to 200 kW, 230 to 690 V

2. 6 pulses box for wall mounting, protection IP21 as standard (UL type 1), IP55 optional (UL type 12)

3. Integrated network reactor for filtering harmonics

4. High performance and overload capacity in all applications

5. Reliable and complete drive

6. Commissioning assistant

7. Options delivered mounted in the drive

8. I / O extension modules

9. Network coupler modules

10. Encoder interface module and optical link module

11. RFI filter, brake chopper

12. Marine certified execution

2.7.2 IEC specific technical characteristics [7]

The range ASC800-01 contains several sizes of the variators, it is necessary to limit the interval of choice. (See annex 7)

The best size I will choose is ASC800-01-0255-5.

1. Nominal power 200 kW.

2. Three-phase supply voltage 380 V, 400 V, 415 V, 440 V, 460 V, 480 V.

3. Size R6

4. Air flow 405 m3 / h

5. Heat dissipation 4500 L

6. Nominal current: 290 A

2.7.3 Dimensions

The dimensions of drive ASC800-01-0255-5 of size R6 are: (see appendix 8)
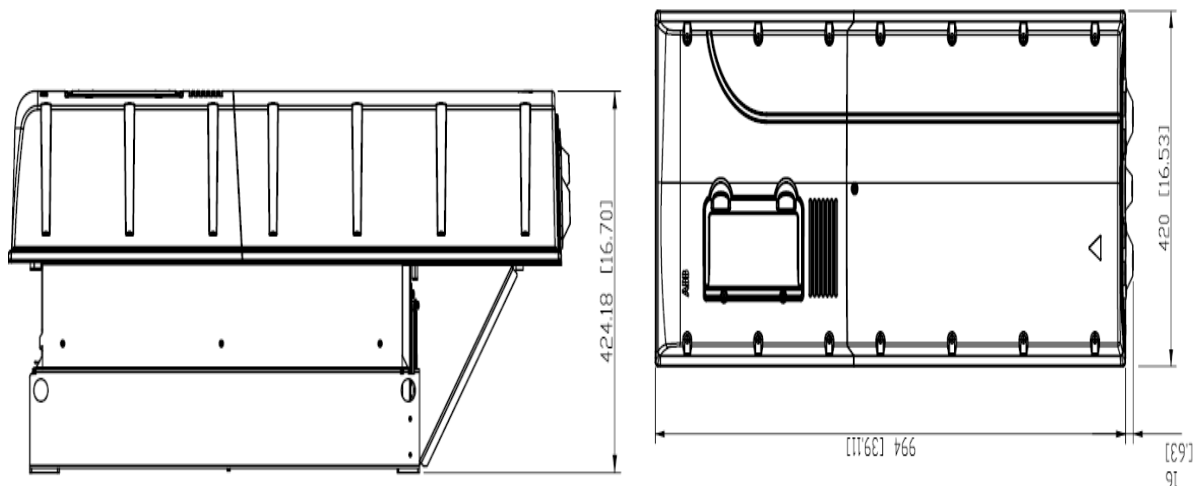
Figure 18 : Frequency drive dimensions

1. Overall height: 994 mm

2. Overall width: 424.18 mm

3. Depth: 399 mm

➔ The price of ASC800-01-0255-5 is: $ 100,000 USD ≈ 252,600 TND

2.7.4 Installation standards

The drive must be mounted in a vertical position, with the fan on the wall side. This fixing wall must be as vertical as possible, made of non-flammable material and strong enough to support the weight of the device, then check that the condition of the wall allows the mounting of the device. The surface (floor) under the appliance must also be made of non-flammable material.

During installation, the clearance distances recommended for good circulation of cooling air and to facilitate servicing and maintenance are to be observed below in millimeters.
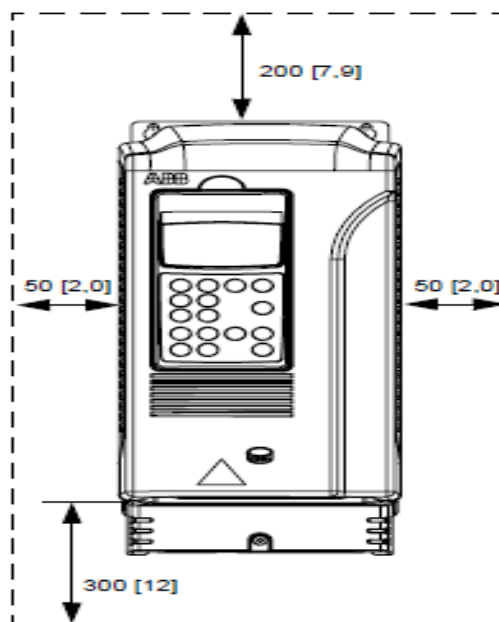
Figure 19 : Installation standards

3. CONCLUSION

This chapter, allowed me on the one hand to present the modeling of the asynchronous machine through a simple mathematical model, this led me to determine its type, its dimensioning. On the other hand to present the model of the drive, its operating principle, its type, its details, advantages, disadvantages and the installation standards.

The following chapter will be devoted to the simulation of the variable speed drive and its various commands.

CHAPTER III :

SIMULATION OF THE SPEED VARIATOR

INTRODUCTION

The objective of this chapter is to simulate the stages of the variable speed drive supplying the three-phase asynchronous motor using two commands: the full wave 180° and the PWM.

1. PRESENTATION OF THE "PSIM" SOFTWARE [8]

PSIM is simulation software for electrical engineering and power electronics. This software makes it possible to draw the schematics starting from the elements of the library (Machines, transformers, electronic switches, command and control elements). The measuring devices arranged on the assembly diagram define the curves representative of the electrical and mechanical quantities that can be obtained after simulation.

2. SYSTEM SIMULATION: SPEED VARIATOR WITH MOTOR

The rotor speed of an asynchronous machine is adjusted by acting on the stator frequency and voltage (or current). Consequently, to provide the means for this action, it is necessary to have a power source capable of delivering an amplitude and frequency voltage adjustable in instantaneous value.

The following figure shows the structure of a variable speed drive implementing an asynchronous machine powered by a voltage inverter:
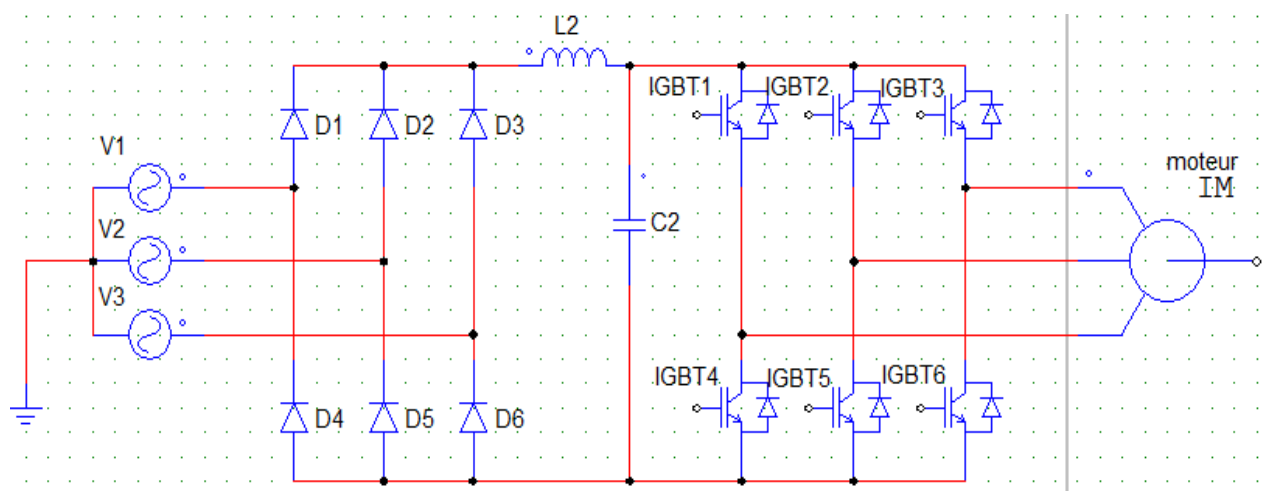
Figure 20 : Variable speed drive of the three-phase asynchronous motor

The activation orders of the six semiconductor switches of the inverter are generated by a control system. The feeding system is made up of:

- Of a rectifier

- A filter

- An inverter

2.1 Variable speed power supply network

The variable speed drive is supplied by a balanced three-phase voltage system. This system has an amplitude equal to 230 x √2 and a frequency equal to 50 Hz.
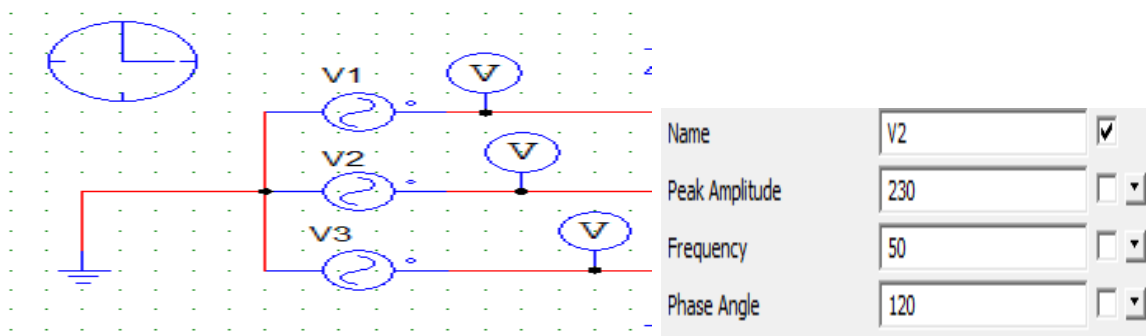
Figure 21 : Balanced three-phase network

1.   V1 = Vm sin (ωt)
2.   V2 = Vm sin (ωt - $\frac{4\pi}{3}$)
3.   V3 = Vm sin (ωt - $\frac{2\pi}{3}$)

I obtain the curves of the signals of the voltages V1, V2 and V3 in the figure below:
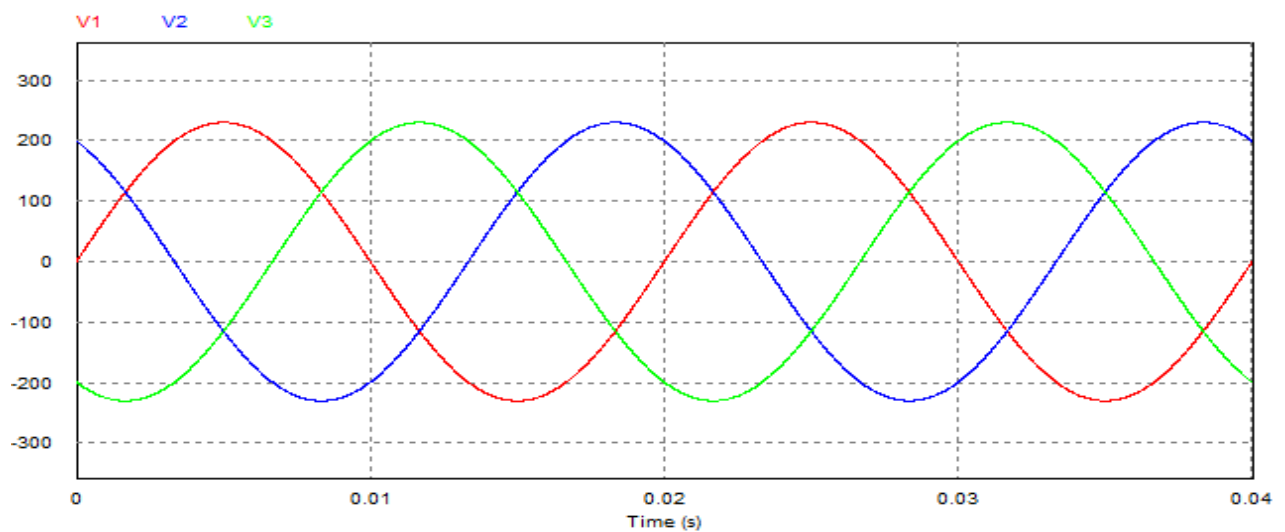
Figure 22 : The signals of the voltages V1, V2, V3

2.2 The rectifier stage

This stage consists of a PD3 all diodes, allows the conversion of the alternating voltage into DC "AC / DC" as it is presented in the following figure:
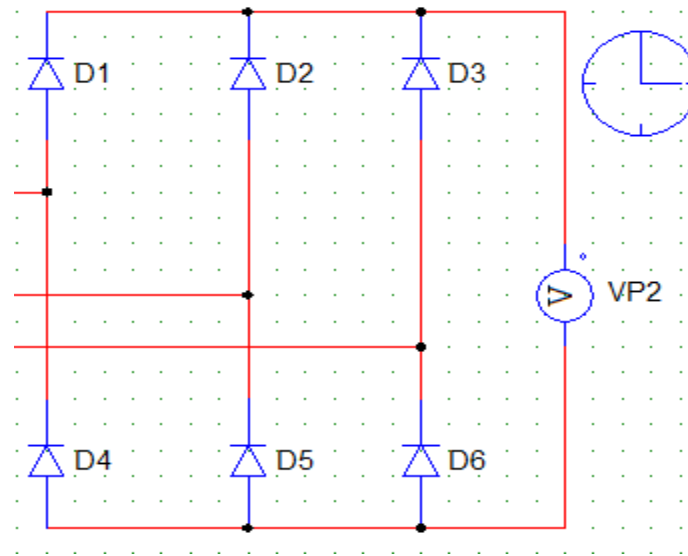
Figure 23 : The rectifier

À la sortie du redresseur, la visualisation de la tension est simulée dans la figure suivante :
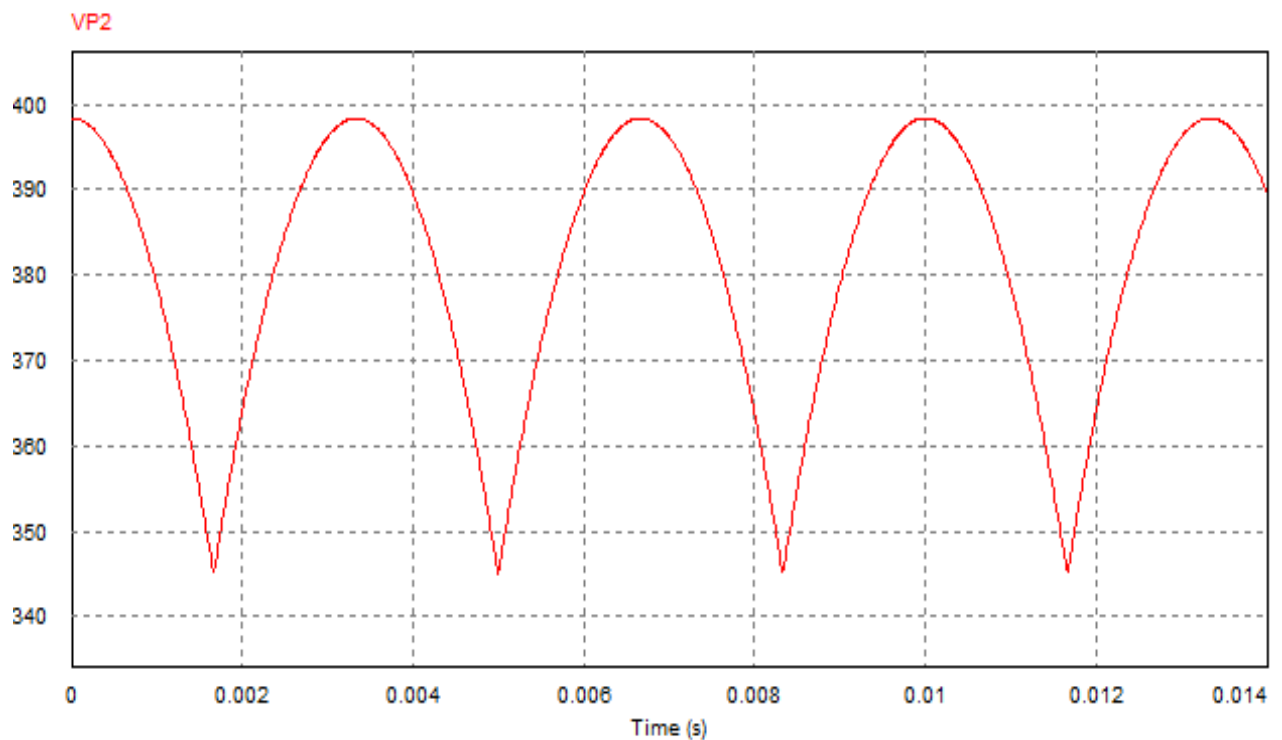
Figure 24 : Response of rectified voltage

The rectified voltage is rippled, which requires a filtering operation.

2.3 The filtering stage

At the output of the rectifier, a second-order LC type filter whose role is to reduce the harmonic terms produced by the switching of the inverter and to filter the disturbances from the catenary, and also to filter the output voltage of the bridge rectifier.
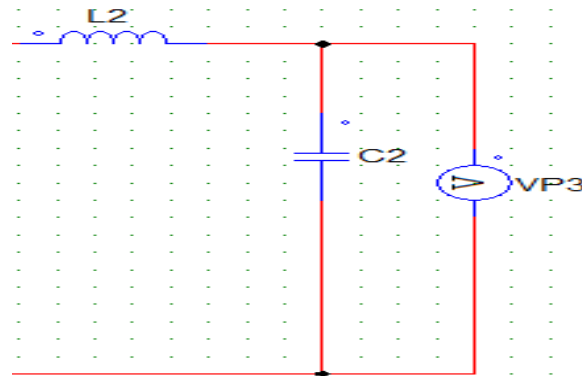
Figure 25 : LC type filter

La visualisation de la tension de sortie est simulée dans la figure suivante :
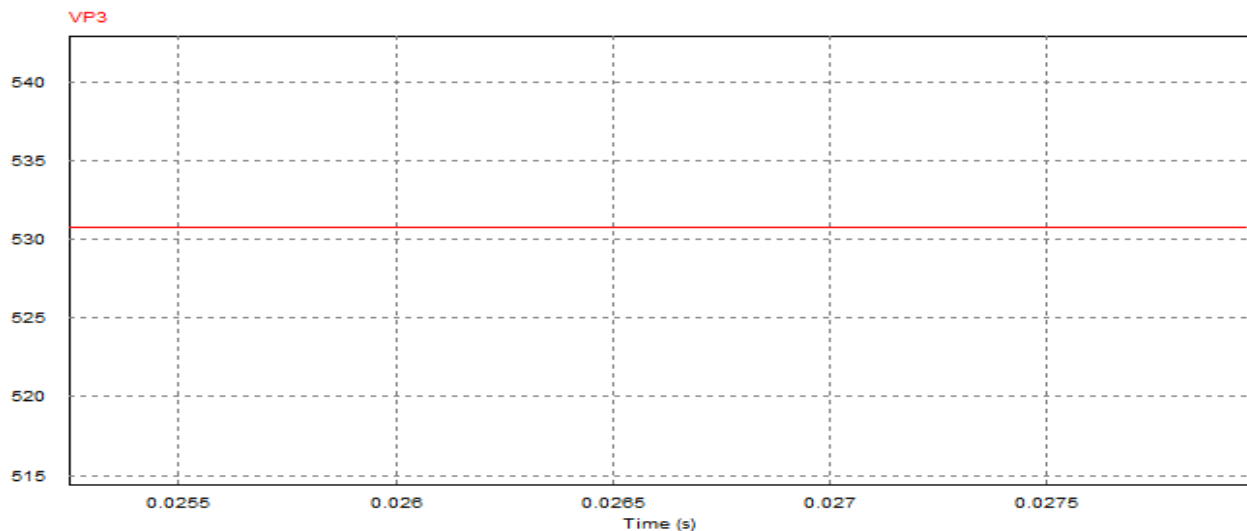
Figure 26 : Simulation of the filtered voltage

2.4 The inverter stage

The voltage inverter converts a DC voltage into three-phase AC voltage. It imposes a certain form of voltage on the machine whatever the current absorbed, and works in forced switching. Adequate control applied to the inverter which allows it to adjust the frequency and amplitude of the output quantities.

Several types of controls differ in the ways of developing the control sequence of the switches, and of adjusting the frequency of the voltage at the output of the inverter to supply the asynchronous machine. In what follows, two control techniques are considered: full wave (180 °) and PWM.

2.4.1 Full wave control (180˚)

Full-wave control is a classic control often used for controlling inverters.

1.   Presentation of the study system

Figure 27 gives the basic schematic in PSIM of the study system. The latter is a variable speed drive supplying the motor. This figure also shows the full wave control stage of the inverter. IGBT type power switches lead so that:

- At all times three switches are in conduction state, and the others are blocked.

- Two switches in the same arm must be controlled in a complementary manner so as not to short-circuit the voltage source, hence the role of interface stage.
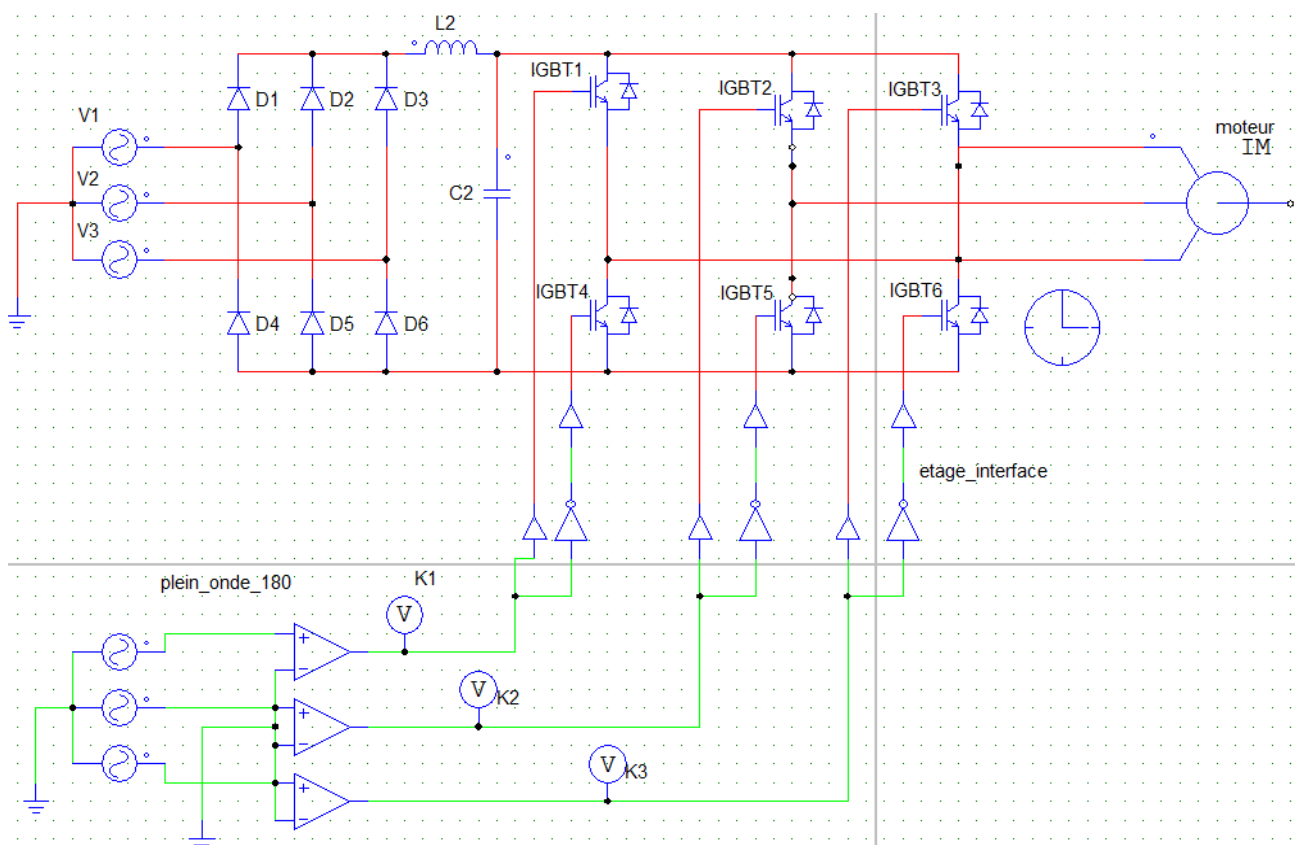
Figure 27 : Basic schematic of the motor controlled at full wave

In full wave control (180˚) the switches controlled for a duration corresponding to a half-period, each transistor conducts for 180˚.

To illustrate this operation, I compare a three-phase voltage system balanced to ground (0V), then at the output of the comparators, I find 3 control signals $K1$, $K2$ and, $K3$ so that two transistors in one same arms are primed at 180˚ offset. The transistors of the neighboring arm are primed at 120 ° offset. This control strategy is shown in Figure 28 over two periods.
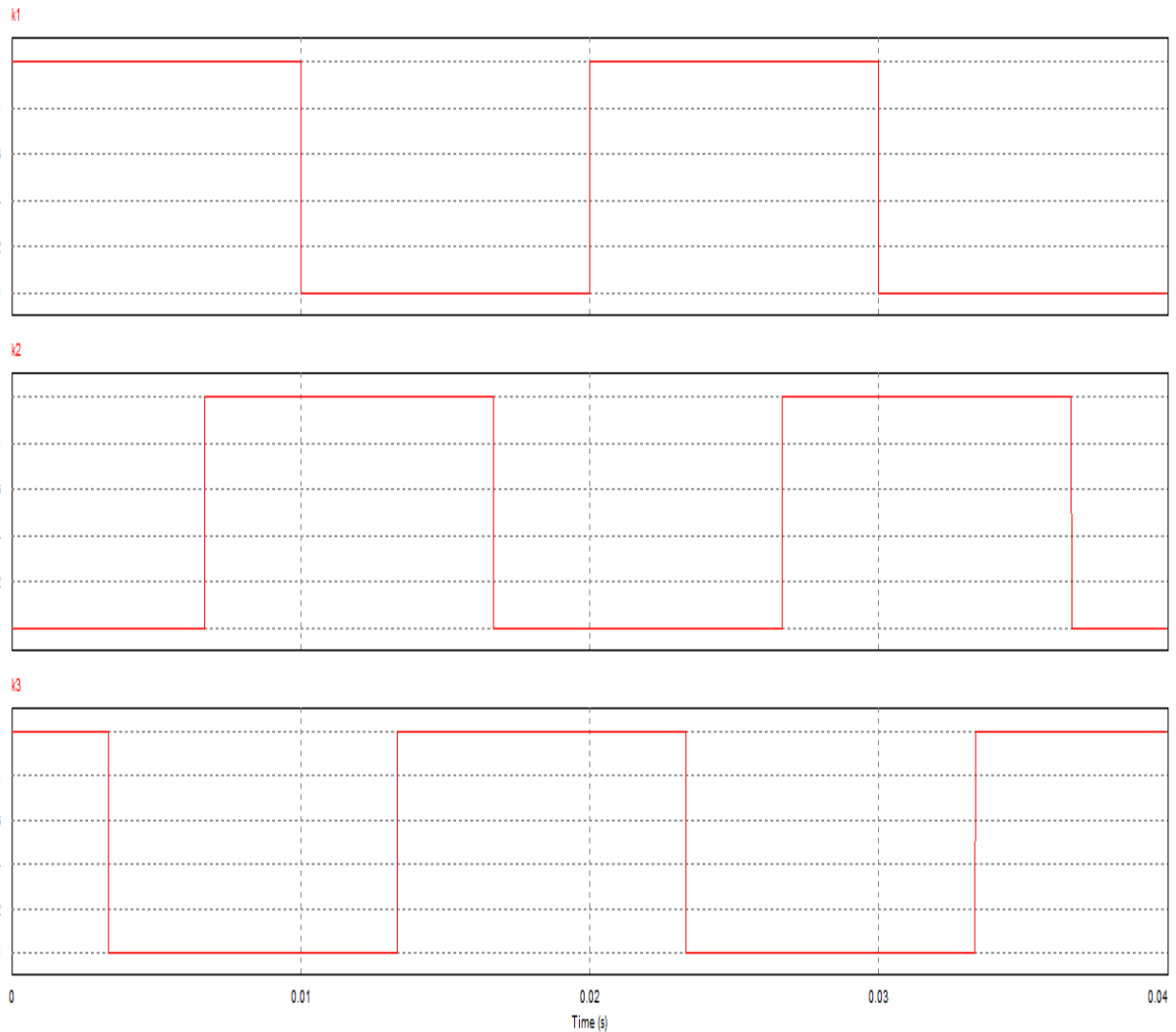
Figure 28 : Control signals k1, k2, k3

2.   Forms of compound voltages

In a second step, I note the waveforms of the compound voltages $U12$, $U23$ and $U31$ as a function of the control signals $K1$, $K2$ and $K3$. I connect voltmeters between the phases to measure $U12$, $U23$ and $U31$ (see figure 29).
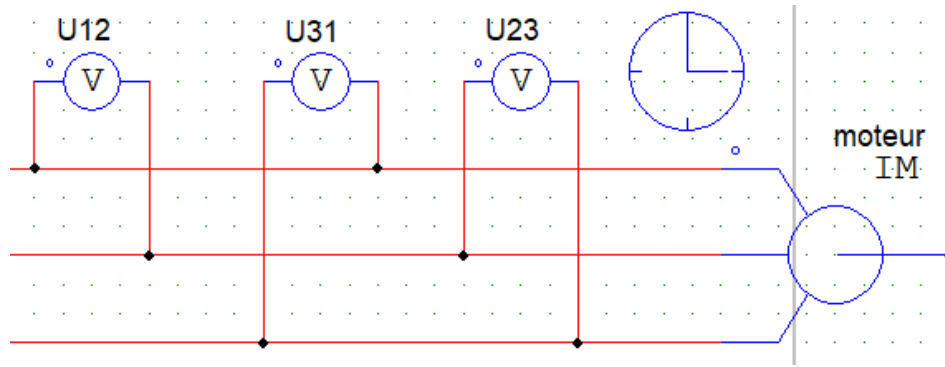
Figure 29 : Connection of voltmeters between phases
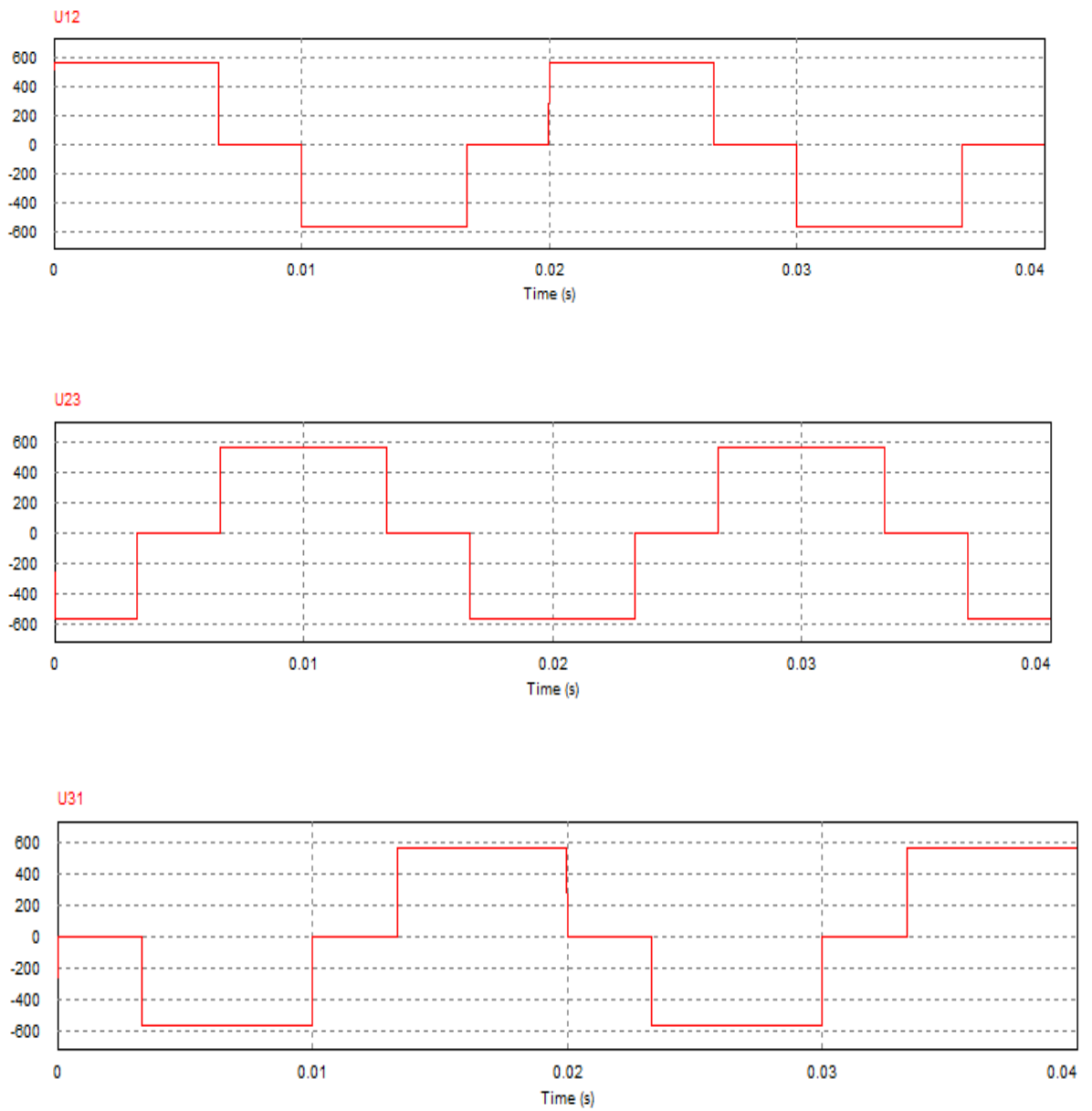
Figure 30 : Compound voltages U12, U23, U31

Figure 30 shows the waveforms of the compound terms, the voltages obtained are not sinusoidal, they have a rectangular shape full of harmonics varying between $+Vdc$, 0, $-Vdc$. It is therefore advisable to use a filter to extract its fundamental having the same frequency.

The following table is obtained from the stages of the compound voltages U12, U23 and U31 and the control signals $K1$, $K2$ and, $K3$.

K1	K2	K3	U12	U23	U31
0	0	0	0	0	0
0	0	1	0	$-Vdc$	$+Vdc$
0	1	0	$-Vdc$	$+Vdc$	0
0	1	1	$-Vdc$	0	$+Vdc$
1	0	0	$+Vdc$	0	$-Vdc$
1	0	1	$+Vdc$	$-Vdc$	0
1	1	0	0	$+Vdc$	$-Vdc$
1	1	1	0	0	0

Tableau 2 : Compound voltages and control signals

3.   Forms of simple voltages

To simulate the simple voltages V1n, V2n and V3n, I will place the voices by each phase.
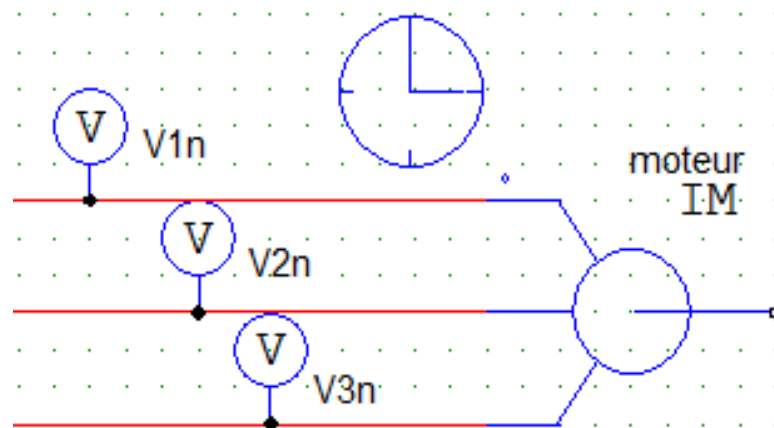
Figure 31 : Voltmeter connections on phases

Figure 32 shows the simulation of single voltages. On these chronograms I see that the three simple tensions have a shape in steps of amplitude $2/3 * Vdc$ and of period T equal to those of the compound tensions. The phase shift angle that they present between them is equal to 120 °.
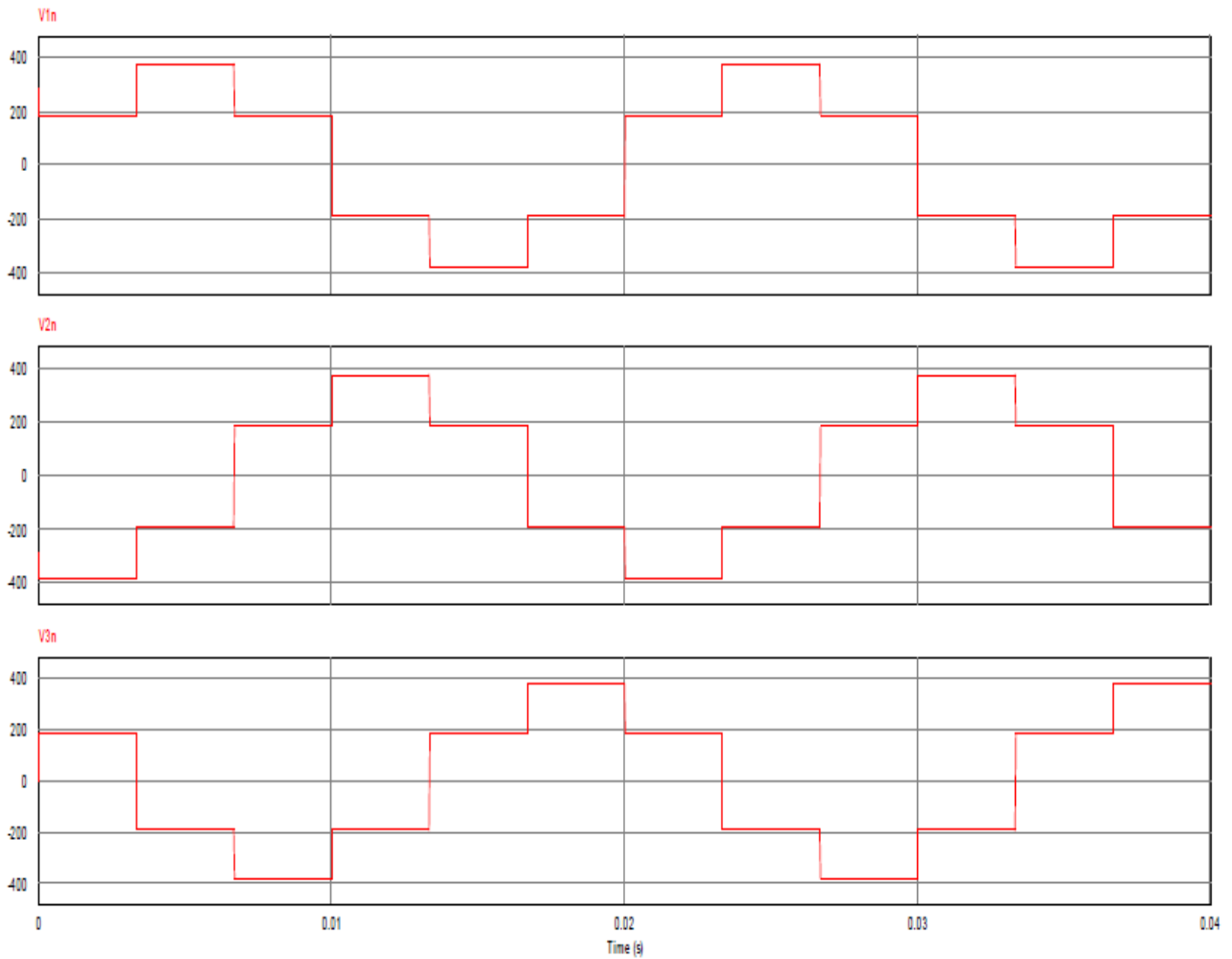
Figure 32 : Simple voltages V1n, V2n, V3n

I note from the appearance of single and compound voltages that a three-phase inverter controlled by a 180 ° control allows frequency adjustment of the simple and compound voltages, but the adjustment of the effective values cannot be achieved.

The forms of the stator currents $i1$, $i2$ and $i3$ are presented in figure 34.
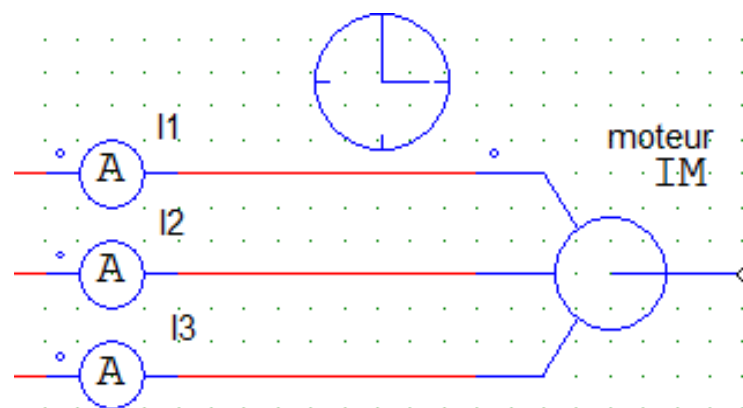
Figure 33 : Connection of ammeters
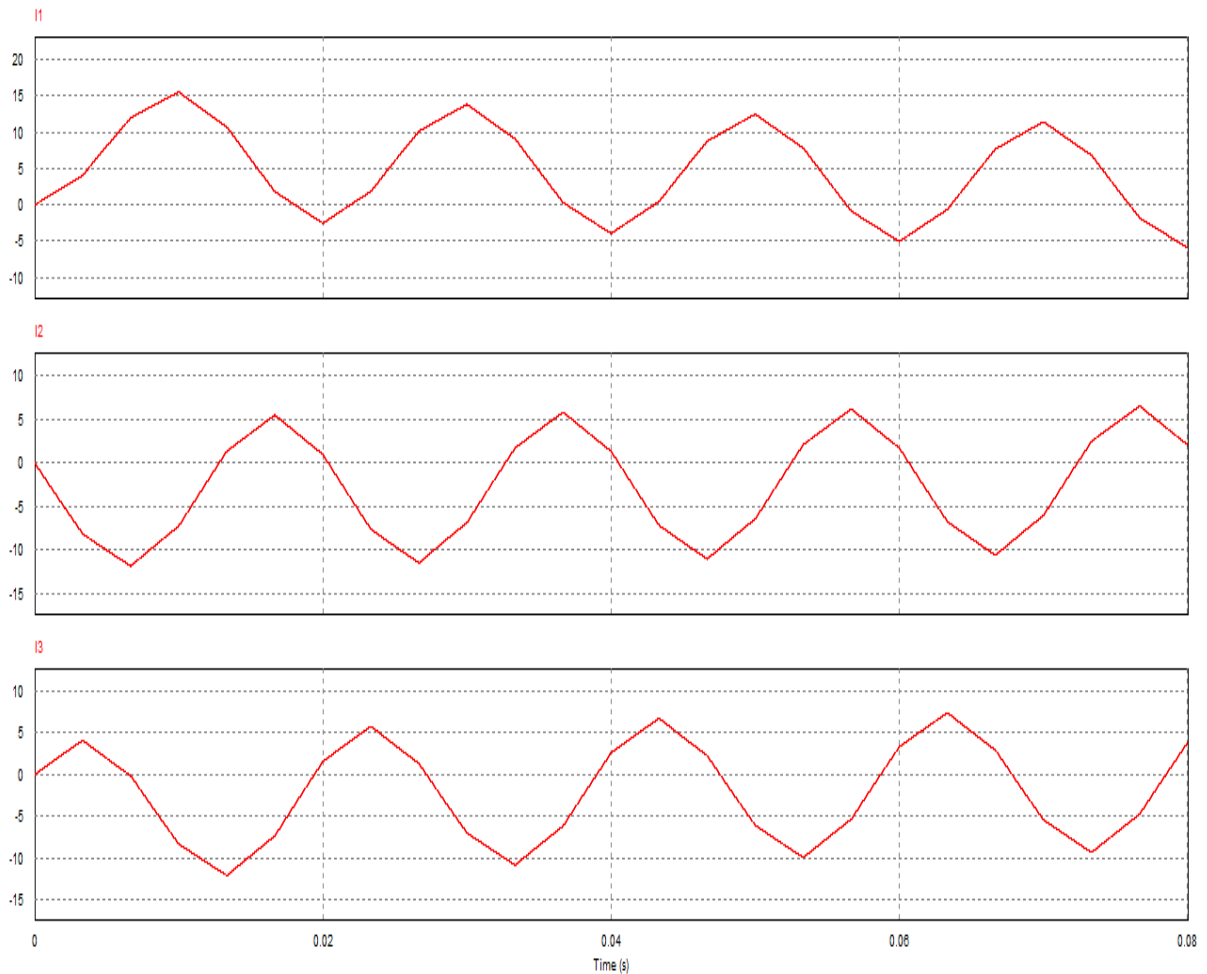
Figure 34 :Forms of current I1, I2, I3

The waveform of stator currents is not sinusoidal, it has harmonics. The filtering operation is not easy enough for this type of structure: the harmonics are not pushed back enough from the fundamental term. This requires the use of high-order filters, which is not easy to implement. This is why I use another technique which is PWM pulse width modulation.

2.4.2 PWM control of an asynchronous machine

The PWM strategy allows the machine to impose waves of voltages of varying amplitudes and frequencies from the standard network. The most common PWM command is called sine-triangle. This technique is based on the comparison of a high frequency signal called carrier with a low reference signal (see Figure 35), the image of the desired voltage at the output of the converter while eliminating harmonics.
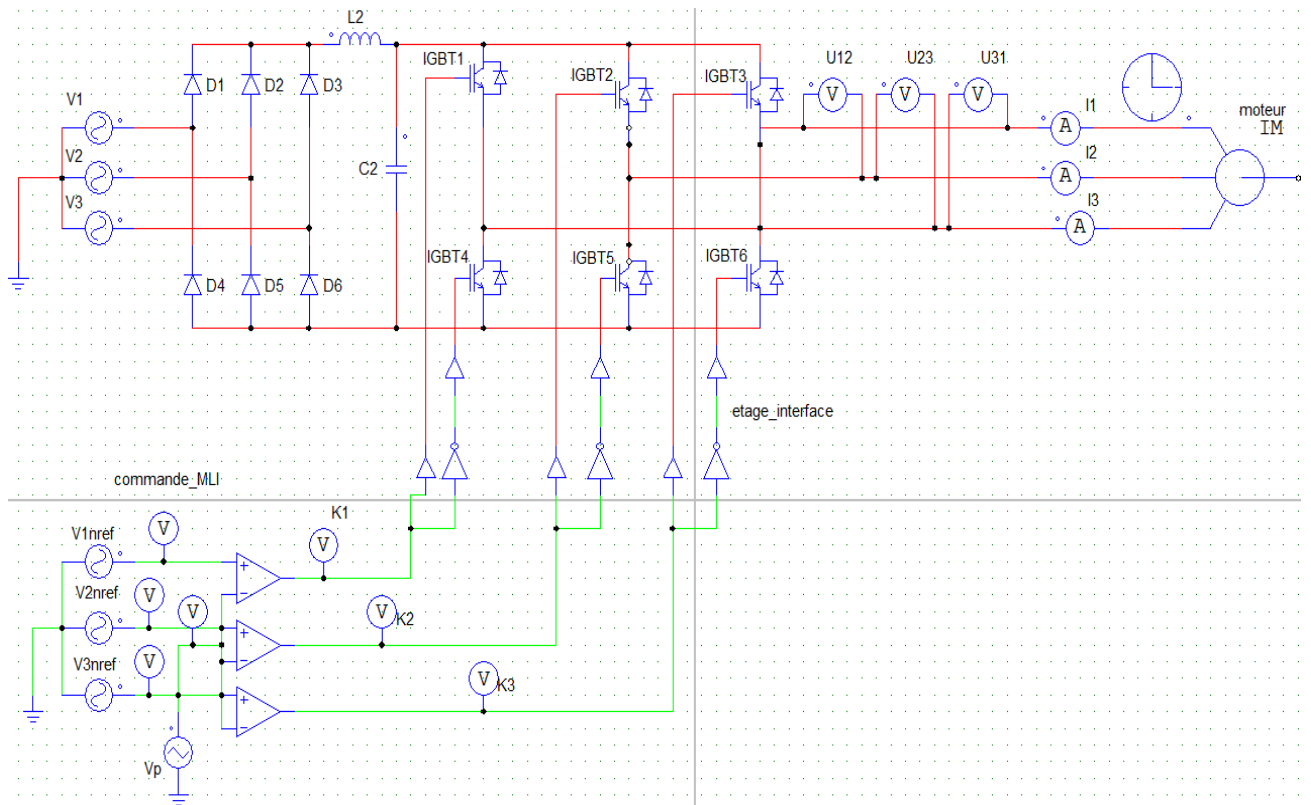
Figure 35 : Basic schematic of the engine with PWM control
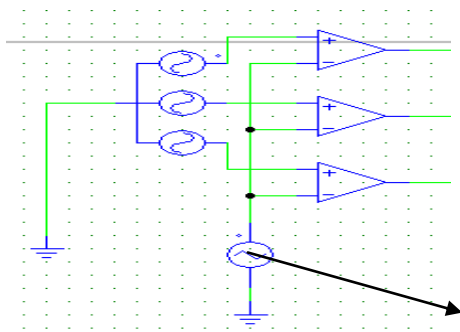
Figure 36 : High frequency triangular carrier

The carrier signal is shown in Figure 37 while the reference voltages are shown in Figure 38.
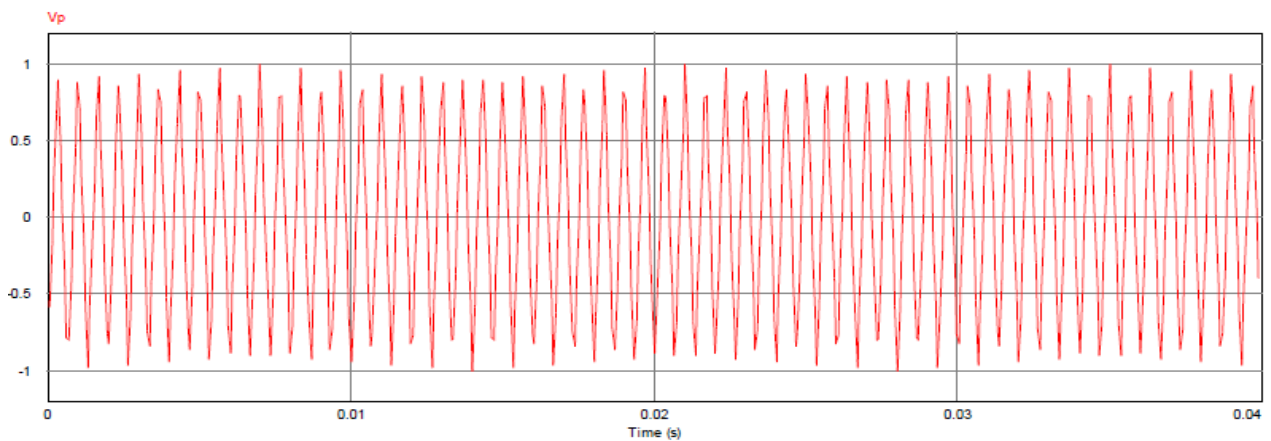
Figure 37 : Carrier simulation

The paces of the voltages $V1nréf$, $V2nréf$ and $V3nréf$ of references called modulating phase shifted $\dfrac{2\pi}{3}$ at the same frequency f are given in the following figure.
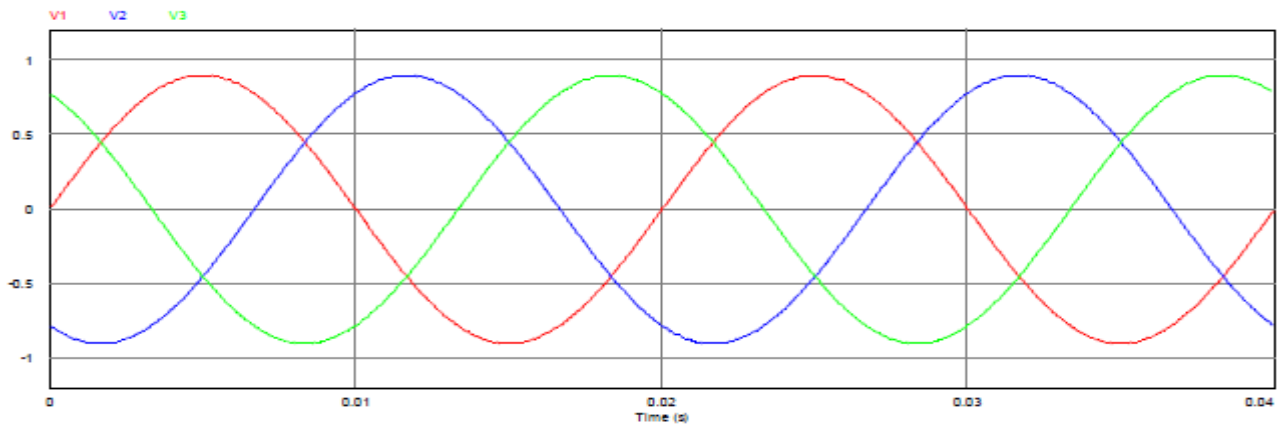
Figure 38 : Simulation of V1nref, V2nref and V3nref voltages

The principle of PWM sine-triangle over a single period is illustrated in Figure 39. The intersections between the reference voltage and the carrier give the opening and closing times of the switches. It is a question of comparing the reference (in blue) to the triangular carrier (in red). The output signal of the switch K1 is worth 1 if the modulator is larger than the carrier, 0 otherwise; the output signal therefore changes state at each intersection of the modulator and the carrier. The patterns of the other control signals K2 and K3 are in Figure 40.
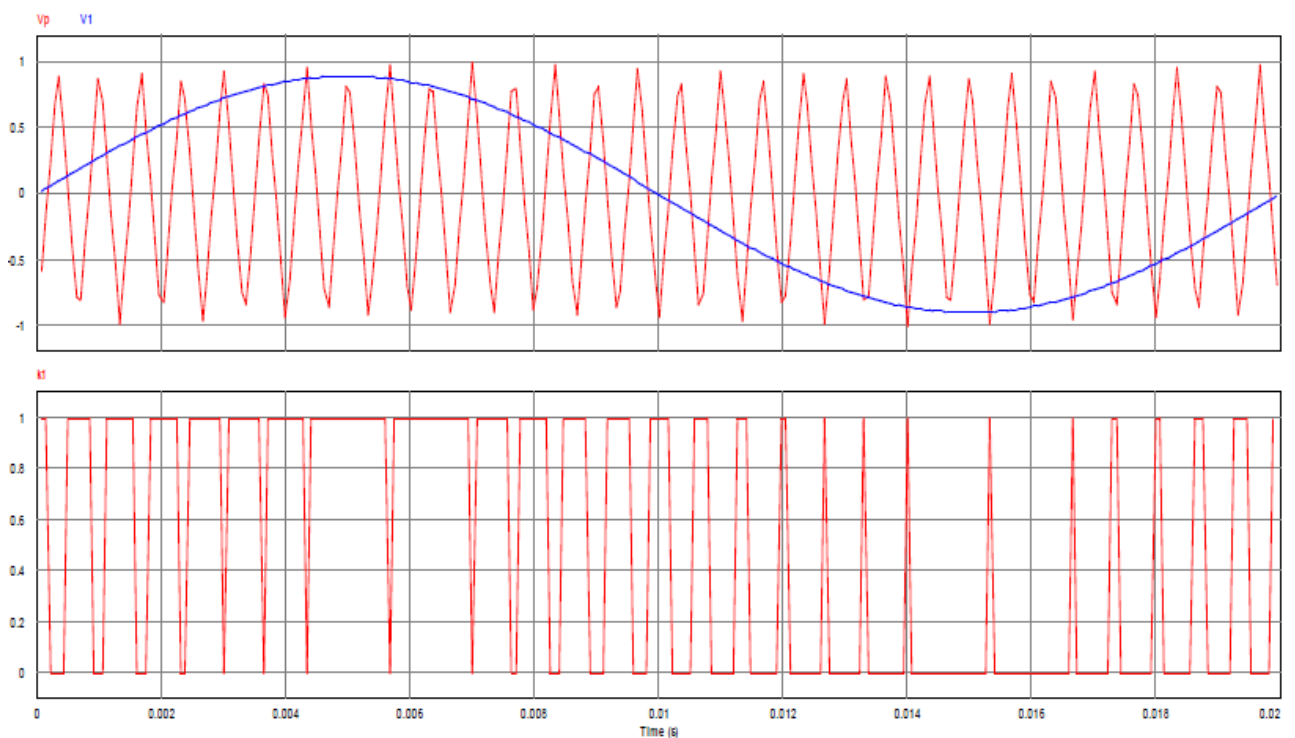
Figure 39 : MLI principle with sawtooth support
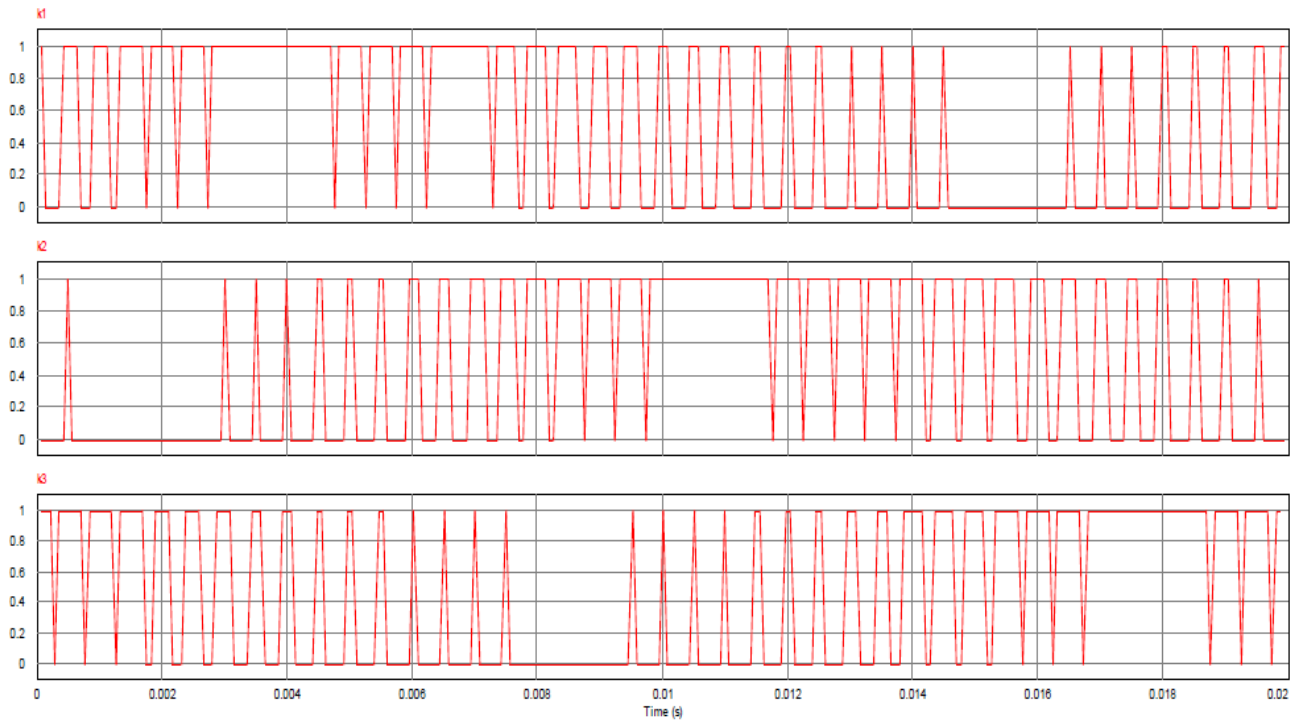
Figure 40 : The control signals k1, k2 and k3

The simulation of the compound voltages *U*31, U23 and *U*12 are shown in figure 41. The simple

voltages V1n, V2n and V3n are shown in figure 42.
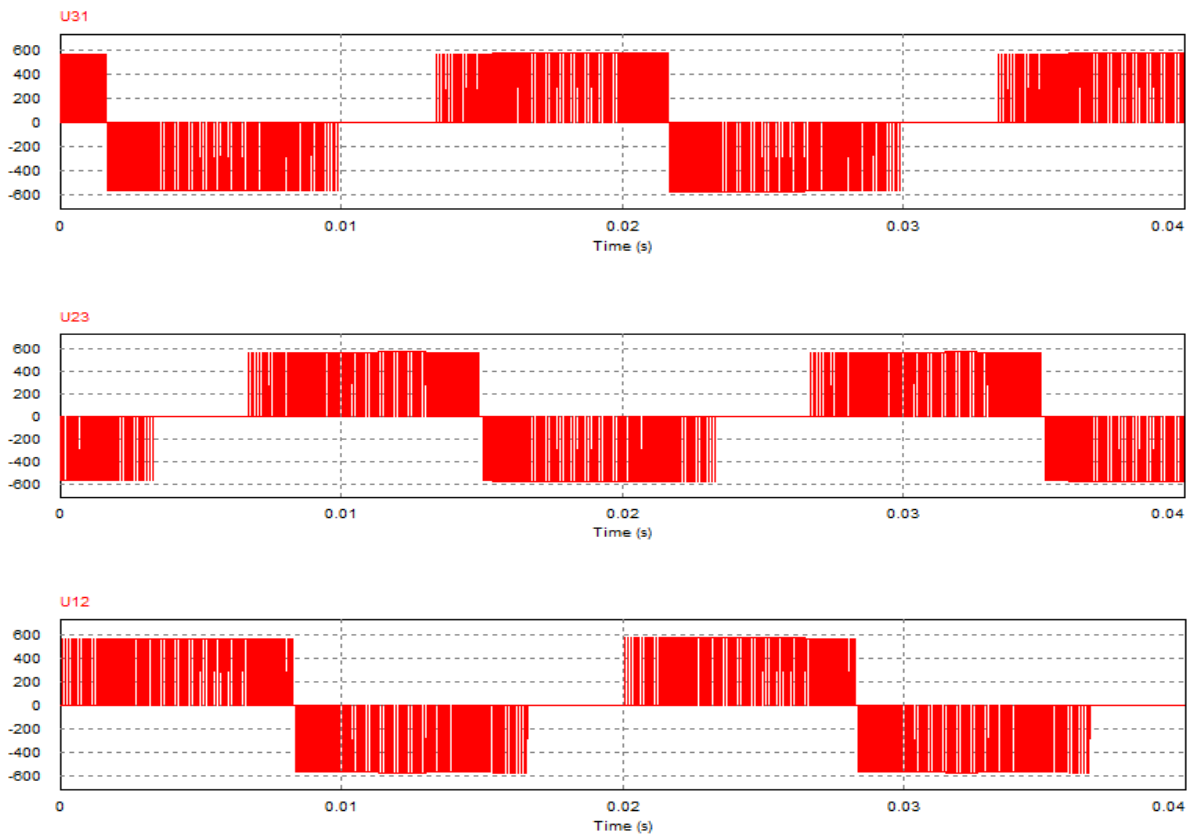
Figure 41 : Compound voltages
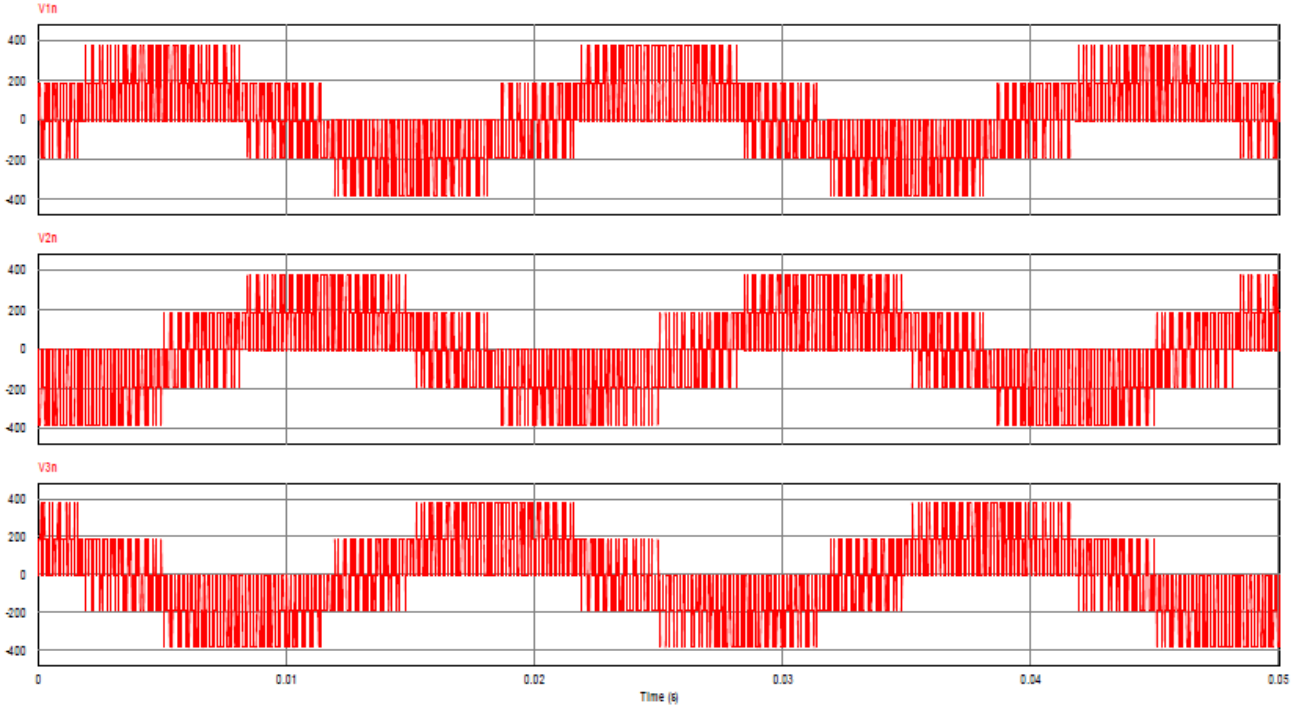
Figure 42 : Simple voltages

The forms of the stator currents *i*1, *i*2 and *i*3 are presented in figure 43.
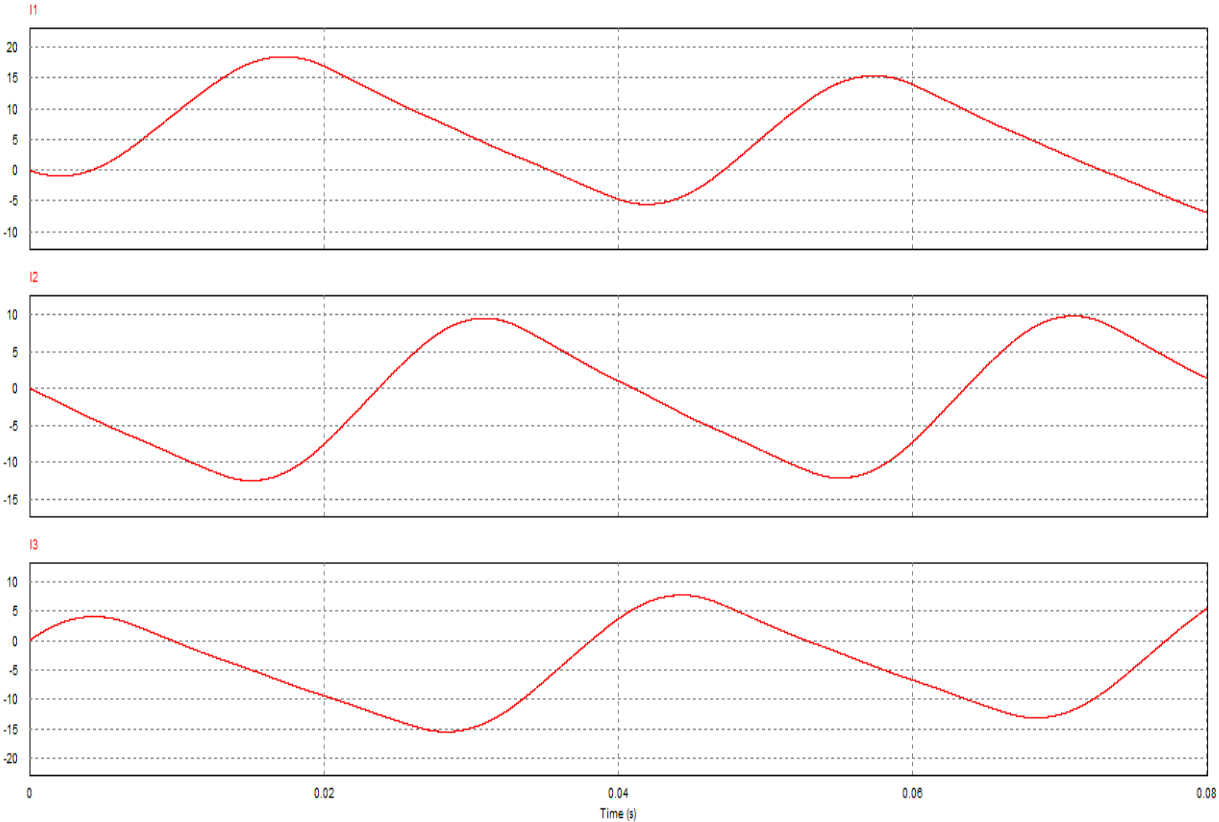
Figure 43 : Current signals i1, i2 and i3

Simulation results show that powering the motor through a PWM inverter reduces ripples and harmonics. So it is clear that the performance of the PWM is significantly better than the full wave command. Indeed, the PWM inverter not only adjusts the frequency but also the amplitude of the stator voltage of the motor. Then, to eliminate the harmonics generated by the full wave command, it will be necessary to use low pass filters, ie filters of high order this is only possible with the PWM command.

3. CONCLUSION

In this chapter, I have presented the simulation of the variable speed drive blocks in the PSIM environment. Then, using simulation, I made a comparison between the PWM triangular sine command and the 180 ° full wave. The results show the advantage of the PWM command over the other.

For more performance of the MLI technique, this command will be implemented for the speed variation in the next practical implementation chapter.

CHAPTER IV :

REALIZATION OF A SPEED VARIATOR BASED ON INVERTER CONTROLLED BY ARDUINO

INTRODUCTION

The objective of this chapter is to create a speed variator based on a PWM inverter for a three-phase asynchronous motor controlled by arduino.

1. GENERALITIES ON ARDUINO CARDS [9]

1.1 Presentation

Arduino is a card that contains everything necessary for the operation of the microcontroller, to be able to use and launch it, simply connect it to a computer using a USB cable. She can take advantage of the resources available and find the answers to her questions. This technology is used in many applications such as industrial electronics. This card has:

54 digital input / output pins (14 of which can be used as PWM outputs)

1. 16 analog inputs (which can also be used as digital input / output pins)

2. 4 UART (hardware serial port),

3. 16Mhz quartz

4. USB connection

5. Jack power connector

6. ICSP connector ("in-circuit" programming)

7. Reset button.
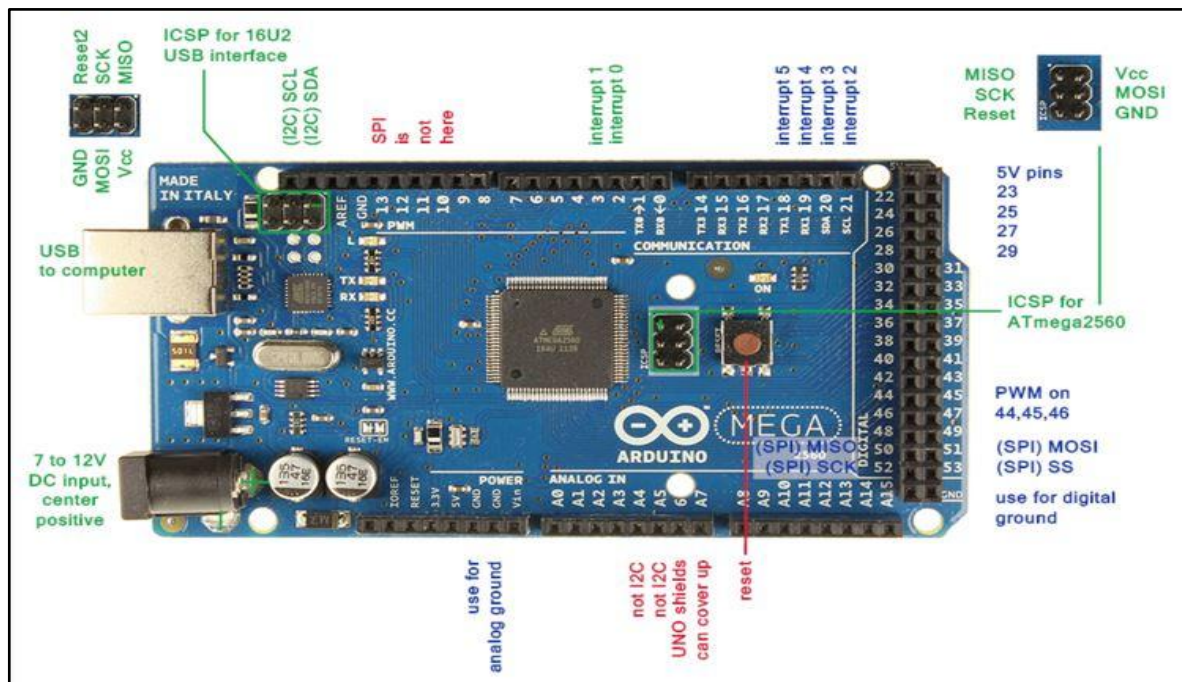
Figure 44 : Arduino card

1.2 Technical specifications

1. Microcontroller: ATmega2560

2. Operating voltage: 5 V

3. Input voltage range (recommended): 7-12 V

4. Range of input voltages (limit): 6-20 V

5. Digital pins I / O: 54

6. Digital pins I / O PWM: 14

7. Analog input pins: 16

8. Direct current by I / O pin: 40 mA

9. Direct current for 3.3 V pins: 50 mA

10. Flash memory: 256 KB

11. Bootloader Flash memory: 8 KB

12. SRAM: 8 KB

13. EEPROM: 4 KB

14. Clock frequency of the crystal oscillator: 16 MHz

15. Dimensions: 101.52 x 53.3 mm

16. Weight: 37 g

1.3 Power supply

Arduino Mega 2560 can be powered either via the USB connection which provides 5V or using an external 6 to 20 volt power supply. However, if the card is powered with less than 7V, the 5V pin could supply less than 5V and the card could be unstable. If more than 12V is used, the card's voltage regulator could heat up and damage the card. Also, the ideal range recommended to power the card is between 7V and 12V.

The power pins are as follows:

1. VIN. The positive input voltage when the Arduino board is used with a source of external voltage (to be distinguished from the 5V of the USB connection or other regulated 5V source).

2. 5V. The regulated voltage obtained using a regulator used to operate the microcontroller and other board components. This voltage supplied by this pin can come either from the supply voltage VIN via the regulator, or from the connection USB (which provides regulated 5V).

3. GND. Ground pin (0V).

1.4 Memory

ATmega 2560 at 256KB of FLASH memory to store the program (including 8KB also used by the bootloader). It also has 8 KB of SRAM (volatile) memory and 4K of EEPROM (non-volatile). The bootloader is a program preprogrammed once and for all in the ATmega and which allows communication between the ATmega and the Arduino software via the USB port, in particular during each programming of the card.

1.5 Digital pins

Each of the 54 digital pins of the Mega card can be used either as a digital input or output. These pins operate in 5V and each pin can supply or receive a maximum of 40mA of intensity

1. Pins 0 to 13: PWM pulse (modulated pulse width) which provides an 8-bit PWM pulse.

1.6 Analog inputs

The card has 16 inputs marked from A0 to A15, which can accept any analog voltage between 0 and 5 V. But the voltage must never exceed 5 Volts, otherwise the microcontroller will be destroyed. To measure voltages greater than 5 Volts, the input must be equipped with a divider bridge.

2. PROTEUS PROGRAM SIMULATION

2.1 Arduino program organization chart
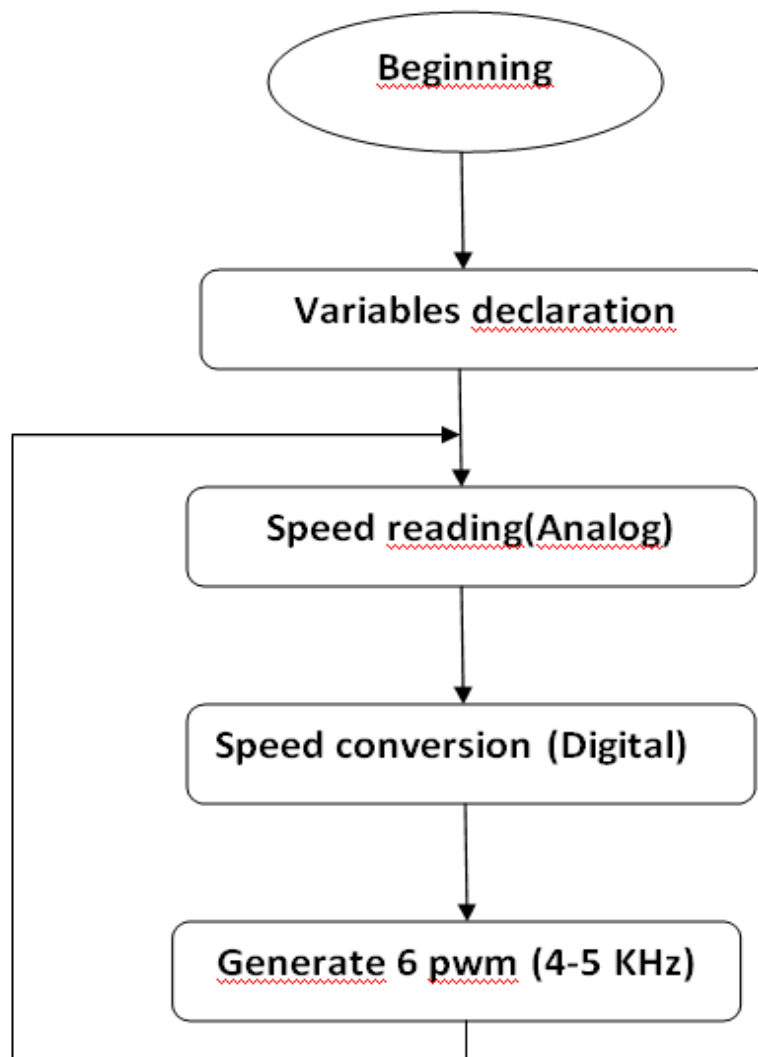
Figure 45: Arduino program organization chart

2.2 Simulation schematic

The simulation schematic is made up of the Arduino Mega board, a 1K potentiometer to vary the frequency of the 6 PWMs, six optocouplers and two oscilloscopes to visualize the signals. For the program of the card see annex 9.
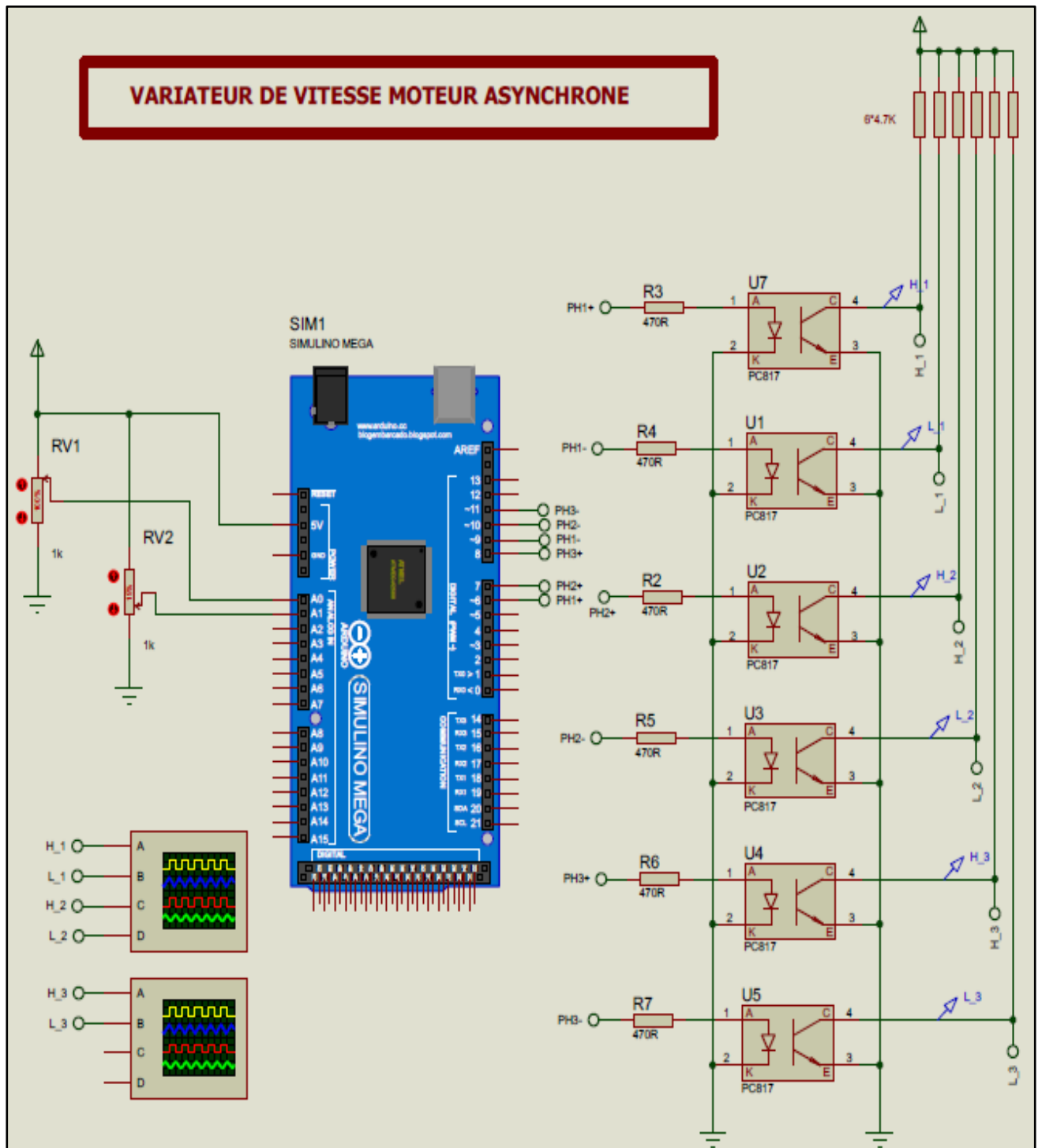
Figure 46 PROTEUS program simulation schematic

2.3 Simulation results

2.3.1 Maximum speed
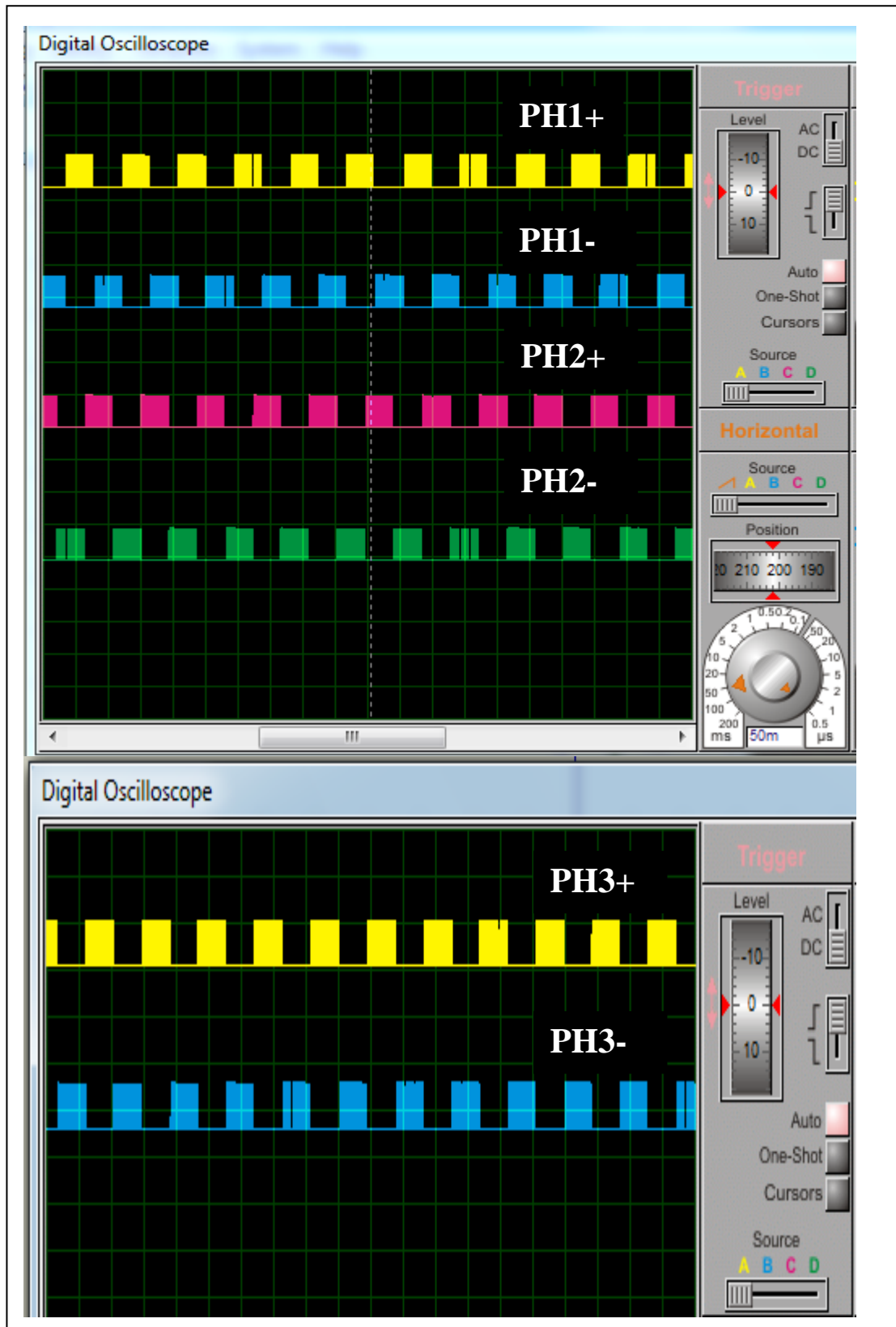
Figure 47 : The 6 PWM with Maximum speed

2.3.2 Average speed
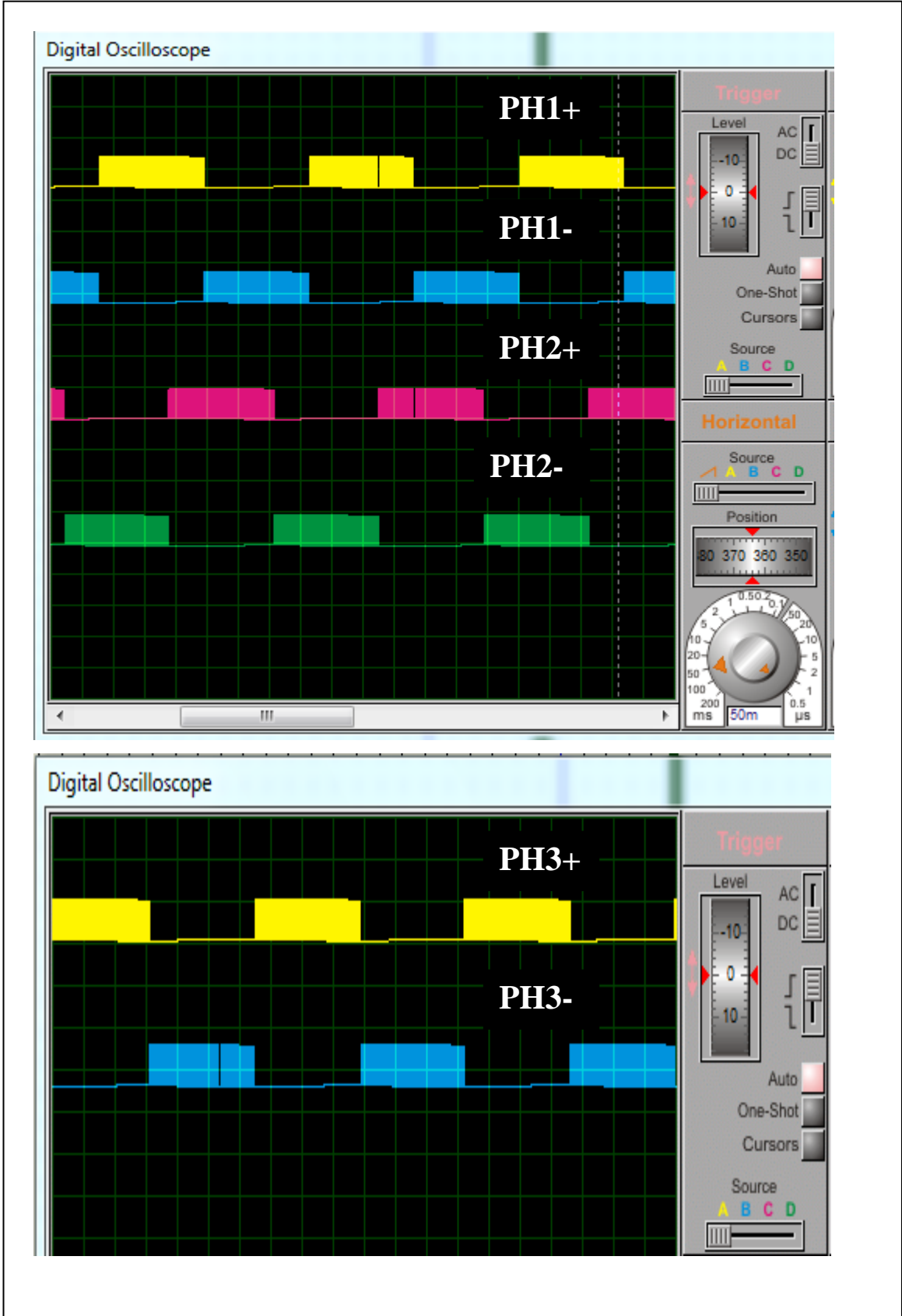
Figure 48 : The 6 PWM with Average speed

2.3.3 Minimum speed
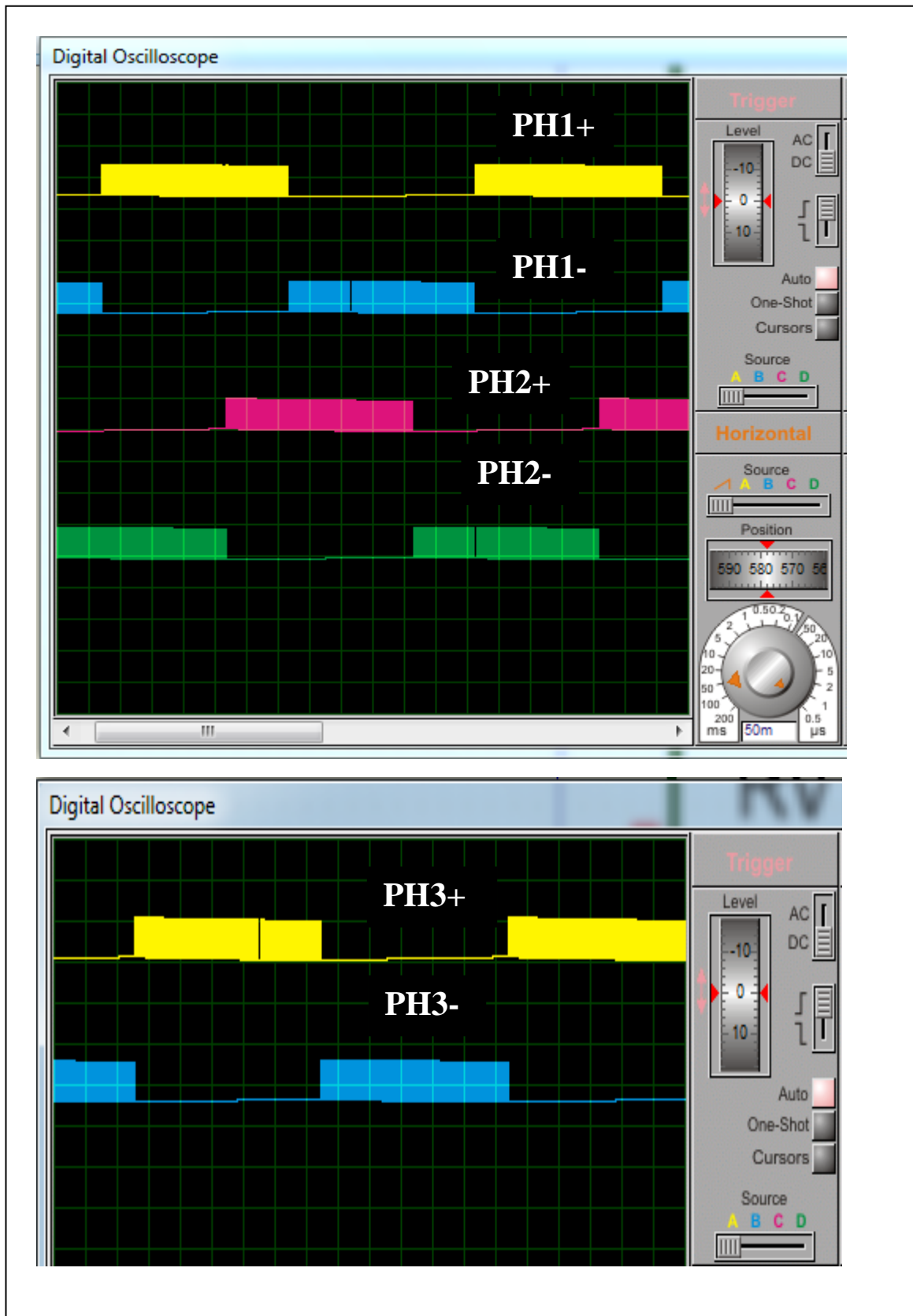
Figure 49 : The 6 PWM with minimum speed

3. DESIGN AND PRACTICAL REALIZATION

Below the synoptic schematic of the project:
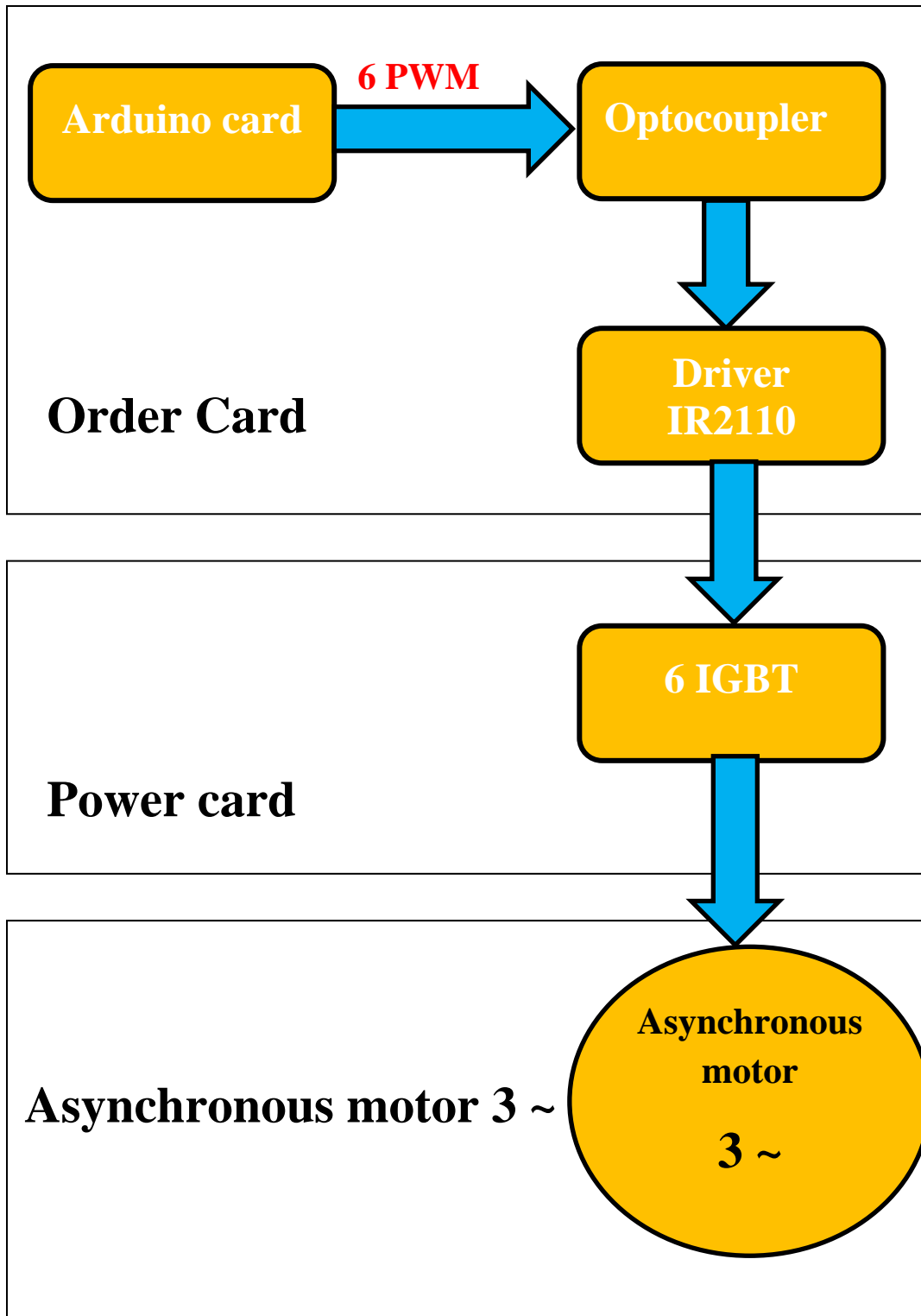
Figure 50 : Synoptic schematic

3.1 Choice of electronic components

The first calculation is the nominal current delivered by the inverter. Consider that the charge is a three-phase 230 / 400V asynchronous motor. I took the motor from my institute laboratories to do my experiment to test the drive, with a power factor of 0.83 and a useful power of 0.33 kW.
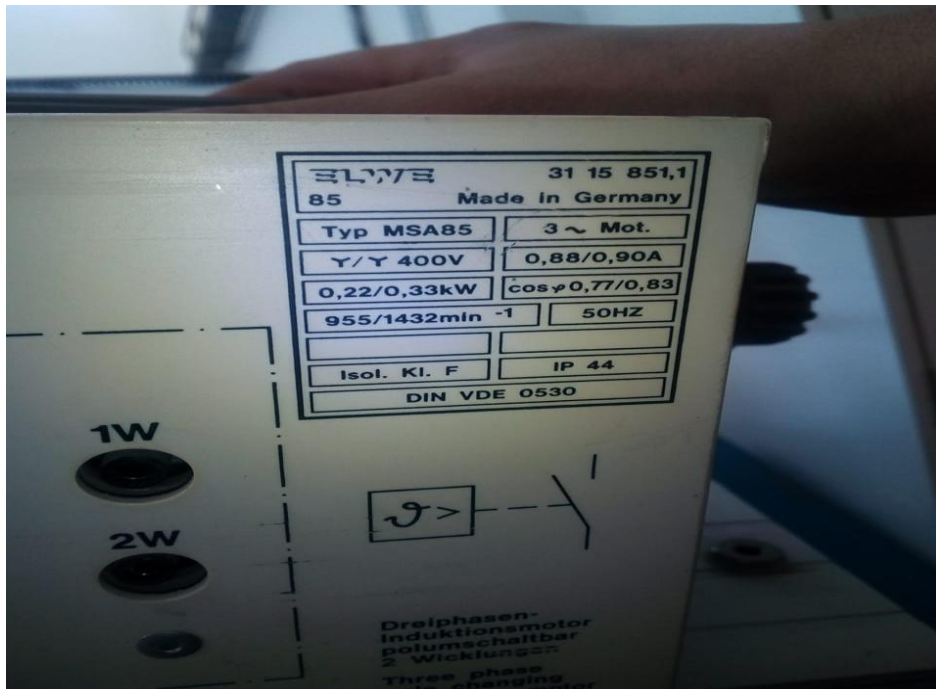
Figure 51 : Three-phase asynchronous motor nameplate

In this case the nominal current is:

$$In = \frac{Pn}{\sqrt{3}.U.\cos\varphi} = \frac{330}{\sqrt{3}.\ 400\ .\ 0,83} = \boxed{0.58\ A}$$

3.2 Order card

Electronic schematic of the control card is schematized by the EAGLE software (figure 56) includes:

3.2.1   5V power supply

The Arduino card is powered from a 9V battery through a jack cable and the control card through a 2-screw terminal block X1. I need a 5V power supply, for this reason I added a 7805 voltage regulator.
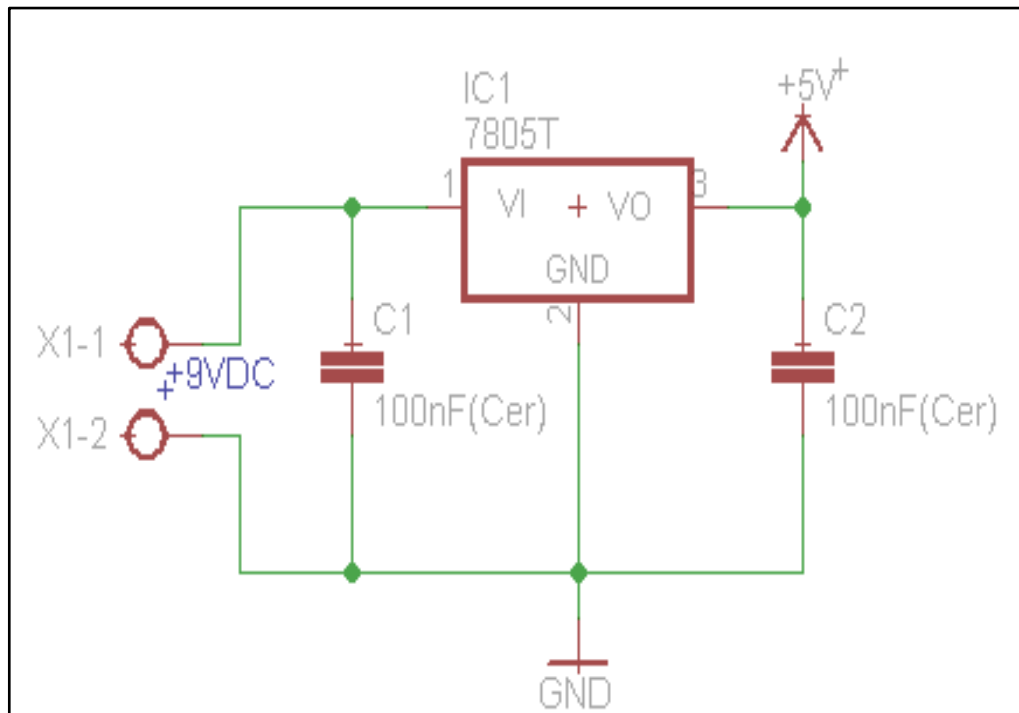
Figure 52 : 5VDC power supply

Figure 53 : 2 screw terminal block

Linear voltage regulators are commercially available as a three-pin integrated circuit. This kind of circuit is simple to use: just connect one pin to ground, another to the supply voltage and I get a regulated voltage at the output.

It is generally necessary to add some capacitors at the input and output serving as a filtering and decoupling energy reservoir. Depending on the power dissipated by the component, depending on the current consumed at the output and the voltage drop across its terminals, it is sometimes necessary to add a dissipator.
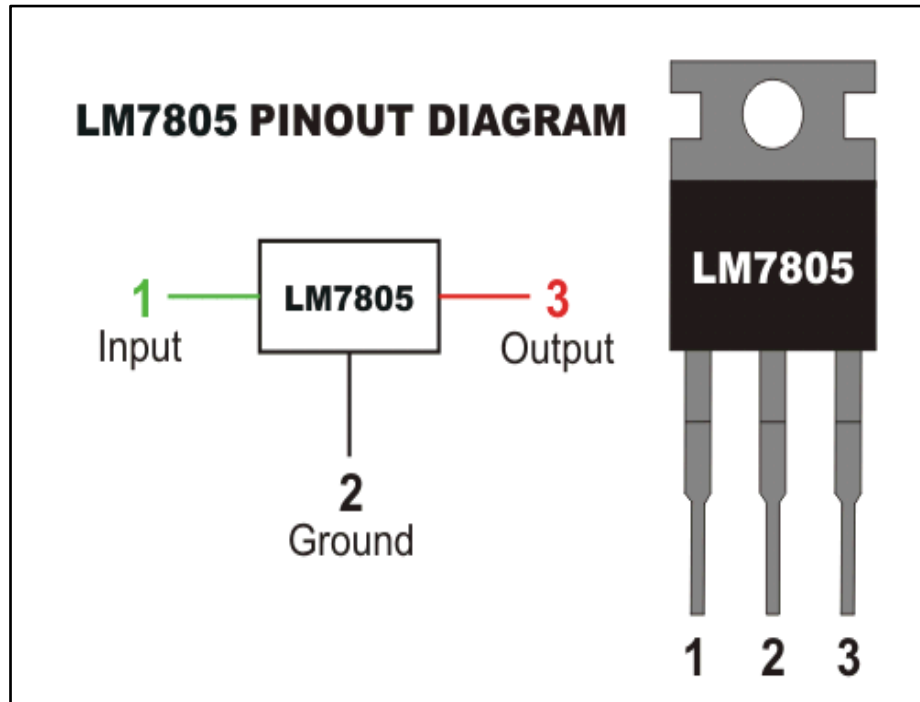
Figure 54 : Regulator 7805 TO 220

3.2.2 Arduino Mega inputs / outputs

The connection between the Arduino card and the control card is made via the Headers male connectors; JP4 for inputs and JP4 for outputs.
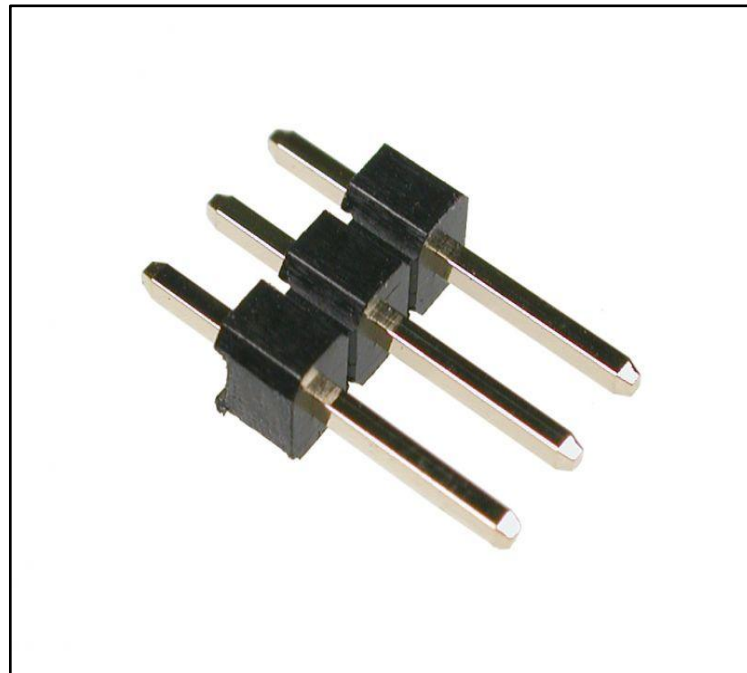
Figure 55 : Header male connector
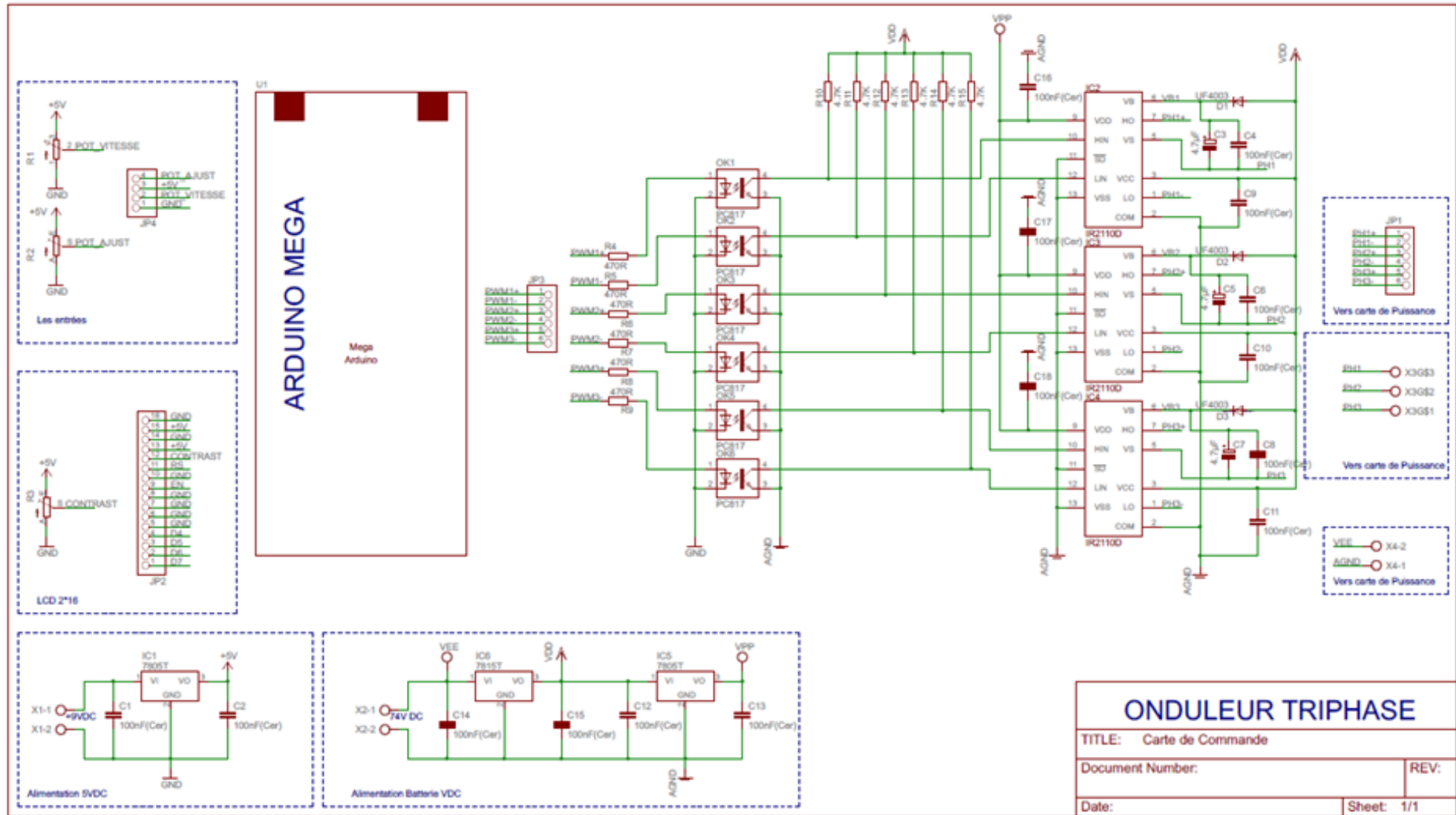
Figure 56 : Order card
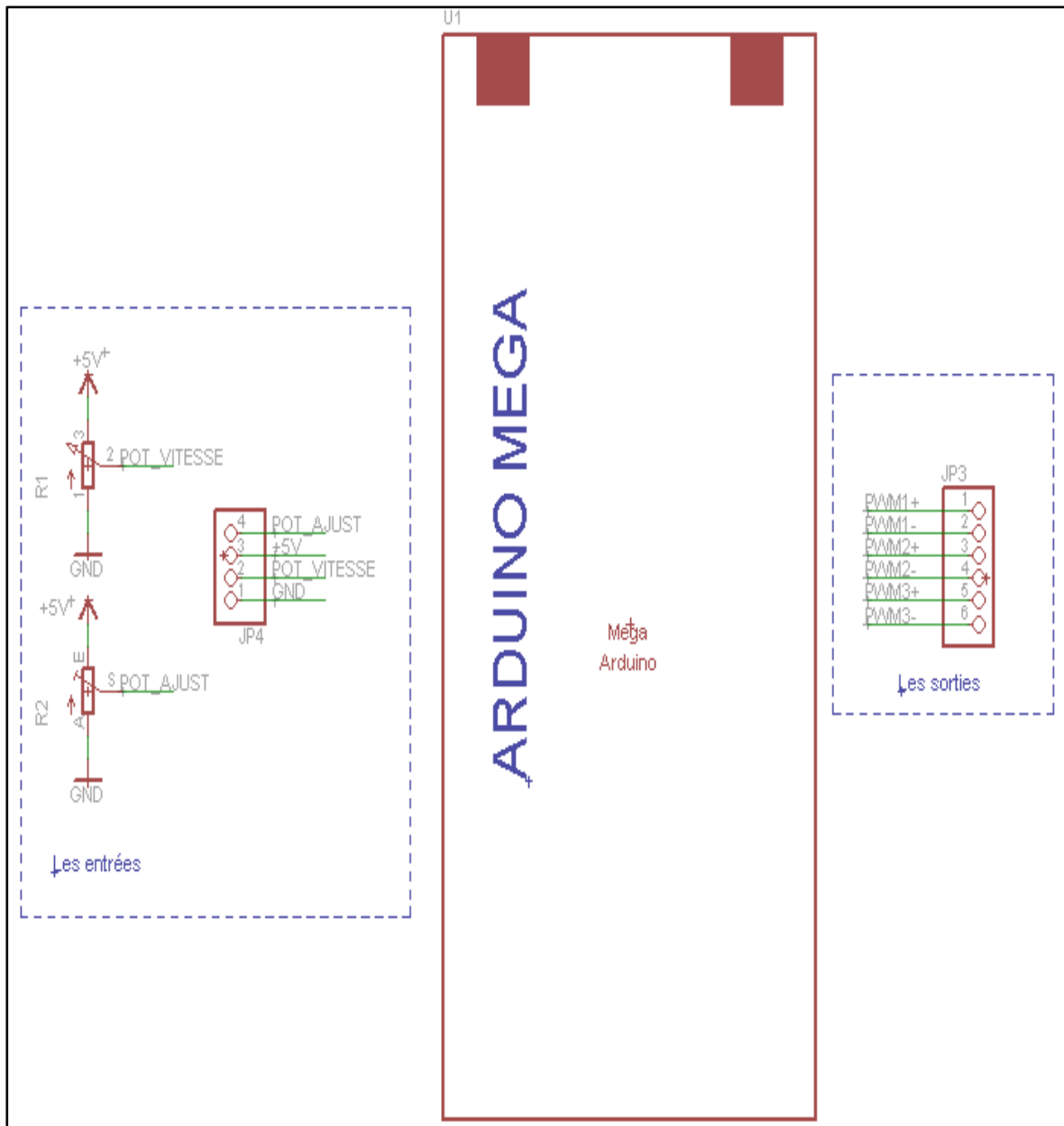
Figure 57 : Arduino input / output connection

3.2.3 Galvanic isolation with PC817

Galvanic isolation aims to remove any electrical link between the control part (Arduino card) and the power part (IGBTs). I realized the galvanic isolation with 6 PC817 optocouplers. And for total isolation I separated masses. In this way, all of the control electronics have a common ground GND and all of the power electronics have another common ground AGND, independent of the first.
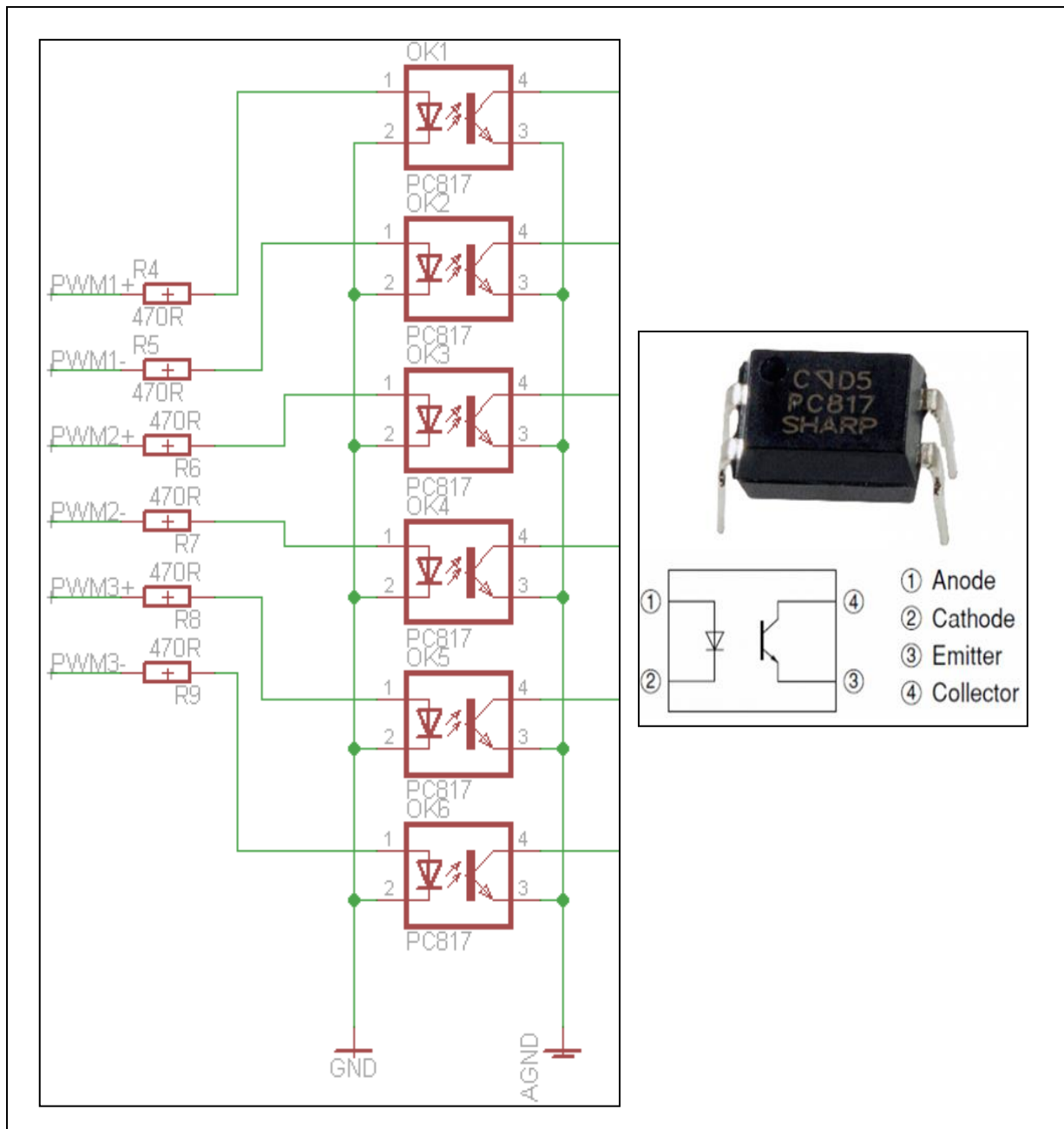
Figure 58 : Galvanic isolation by the PC817 optocoupler

PC817 optocoupler consists of an infrared LED and a phototransistor. There is electrical isolation between the two. When a current is passed through the LED, it emits infrared in a housing well sealed from light. The light emitted by the LED is captured by the phototransistor which then becomes on. We can therefore transmit an electric current while electrically insulating.

3.2.4 Driver 2110

It is an integrated circuit which allows high-frequency control of 2 IGBTs, at voltages up to 600v, guaranteeing the electrical insulation of each stage. Below :
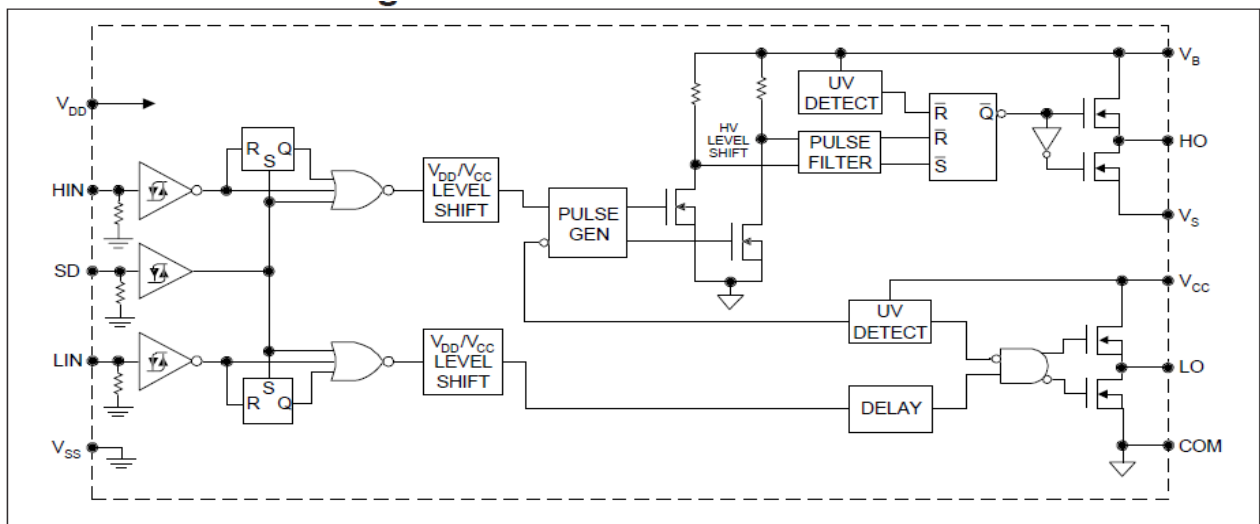
Figure 59 : IR2110 functional diagram

HIN, LIN and SD inputs are logic inputs, CMOS and TTL LS compatible. The tilting levels are linked to the value of the supply voltage VDD. For example, for VDD = 15v, the high level is between 9.5v and 15v, the low level is between 0v and 6v.

a. Function of the digital inputs:

The following study concerns HIN, but applies in the same way to LIN.
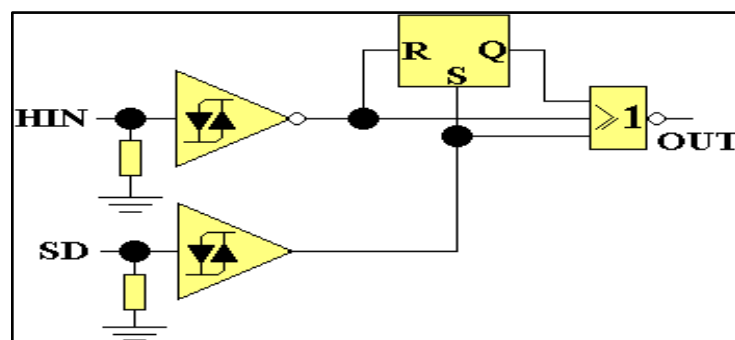
Figure 60 : HIN study

The logic input SD, when high, blocks the output OUT (OUT = 0). When SD is low, the pulses arriving on HIN are present on the output OUT.

Thanks to the flip-flop RS, a pulse partially blocked by SD, remains blocked until its end. This property can be used to modulate the pulse widths from the SD input.
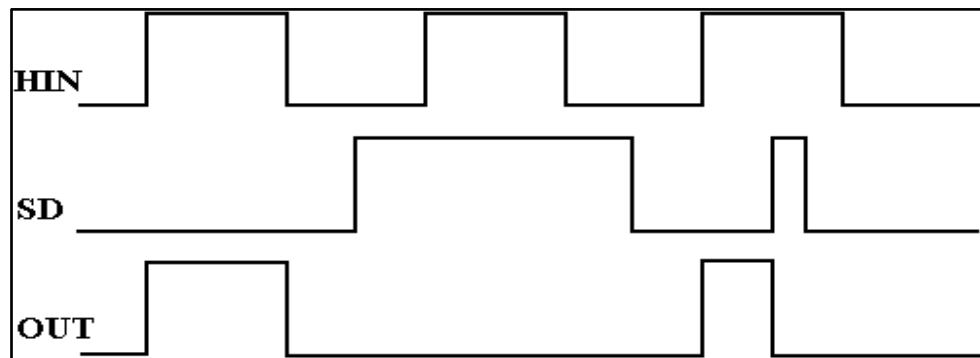
Figure 61 : HIN diagram

b. Low output stage

This stage has an LO output which can deliver a current of 2A via the push-pull T1-T2. These transistors have a complementary operation. When the voltage Vcc is insufficient, T1 is blocked and T2 is saturated. Otherwise, DELAY sets the state of T1 and T2.
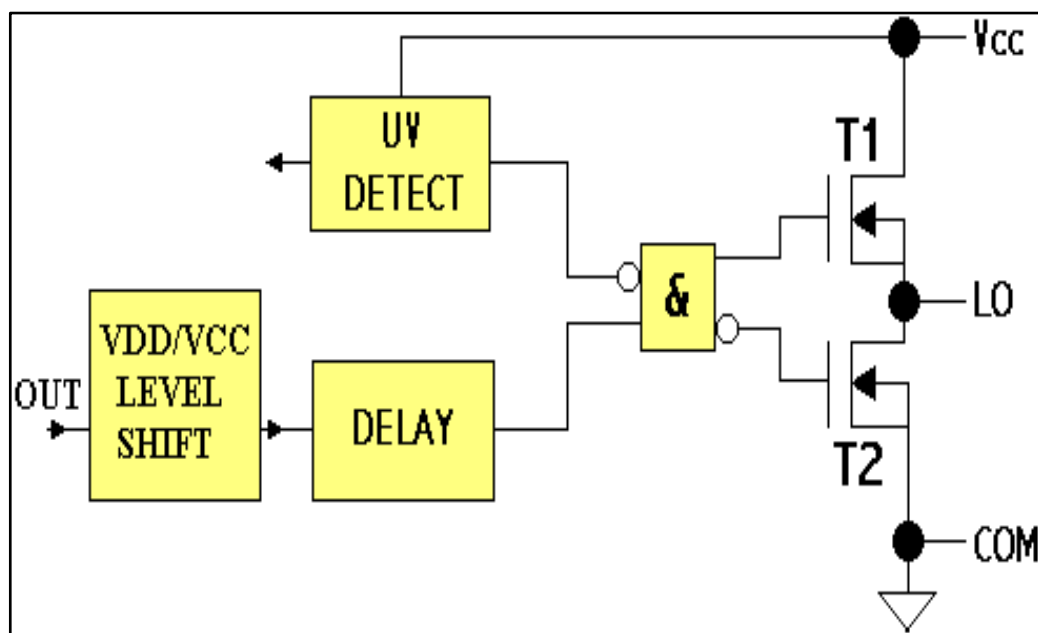
Figure 62 : Low output stage

c. High output stage

This stage has an HO output which can deliver a current of 2A via the push-pull T3-T4. These transistors have a complementary operation.

When the voltage VB is insufficient, T3 is blocked and T4 is saturated. Otherwise, it is PULSE FILTER which fixes the state of T1 and T2.
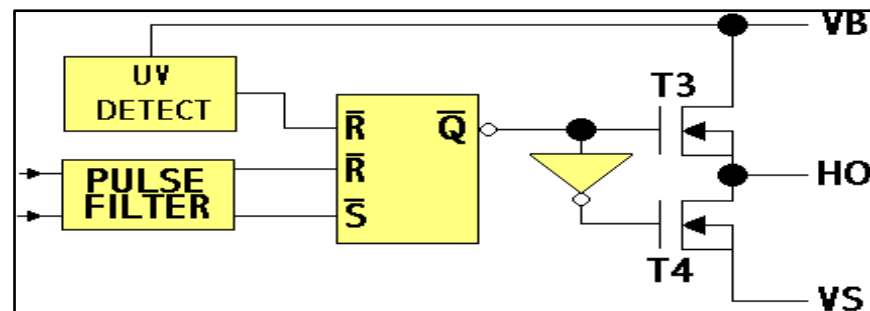
Figure 63: High output stage

d. Application mounting

In this mounting, the capacitors C1, C2 and C3 ensure the filtering of the VDD, VCC and VB supplies. The VCC voltage must be between 10v and 20v, the VDD voltage between 4.5v and 20v. The VB supply is obtained from VCC, by loading C2 via D and Load, when T2 is saturated.
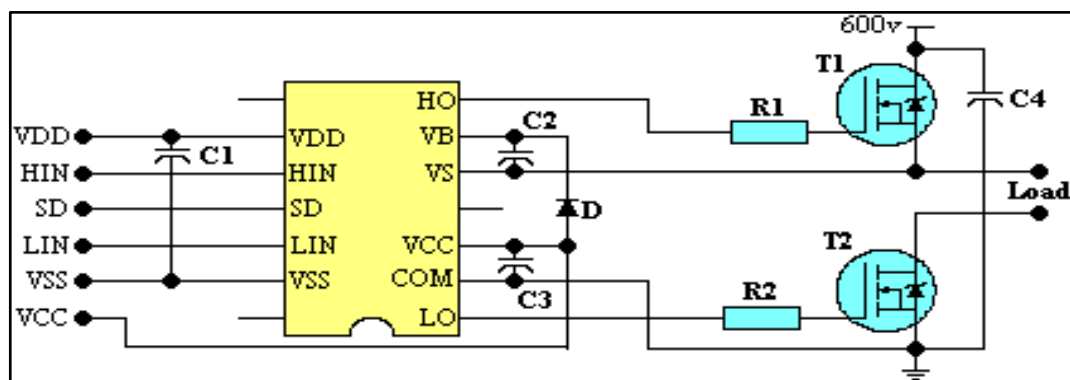
Figure 64 : Application mounting

3.3 Routing of Control card

Using EAGLE design software; I carried out the routing of the control card on a single-sided printed circuit of dimension 156 * 105 mm.
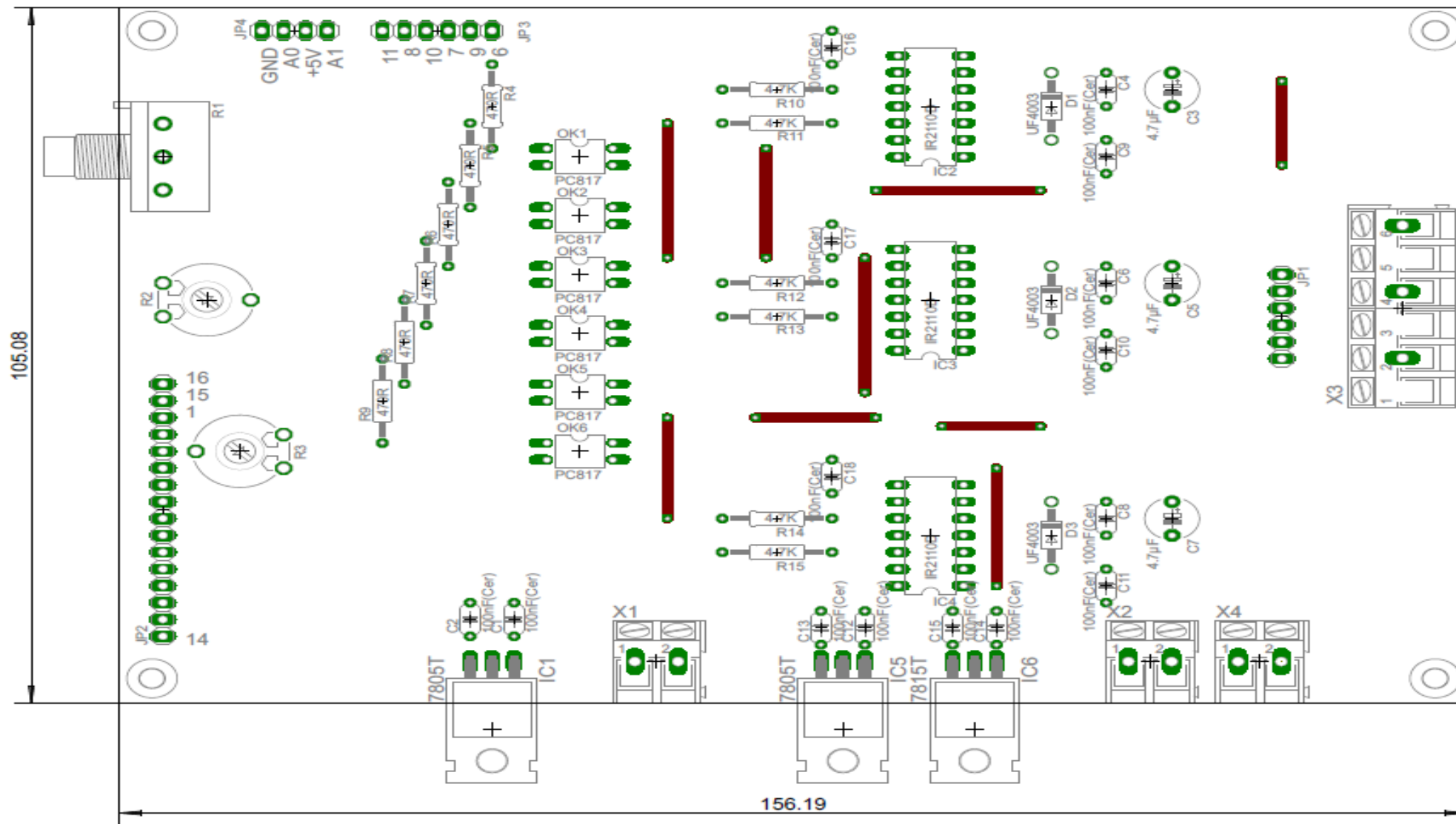
Figure 65 : Mounting schematic of the control card
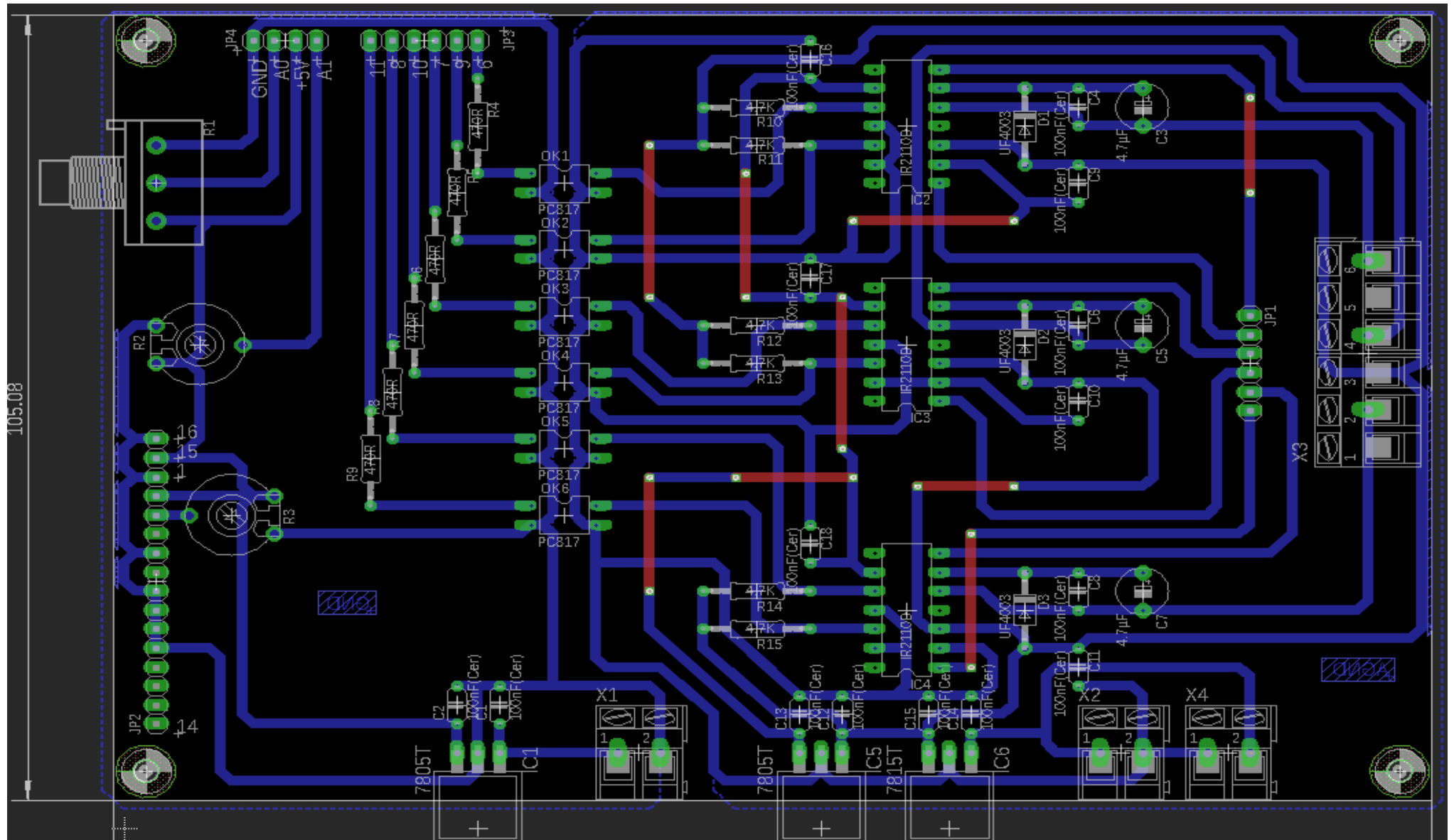
Figure 66 : Routing of control card
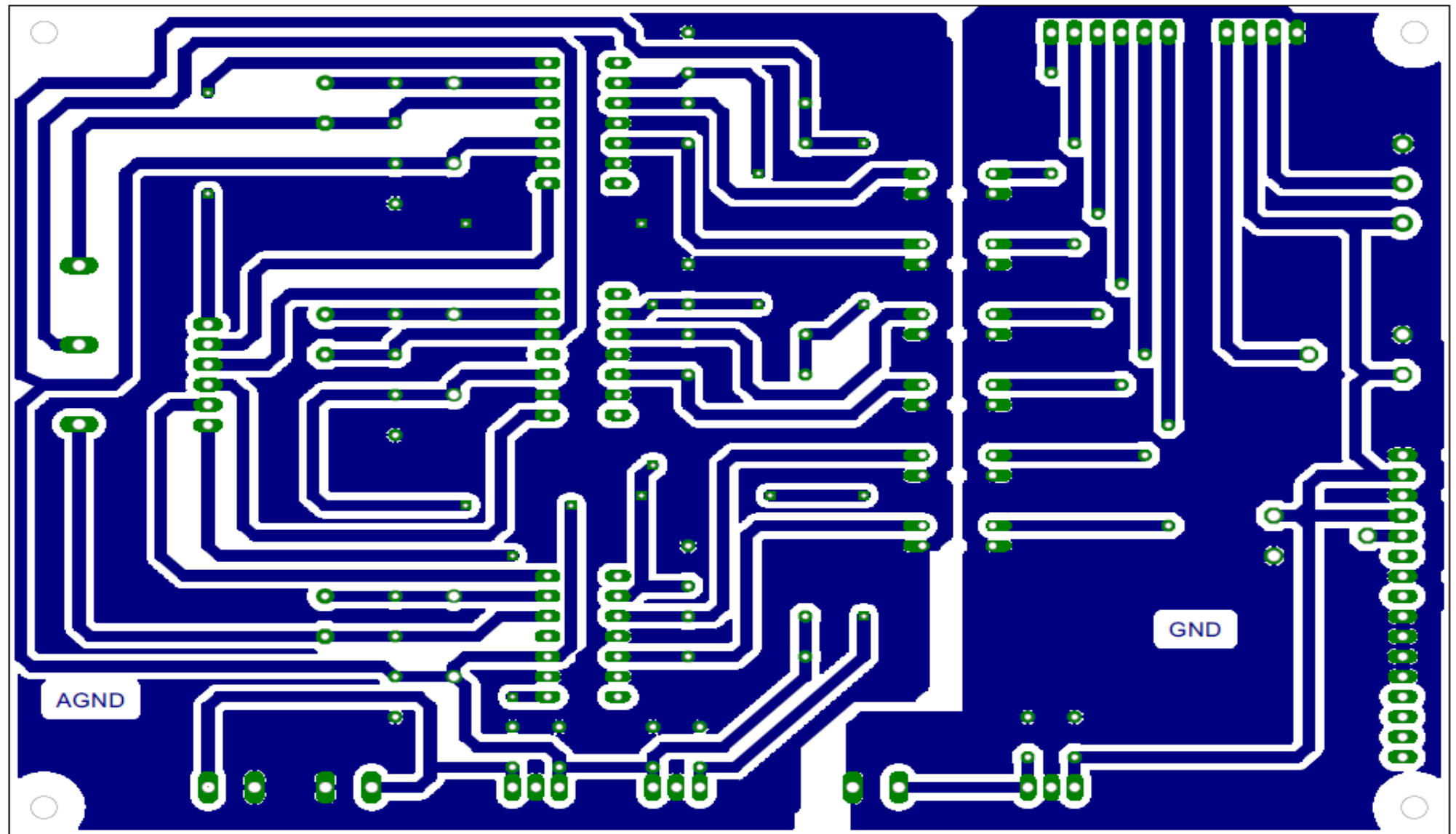
Figure 67 : Rear side of the control card

3.4 Power card

3.4.1 Introduction

Transistors are manufactured for high currents, voltages and switching frequencies. They replace the thyristors in the inverters of variable speed drives. The value of the current in the transistors does not necessarily go through zero as in the case of diodes and thyristors. The transistor can be asked to switch at any time by changing the polarity of the control electrode. The most recent developments in semiconductor technology have made it possible to substantially increase the switching frequency of transistors. The upper threshold is now above several hundred KHz. It is therefore possible to avoid the magnetic noise produced by the magnetization by pulse of the motor.

Another advantage of the high switching frequency is the great flexibility of the drive output voltage. It is in fact possible to obtain a perfectly sinusoidal motor current provided that the control circuit turns the converter transistors on and off according to a suitable path. The switching frequency of the inverter is a compromise between losses in the motor and losses in the inverter. If the switching frequency increases, the losses in the inverter also increase.

The high frequency transistor that will be used is the insulated gate bipolar (IGBT). It combines the advantages of bipolar transistors (high voltages and currents) and those of MOSFET transistors (rapid switching, low control energy).

The electronic schematic of the power card is produced by the EAGLE software (figure 68):
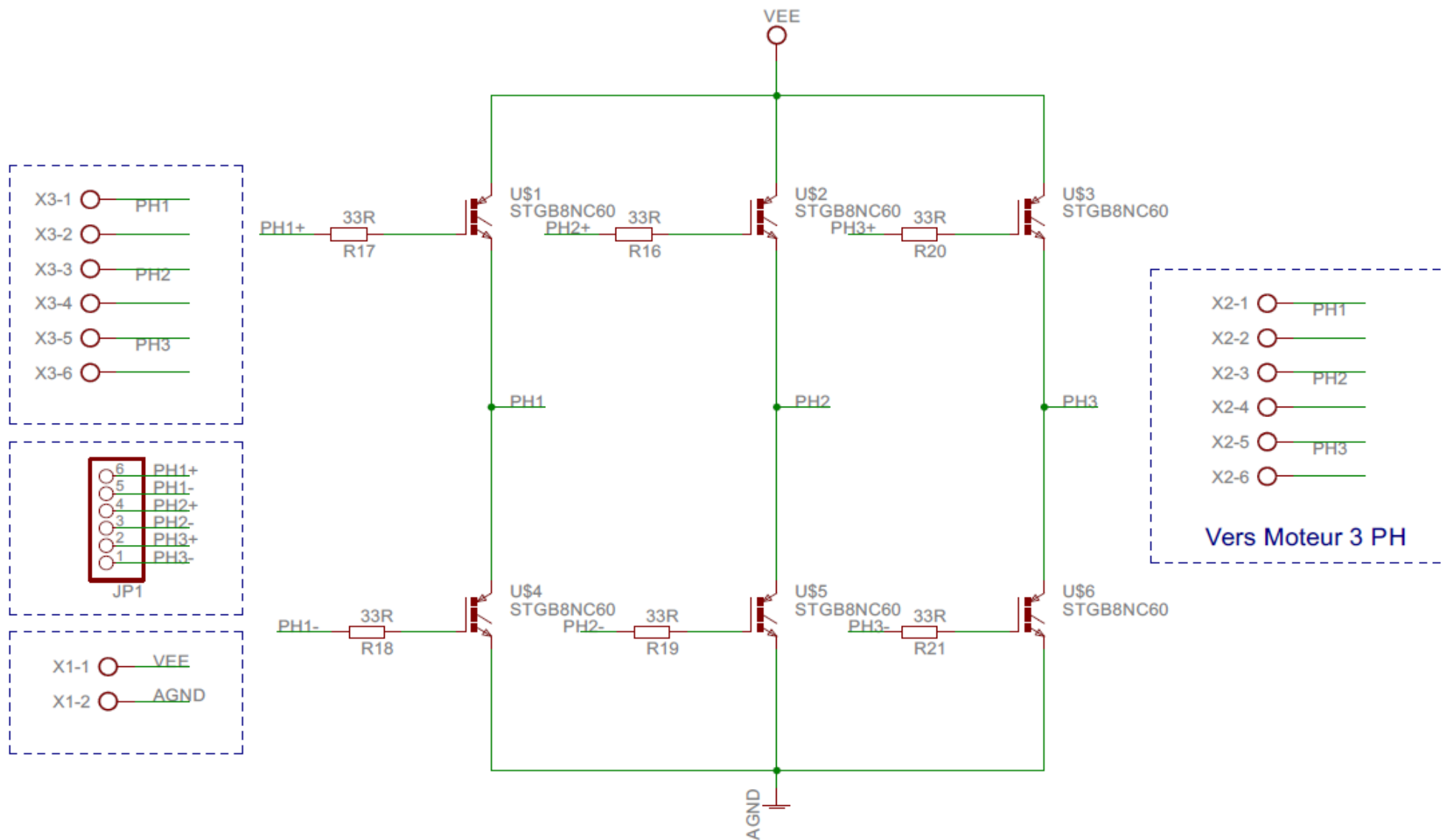
Figure 68 : Electronic schematic of the power card

3.4.2 IGBT

An NPN-type IGBT has, like a bipolar transistor, a collector and an emitter, but the base replaced by a high impedance electrode which is the gate of an MOS. It consists of a low gain power PNP bipolar transistor associated with an N channel MOS which supplies the basic current. The internal structure is shown in the figure opposite. I chose to use the IGBT 50N60.
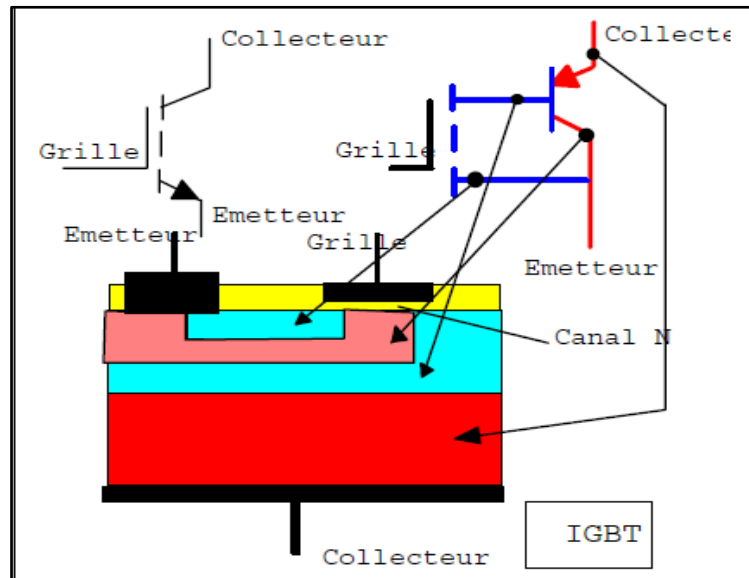
Figure 69: Structure of an IGBT
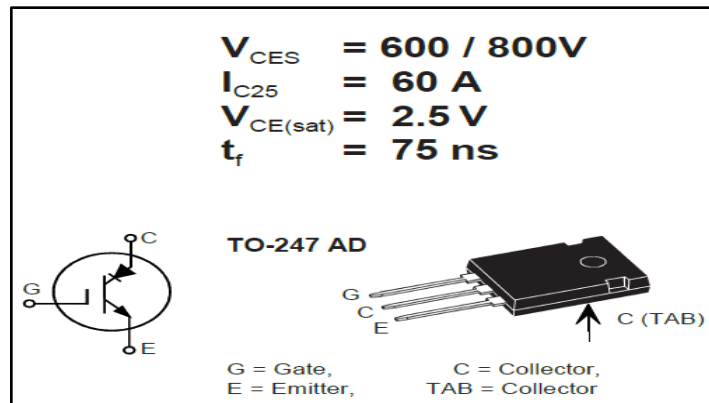
Figure 70: IGBT 50N60

3.5 Routing of the power card

I carried out the routing of the power card on a single-sided printed circuit of dimension 132 * 98 mm.
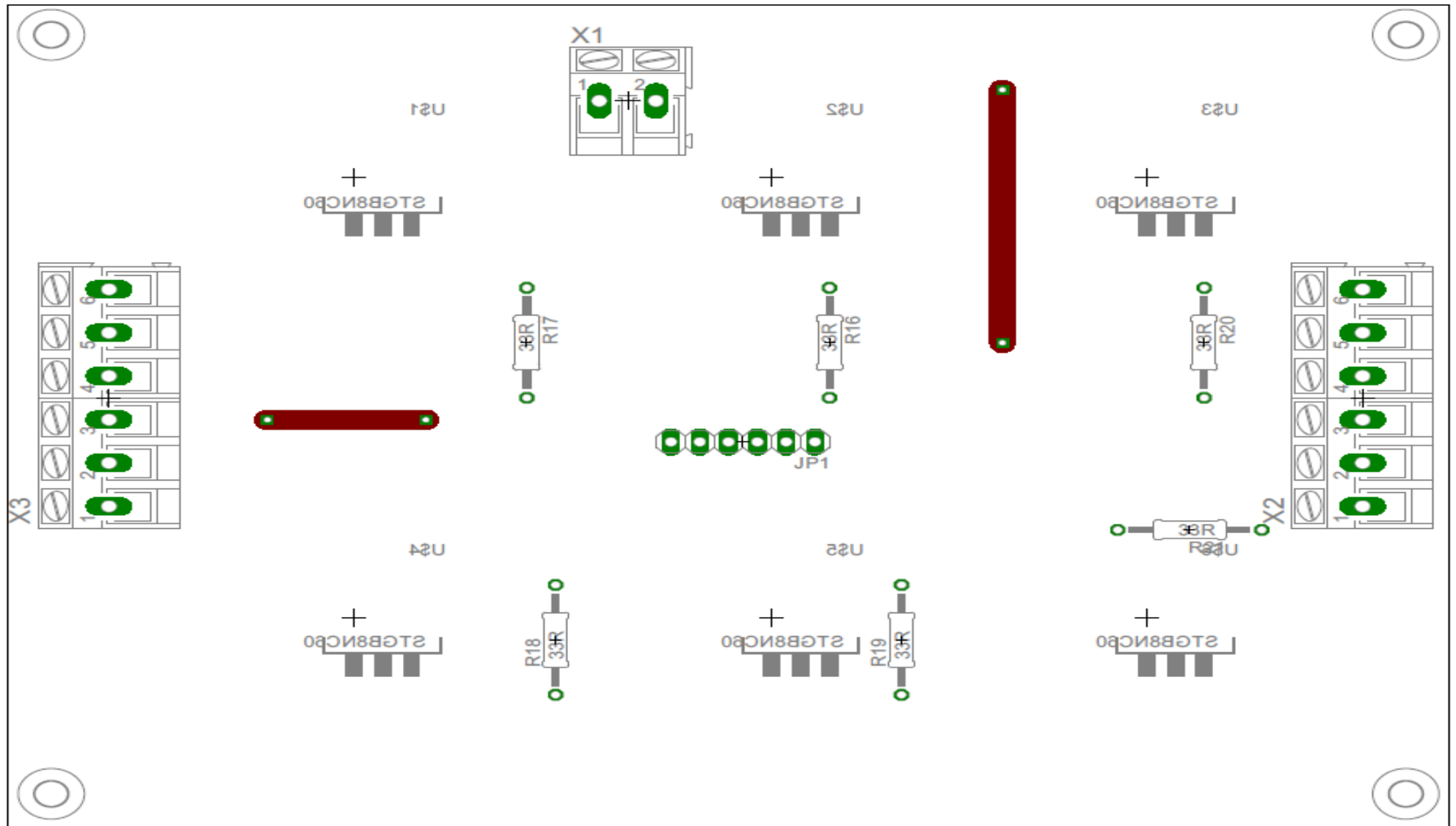
Figure 71 : Mounting schematic of the power card
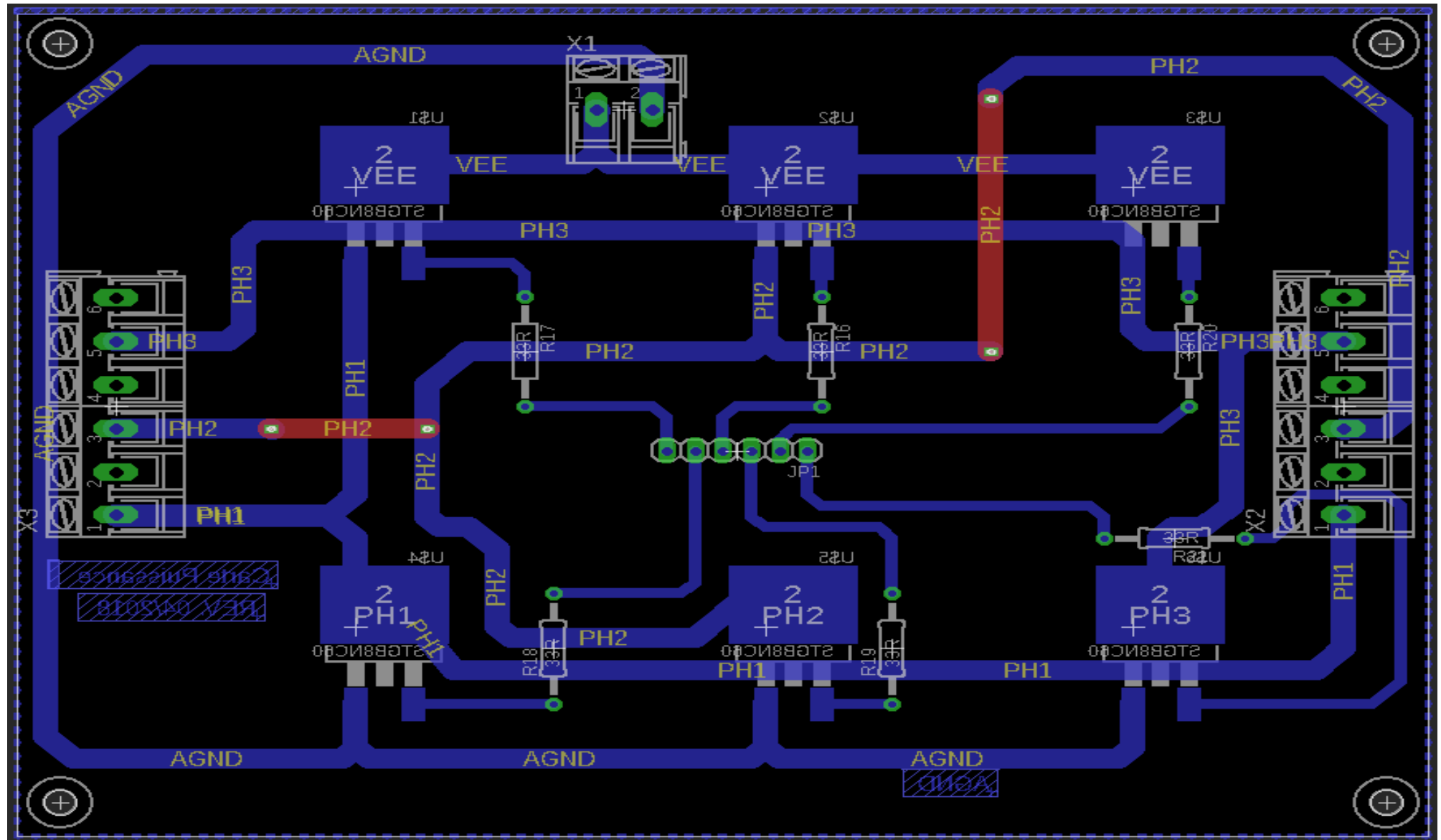
Figure 72 : Routing of the power card
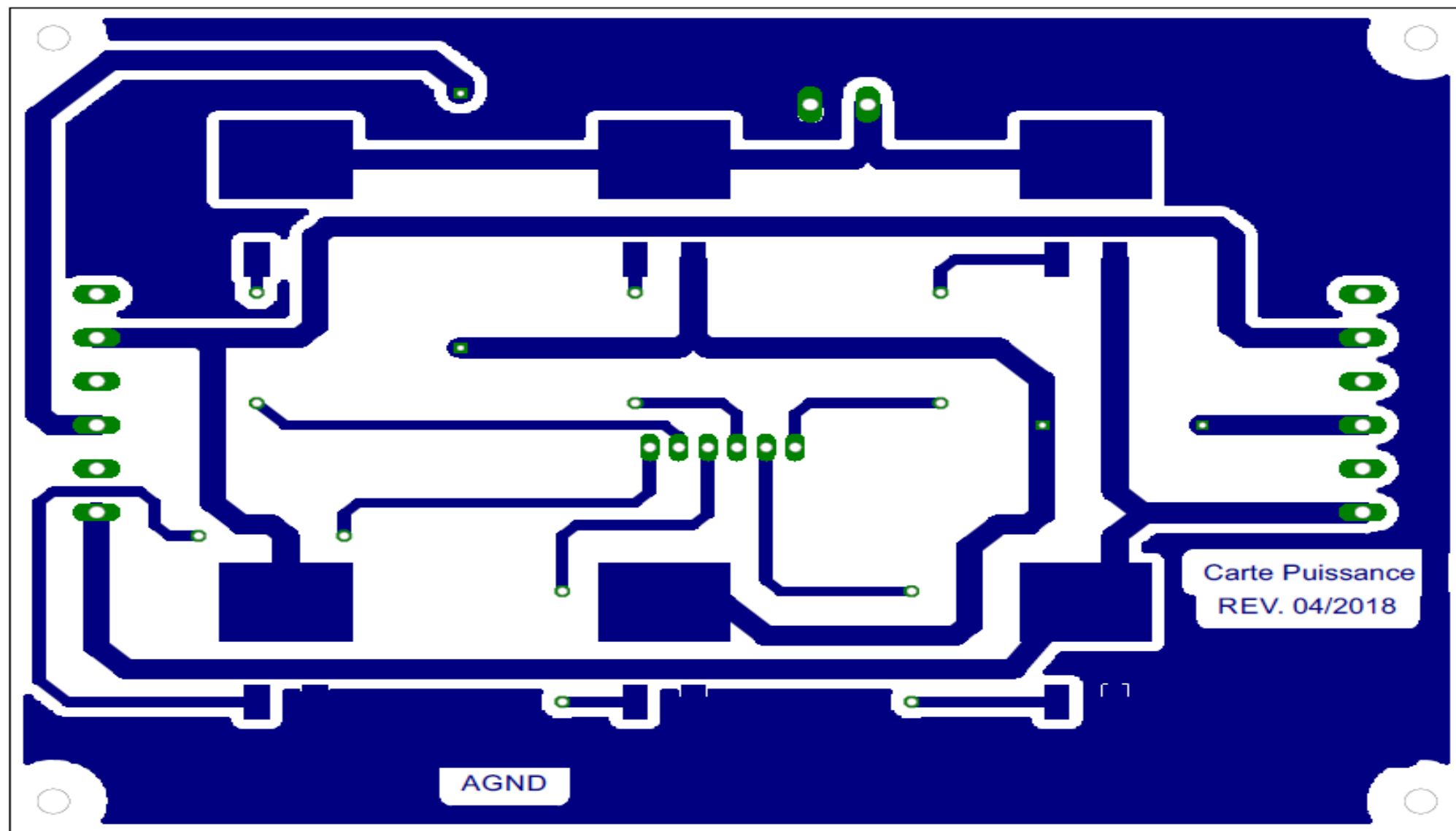
Figure 73 : Reare side of the power card

3.6 Routing of the display card

For details and the PIC18F2550 program see annex 10.
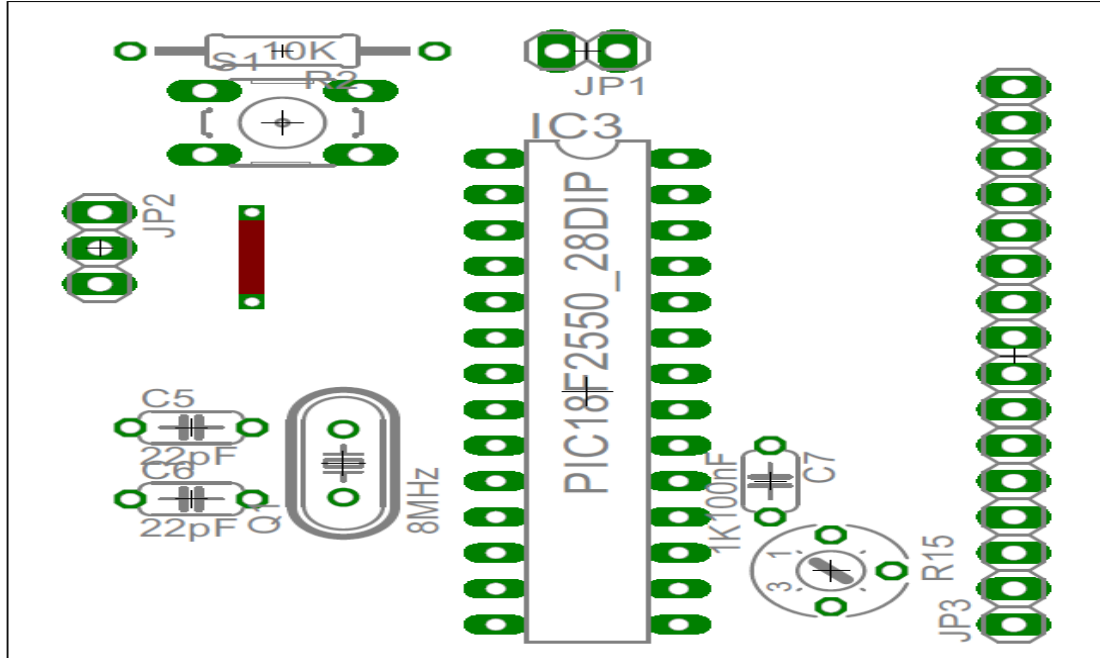
Figure 74 : Mounting schematic of the display card
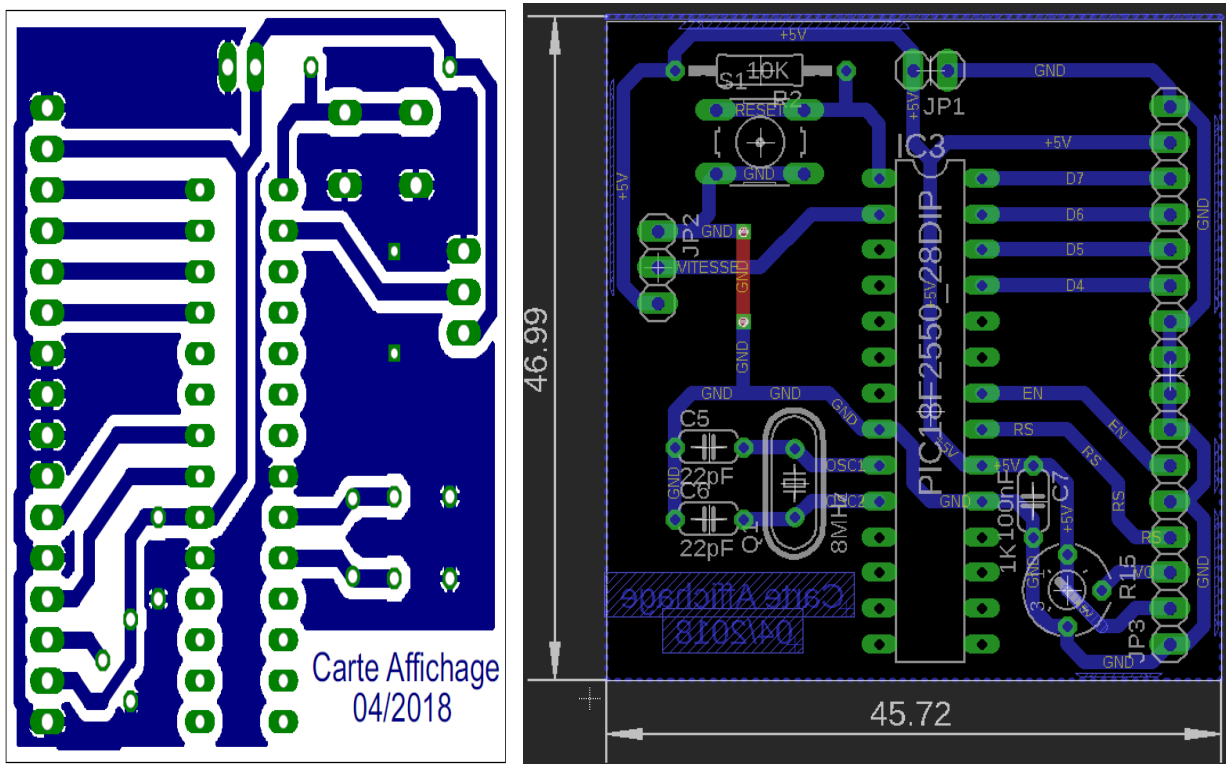
Figure 75 : Routing of display card

4. PRACTICAL REALIZATION

4.1 Order card

Component side
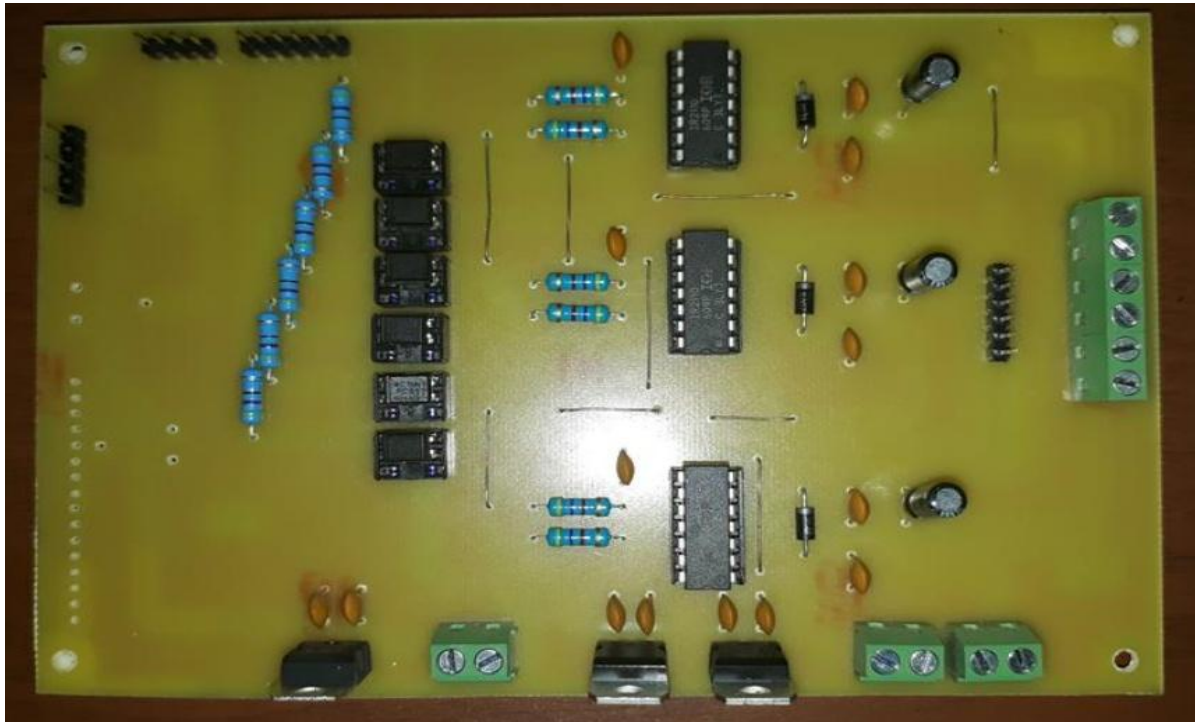
Figure 76: Component side of the control card

Face of solder
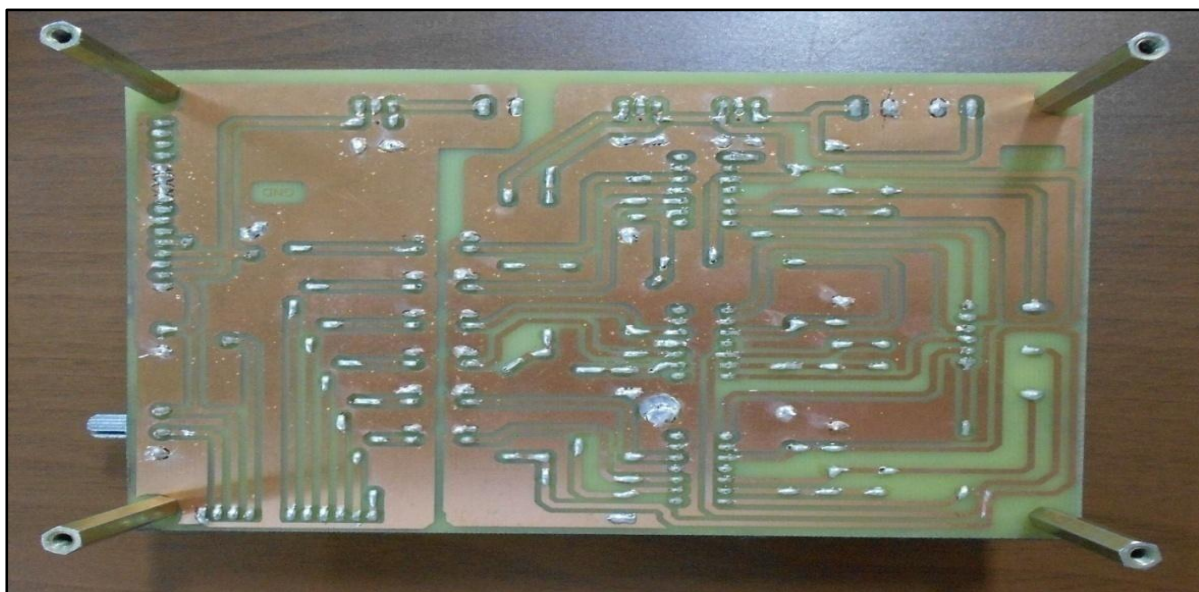
Figure 77: Solder side of the control card

4.1.1 Mounting
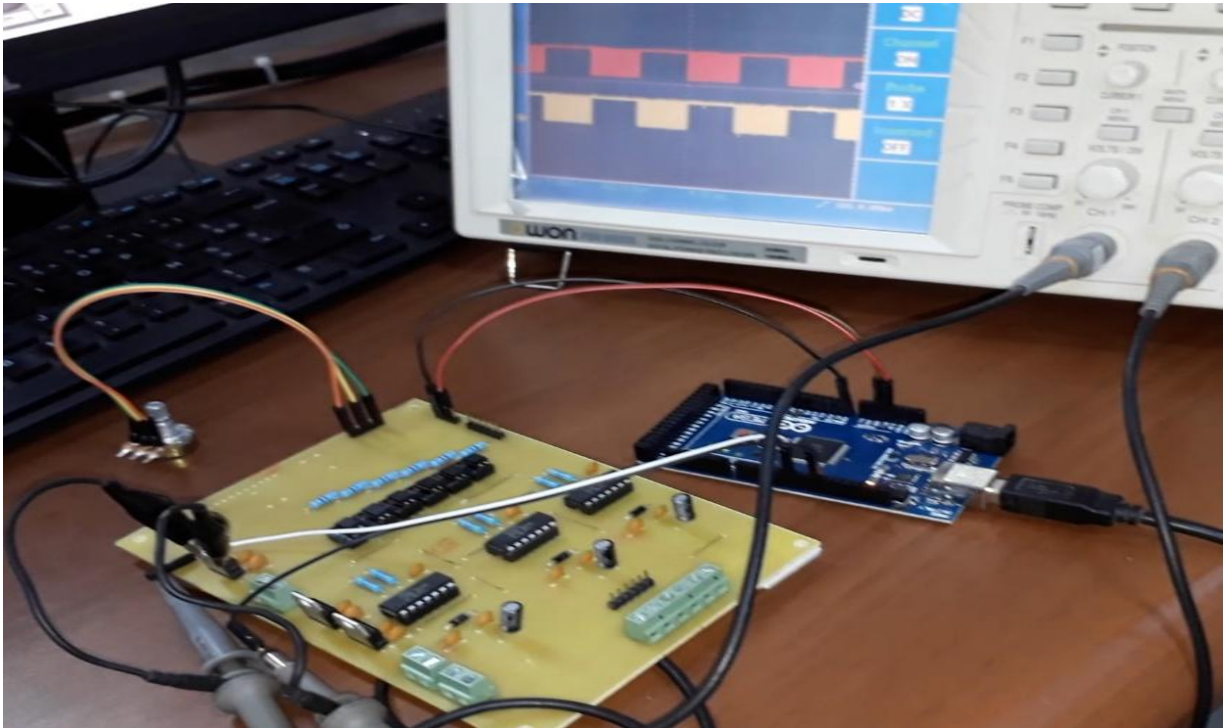
Figure 78: Mounting of the control card

4.1.2 Visualization on oscilloscope
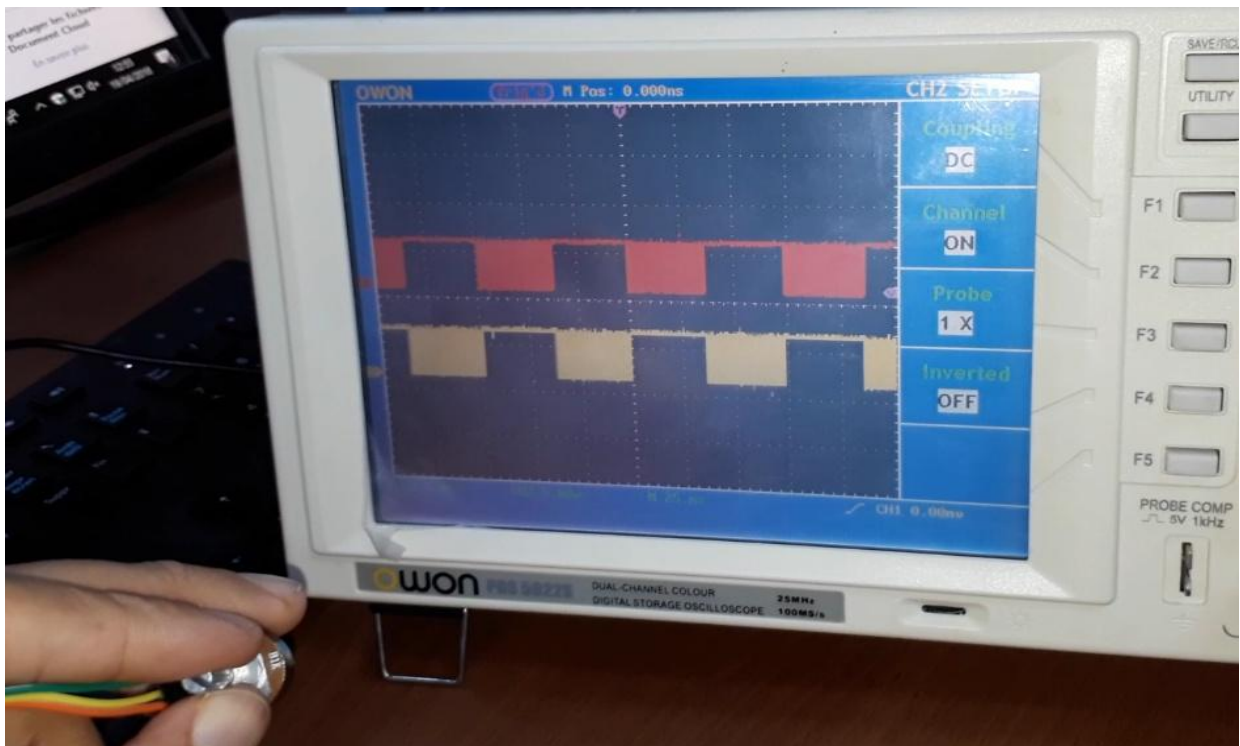
Figure 79: Visualization of control signals

4.2 Power card

Component side
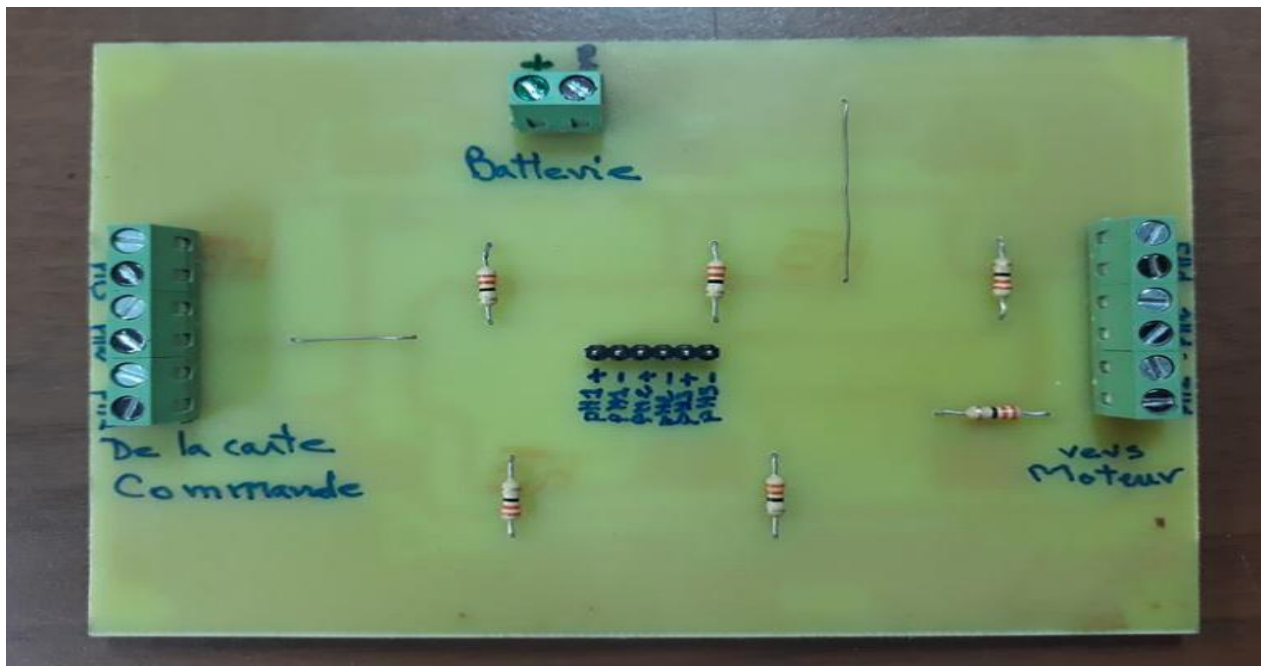
Figure 80: Face components of the power card

Solder face
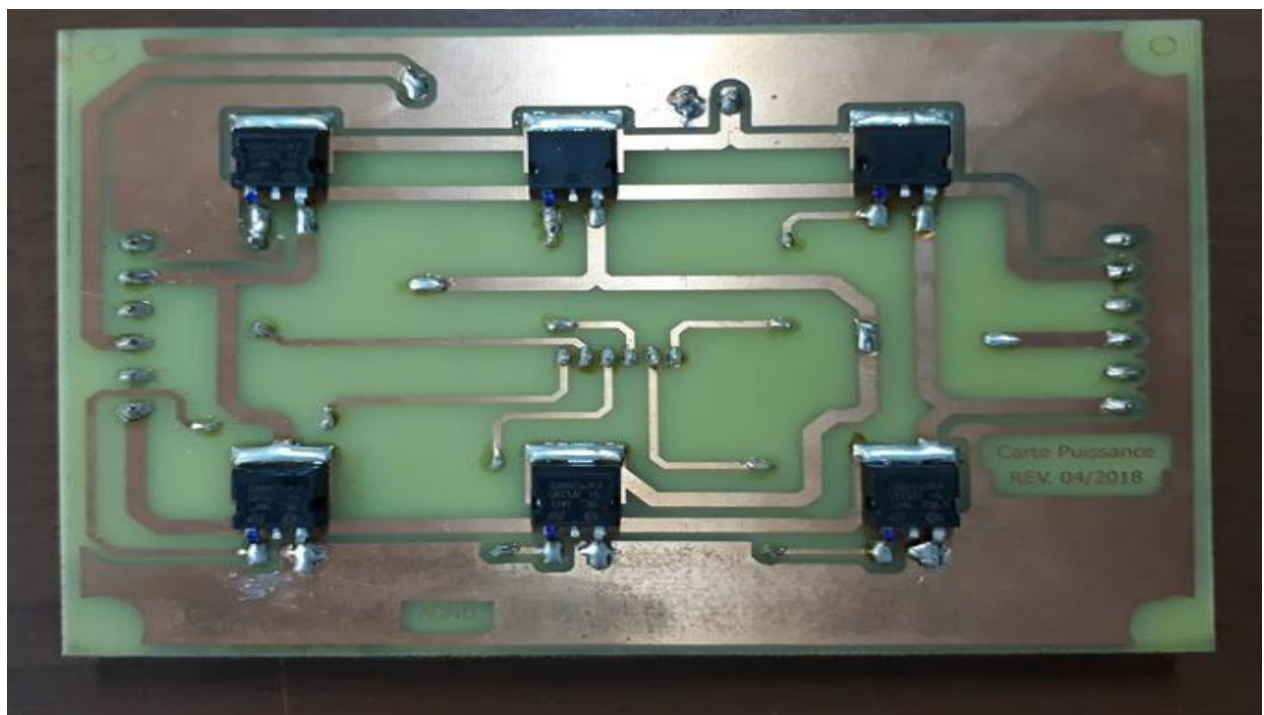
Figure 81: Solder face of the power card

4.3 Display card
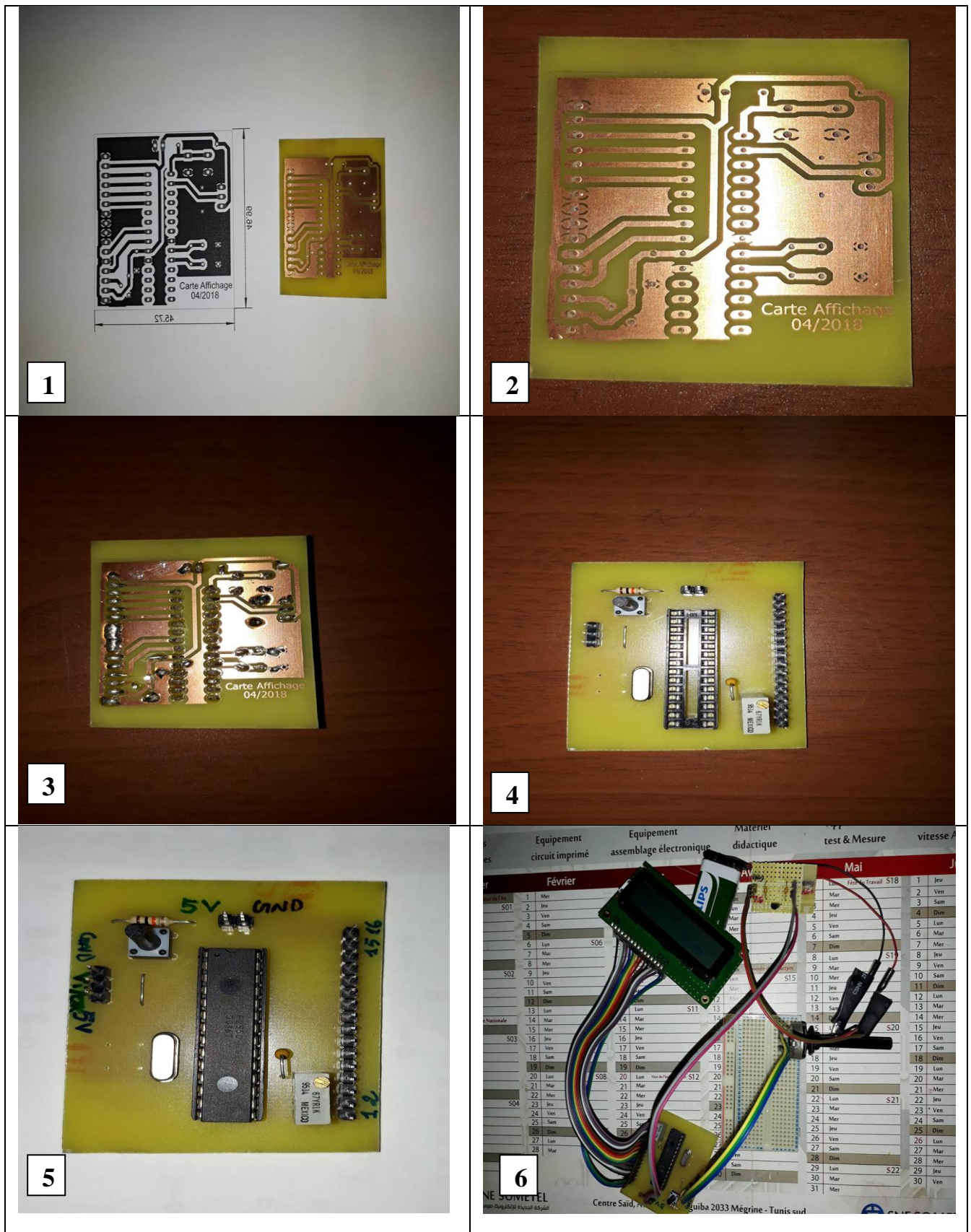
Figure 82 : Display card

4.4 Variator carcass

4.4.1 3D realization plan
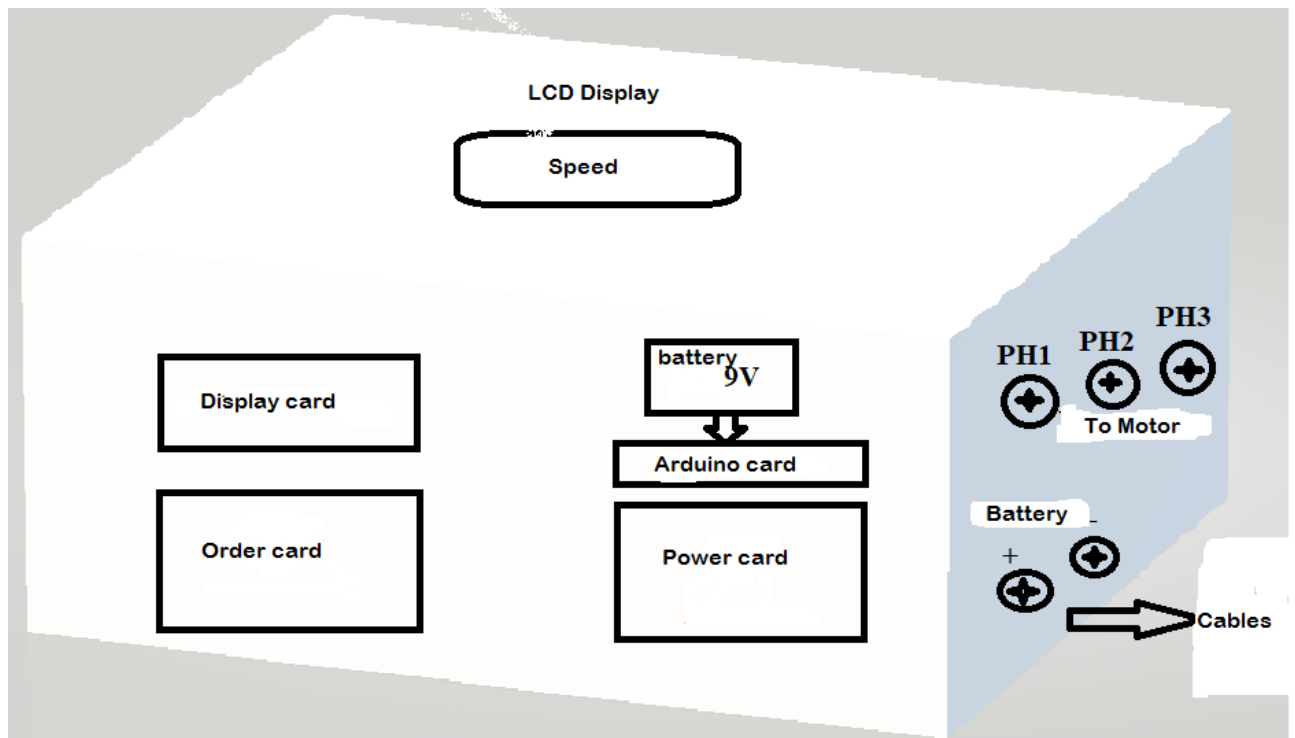
Figure 83 : 3D realization plan

4.4.2 Fixing of cards and wires
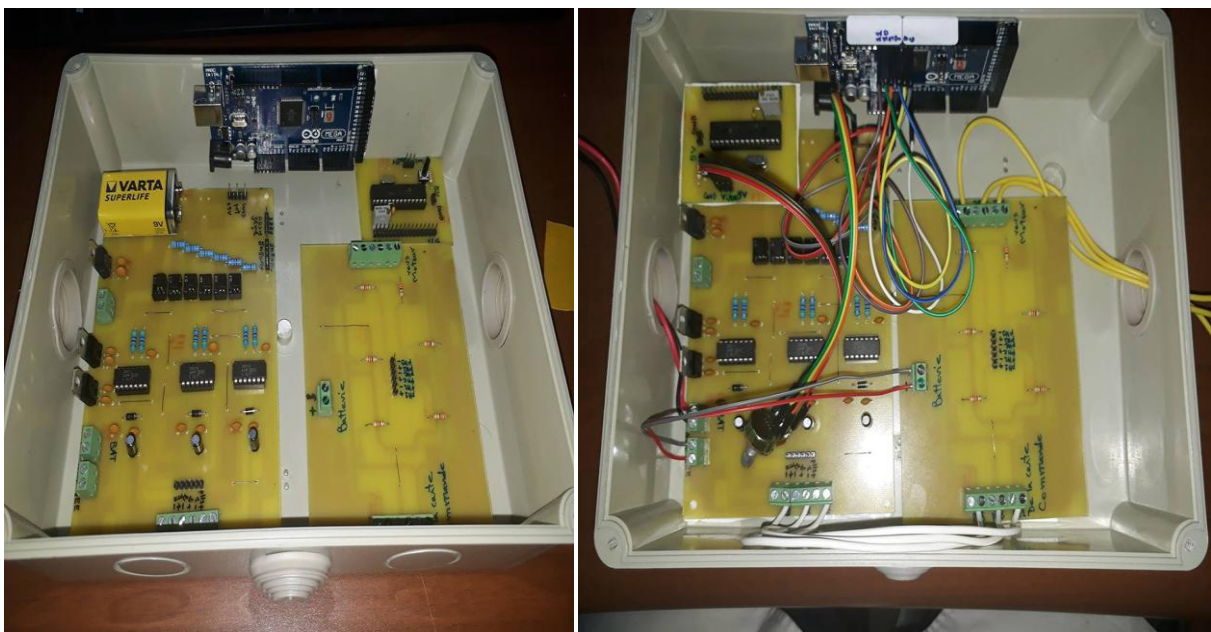
Figure 84 : Fixing of cards and wires

Figure 85 : General view of the variator

5. ECONOMIC STUDY

Components and reference	Quantity	Price
ARDUINO MEGA 2560 R3 VC with Package	1 unit	69.000 DT
Wires jumpers male / male 20cm Lot of 40 threads	1 unit	8.000 DT
Wires jumpers male / female 20cm Lot of 40 threads	1 unit	8.000 DT
Barelle SIL Male 29P 2.54mm	1 unit	0.870 DT
Varta SUPERLIFE 9V battery Pressure connector	1 unit	3.000 DT
9V battery 30cm cable with 2.5mm jack connector	1 unit	2.500 DT
POTNETIOMETRE 20 TOURS 5% 1KOhm	1 unit	0.950 DT
POTNETIOMETRE linear 1Kohm, rod M5XL20	1 unit	3.000 DT
Resistance 470ohm 1/2w 5%	7 units	0.630 DT
Support double lyre 6 pins	6 units	0.840 DT
Regulator 15V TO220 7815CH	1 unit	0.550 DT
Regulator 15V TO220 7805CT, CH	2 units	1.100 DT
Heatsink TO-220-21K/W, V8508B-L	1 unit	1.700 DT
Ceramic capacitor 100nf 50v	16 units	1.600 DT
Terminal block 2P × 5mm	14 units	5.600 DT
Resistance 4.7Kohm 1/4w 5%	6 units	0.280 DT
Support double lyre pin	1 unit	0.450 DT
Resistance 33ohm 1/4w 5%	6 units	0.280 DT
Resistance 1.0Kohm 1/4w 5%	10 units	0.400 DT
IGBT 50N60	6 units	132.000 DT
Power Bank aXis 5V 5200mAh	1 unit	10.000 DT

Fan astrum 5VDC	1 unit	15.000 DT
Manufacture of plastic case + accessories	1 unit	50.000 DT
Display card	1 unit	30.000 DT
PC 817	6 units	3.900 DT
IR2110	3 units	13.980 DT
Capacitor 4.7uF	3 units	0.150 DT
PIC18F2550	1 unit	14.665 DT
Support 28 legs	1 unit	0.400 DT
Resistance 10K ¼ w	1 unit	0.050 DT
button PCB	1 unit	0.338 DT
Bar connector connector heauder mal double	1 unit	1.410 DT
Condo. Ceramic 100 nF	1 unit	0.095 DT
Potentiometer without axis 1K	1 unit	1.934 DT
Condo. Ceramic 22 nF	2 units	0.070 DT
Quartz 8 MHz	1 unit	0.795 DT
LCD 2*16	1 unit	29.775 DT
Order card	1 unit	160.000 DT
Power card	1 unit	160.000 DT
Training in card making, drilling and welding	1 unit	400.000 DT
Total	******	**1128.812 DT**

Table 3 : Economic study

6. CONCLUSION

In this chapter, I have made a PWM inverter-based speed controller for a three-phase asynchronous motor driven by arduino and I have presented the different simulations of these tests.

GENERAL CONCLUSION AND PERSPECTIVE

This work mainly concerns the study, for the benefit of the GINOR factory, of the change of a DC motor, presenting frequent faults, by a three-phase asynchronous motor controlled by a frequency drive.

I studied the choice of the asynchronous motor as well as its variator. I simulated the operation by comparing the full wave command and M.L.I. and showing the advantage of the latter. In addition I carried out the practical realization of the variator in which I encountered several difficulties that I was able to solve them.

Of course, improvements can be made in the drive control. They consist of controlling it by other special circuits or by a PLC via the communication buses.

This work allowed me to broaden my knowledge in the field of power and control electronics as well as the mastery of the simulation tool and the realization of electronic cards.

Technical data
IE2 cast iron motors, 3000 r/min

IP 55 - IC 411 - Insulation class F, temperature rise class B
IE2 efficiency class according to IEC 60034-30-1; 2014

Output kW	Motor type	Product code	Speed r/min	Efficiency IEC 60034-30-1; 2014 Full load 100%	3/4 load 75%	1/2 load 50%	Power factor Cos φ	Current I_N A	I_s/I_N	Torque T_N Nm	T_l/T_N	T_b/T_N	Moment of inertia J = 1/4 GD^2kgm²	Weight kg	Sound pressure level L_{PA} dB
3000 r/min = 2 poles				400 V 50 Hz				CENELEC-design							
0.37	M3BP 71 MA 2	3GBP071321-••B	2768	74.8	74.7	71.0	0.78	0.91	4.5	1.27	2.2	2.3	0.000390	11	58
0.55	M3BP 71 MB 2	3GBP071322-••B	2813	77.8	78.3	76.0	0.79	1.29	4.3	1.86	2.4	2.5	0.000510	11	56
0.75	M3BP 80 MB 2	3GBP081322-••B	2895	80.6	79.9	76.2	0.74	1.81	7.7	2.4	4.2	4.2	0.00100	16	57
1.1	M3BP 80 MC 2	3GBP081323-••B	2870	81.8	82.4	80.2	0.80	2.4	7.5	3.6	2.7	3.5	0.00120	18	60
1.5	M3BP 90 SLB 2	3GBP091322-••B	2900	82.2	84.1	82.7	0.86	3.0	7.5	4.9	2.5	2.6	0.00254	24	69
2.2	M3BP 90 SLC 2	3GBP091323-••B	2885	84.7	86.7	85.7	0.87	4.3	6.8	7.2	1.9	2.5	0.00280	25	64
3	M3BP 100 LB 2	3GBP101322-••B	2925	85.2	84.9	82.8	0.86	5.9	9.1	9.7	3.1	3.5	0.00528	36	68
4	M3BP 112 MB 2	3GBP111322-••B	2895	86.1	87.0	86.6	0.86	7.7	8.1	13.1	2.9	3.2	0.00575	37	70
5.5	M3BP 132 SMB 2	3GBP131322-••B	2865	88.0	88.6	88.0	0.86	10.4	7.0	18.3	2.0	2.7	0.01275	68	70
7.5	M3BP 132 SMC 2	3GBP131324-••B	2890	88.6	88.8	87.5	0.84	14.5	7.3	24.7	2.0	3.6	0.01359	70	70
11	M3BP 160 MLA 2	3GBP161031-••G	2938	90.6	91.5	91.1	0.90	19.2	7.5	35.7	2.4	3.1	0.044	127	69
15	M3BP 160 MLB 2	3GBP161036-••G	2934	91.5	92.4	92.2	0.90	26.0	7.5	48.8	2.5	3.3	0.053	141	69
18.5	M3BP 160 MLC 2	3GBP161037-••G	2932	92.0	93.1	93.1	0.92	31.5	7.5	60.2	2.9	3.4	0.063	170	69
22	M3BP 180 MLA 2	3GBP181031-••G	2952	92.2	92.7	92.2	0.87	39.5	7.7	71.1	2.8	3.3	0.076	190	69
30	M3BP 200 MLA 2	3GBP201035-••G	2956	93.1	93.5	92.8	0.90	51.6	7.7	96.9	2.7	3.1	0.178	283	72
37	M3BP 200 MLB 2	3GBP201036-••G	2959	93.4	93.7	92.9	0.90	63.5	8.2	119	3.0	3.3	0.196	298	72
45	M3BP 225 SMA 2	3GBP221031-••G	2961	93.6	93.9	93.1	0.88	78.8	6.7	145	2.5	2.5	0.244	347	74
55	M3BP 250 SMA 2	3GBP251031-••G	2967	94.1	94.4	93.8	0.88	95.8	6.8	177	2.2	2.7	0.507	405	75
75 [3]	M3BP 280 SMA 2	3GBP281210-••G	2978	94.3	94.1	92.8	0.88	130	7.6	240	2.1	3.0	0.800	625	77
90 [3]	M3BP 280 SMB 2	3GBP281220-••G	2976	94.6	94.5	93.5	0.90	152	7.4	288	2.1	2.9	0.900	665	77
110 [3]	M3BP 315 SMA 2	3GBP311210-••G	2982	94.9	94.4	92.9	0.86	194	7.6	352	2.0	3.0	1.20	940	78
132 [3]	M3BP 315 SMB 2	3GBP311220-••G	2982	95.1	94.8	93.6	0.88	227	7.4	422	2.2	3.0	1.40	940	78
160 [3]	M3BP 315 SMC 2	3GBP311230-••G	2981	95.4	95.2	94.2	0.89	271	7.5	512	2.3	3.0	1.70	1025	78
200 [3]	M3BP 315 MLA 2	3GBP311410-••G	2980	95.7	95.7	94.9	0.90	335	7.7	640	2.6	3.0	2.10	1190	78
250 [3]	M3BP 355 SMA 2	3GBP351210-••G	2984	95.7	95.5	94.5	0.89	423	7.7	800	2.1	3.3	3.00	1600	83
315 [3]	M3BP 355 SMB 2	3GBP351220-••G	2980	95.7	95.7	95.1	0.89	533	7.0	1009	2.1	3.0	3.40	1680	83
355 [3]	M3BP 355 SMC 2	3GBP351230-••G	2984	95.7	95.7	95.2	0.88	608	7.2	1136	2.2	3.0	3.60	1750	83
400 [3]	M3BP 355 MLA 2	3GBP351410-••G	2982	96.9	96.6	95.9	0.88	677	7.1	1280	2.3	2.9	4.10	2000	83
450 [3]	M3BP 355 MLB 2	3GBP351420-••G	2983	97.1	97.0	96.4	0.90	743	7.9	1440	2.2	2.9	4.30	2080	83
500 [3]	M3BP 355 LKA 2	3GBP351810-••G	2982	96.9	96.9	96.5	0.90	827	7.5	1601	2.0	3.9	4.80	2320	83
560 [2]	M3BP 400 LA 2	3GBP401510-••G	2988	97.2	97.2	96.6	0.89	934	7.8	1789	2.1	3.4	7.90	2950	82
560 [2]	M3BP 400 LKA 2	3GBP401810-••G	2988	97.2	97.2	96.6	0.89	934	7.8	1789	2.1	3.4	7.90	2950	82
560 [3]	M3BP 355 LKB 2	3GBP351820-••G	2983	97.0	97.0	96.5	0.90	925	8.0	1792	2.2	4.1	5.20	2460	83
630 [2]	M3BP 400 LB 2	3GBP401520-••G	2987	97.4	97.4	96.9	0.89	1048	7.8	2014	2.2	3.4	8.20	3050	82
630 [2]	M3BP 400 LKB 2	3GBP401820-••G	2987	97.4	97.4	96.9	0.89	1048	7.8	2014	2.2	3.4	8.20	3050	82
710 [2]	M3BP 400 LC 2	3GBP401530-••G	2987	97.5	97.4	97.0	0.89	1180	7.8	2269	2.6	3.4	9.30	3300	82
710 [2]	M3BP 400 LKC 2	3GBP401830-••G	2987	97.5	97.4	97.0	0.89	1180	7.8	2269	2.6	3.4	9.30	3300	82
800 [1] [2]	M3BP 450 LA 2	3GBP451510-••G	2990	97.2	97.1	96.4	0.88	1349	7.8	2554	1.3	3.2	12.5	4000	85
900 [1] [2]	M3BP 450 LB 2	3GBP451520-••G	2990	97.3	97.2	96.6	0.88	1517	7.8	2874	1.5	3.1	14.0	4200	85
1000 [1] [4]	M3BP 450 LC 2	3GBP451530-••G											15.5	4400	85

[1] Temperature rise class F
[2] Unidirectional fan, variant code 044 or 045 is mandatory
[3] 3 dB(A) sound pressure level reduction with unidirectional fan construction. Direction of rotation must be stated when ordering, see variant codes 044 and 045
[4] Data on request

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☎ : 01 45 14 28 28
📠 : 01 48 73 63 15

3. Il faut ensuite définir le **type de service** pour le moteur :

Philippe LE BRUN
Lycée Louis ARMAND
173 Bd de Strasbourg
94736 NOGENT sur Marne

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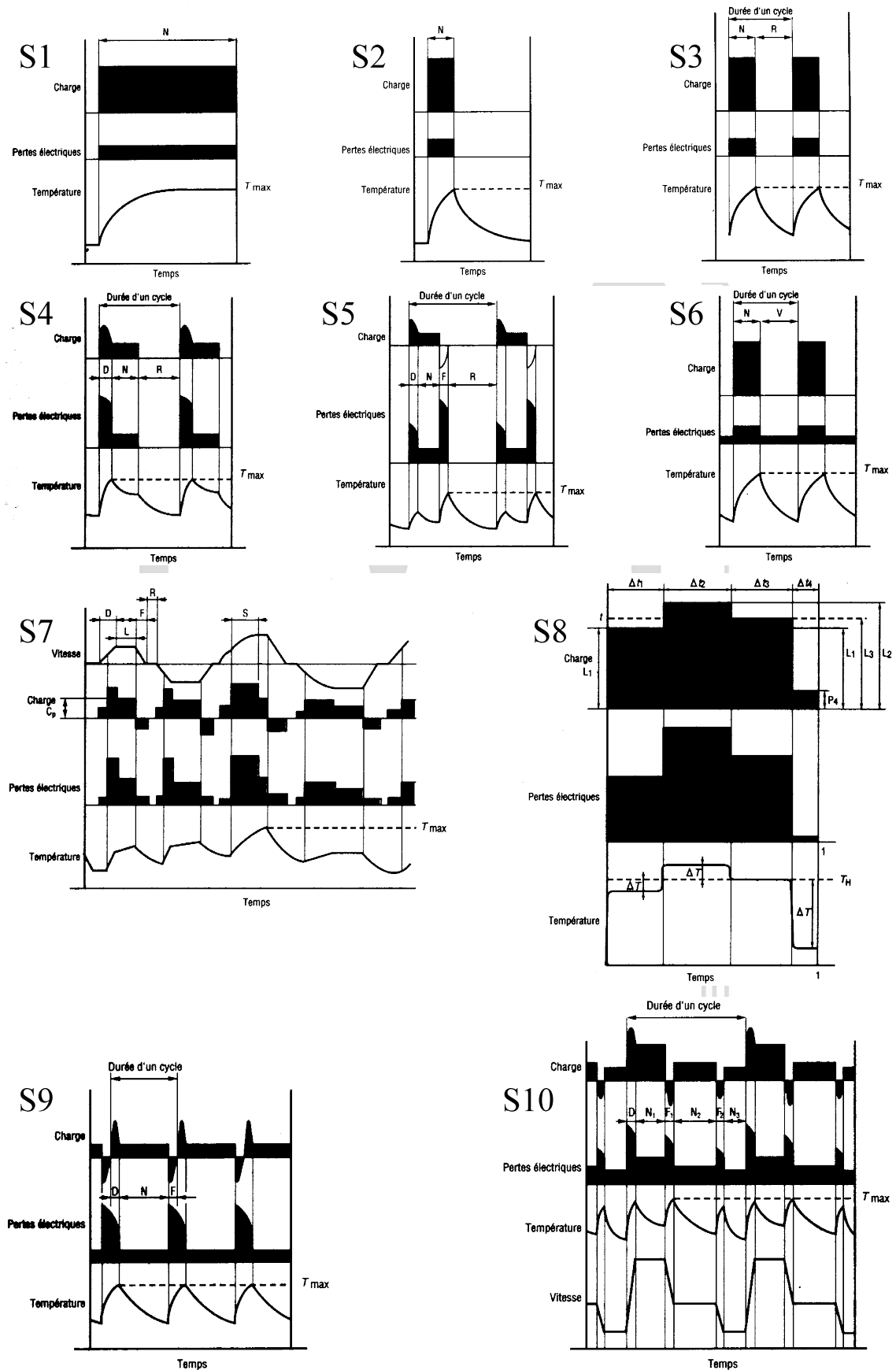
a) **Service continu - Service type Sl** : Fonctionnement à charge constante nominale d'une durée suffisante pour que l'équilibre thermique soit atteint. Fdm (facteur de marche) = 1 et n (nombre de démarrages équivalent par heure) <= 6.

b) **Service temporaire - Service type S2** : Fonctionnement à charge constante nominale pendant un temps déterminé N, moindre que celui requis pour atteindre l'équilibre thermique, suivi d'un repos d'une durée suffisante pour rétablir à 2° C près l'égalité de température entre la machine et le fluide de refroidissement. Fdm selon cahier des charges et n = 1.

c) **Service Intermittent périodique - Service type S3** : Suite de cycles de service identiques comprenant chacun une période de fonctionnement à charge constante nominale N et une période de repos R. Dans ce service, le cycle est tel que le courant de démarrage n'affecte pas l'échauffement de façon significative. Fdm = N/N+R et n = 0.

d) **Service intermittent périodique à démarrage - Service type S4** : Suite de cycles de service identiques comprenant une période appréciable de démarrage D, une période de fonctionnement à charge constante nominale N et une période de repos R. Fdm = N+D/N+D+R et n selon cahier des charges, remplacer n par 4n dans la formule.

e) **Service intermittent périodique à freinage électrique - Service type S5** : Suite de cycles de service périodiques comprenant chacun une période de démarrage D, une période de fonctionnement à charge constante nominale N, une période de freinage électrique rapide F et une période de repos R. Fdm = N+D+F/N+D+F+R et n selon cahier des charges, remplacer n par 4n dans la formule.

f) **Service ininterrompu périodique à charge intermittente - Service type S6** : Suite de cycles de service identiques comprenant chacun une période de fonctionnement à charge constante nominale N et une période de fonctionnement à vide V. Il n'existe pas de période de repos. Fdm = N/N+V et n = 0. Calcul de P pour régime intermitent.

g) **Service ininterrompu périodique à freinage électrique - Service type S7** : Suite de cycles de service identiques comprenant chacun une période de démarrage D, une période de fonctionnement à charge constante L et une période de freinage électrique F. Il n'existe pas de période de repos. Fdm = 1 et n selon cahier des charges, remplacer n par 4n dans la formule.

h) **Service ininterrompu périodique à changements liés de charge et vitesse - Service type S8** : Suite de cycles de service identiques comprenant chacun une période de fonctionnement à charge constante L1 correspondant à une vitesse de rotation prédéterminée, suivie d'une ou plusieurs périodes de fonctionnement à d'autres charges constantes L2 L3 correspondant à différentes vitesses de rotation. Il n'existe pas de période de repos. Fdm = 1 et n selon cahier des charges, remplacer n par 4n dans la formule. Calcul de P pour régime intermittent.

i) **Service à variations non périodiques de charge et de vitesse - Service type S9** : Service dans lequel la charge et la vitesse ont une variation non périodique dans la plage de fonctionnement admissible. Ce service inclut fréquemment des surcharges appliquées qui peuvent être largement supérieures à la pleine charge. Pour ce service type, des valeurs appropriées à pleine charge devront être considérées comme bases du concept de surcharge. Fdm = 1 et n selon cahier des charges, remplacer n par 4n dans la formule. Calcul de P pour régime intermittent.

j) **Service à régimes constants distincts - Service type S10** : Service comprenant au plus quatre valeurs distinctes de charges (ou charges équivalentes), chaque valeur étant appliquée pendant une

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durée suffisante pour que la machine atteigne l'équilibre thermique. La charge minimale pendant un cycle de charge peut avoir la valeur zéro (fonctionnement à vide ou temps de repos). Fdm = 1 et n = 0. Calcul de P pour régime intermittent.

Détermination de la puissance apparente en fonction des services $\boxed{\text{S1 à S10}}$

$$P_a = \sqrt{\frac{n \times t_d \times \left[\dfrac{I_d}{I_n} \times P_n \right]^2 + (3600 - n \times t_d) P_u^2 \times F_{dm}}{3600}}$$

Dans laquelle :

t_d : temps de démarrage avec un moteur de puissance Pn (s)

n : nombre de démarrages équivalent par heure $n = n_D + 3.n_F + 0,5.n_i$

n_D : nombre de démarrages dans l'heure

n_F : nombre de freinages électriques dans l'heure

n_i : nombre d'impulsion (démarrage incomplet jusqu'à 1/3 de la vitesse finale) dans l'heure

Fdm : facteur de marche (%) = durée de fonctionnement à P_u / durée totale du cycle

I_d/I_n : appel de courant avec un moteur de puissance P_n

P_u : puissance utile du moteur pendant le cycle d'utilisation hors démarrage

P_n : puissance nominale du moteur pressenti

Pour les régimes à charges intermittentes :

$$P_u = \sqrt{\frac{P_1^2.t_1 + P_2^2.t_2 + ... + P_n^2.t_n}{t_1 + t_2 + ... + t_n}}$$

- Les P_i inférieures à $\dfrac{P_n}{2}$ (puissance nominale moteur) seront remplacées par $\dfrac{P_n}{2}$

- Aucun des P_i ne dépassera $2 \times P$

- Le temps de démarrage réel ne dépasse pas 5 s

- Le couple accélérateur reste toujours suffisant sur la période de démarrage

4. Il est possible de sélectionner un moteur en fonction de la **puissance** et de la **vitesse** désirée.

Ce choix est valable pour des conditions d'utilisation normales suivantes (norme CEI 34-1)
- Température ambiante comprise entre + 5 et + 40 °C,
- Altitude inférieure à 1000 m,
- Pression atmosphérique : 1050 m bar,
- Mode de refroidissement IC 411,
- Taux harmonique < 10%,
- Déséquilibre de tension < 2%,
- Tension d'alimentation de 230 V / 400 V 50 Hz +/- 10%,
- Chute de tension maximale entre le point de livraison et le point d'utilisation < 4%,
- Classe d'isolation F,
- Degrés de protection IP 55.

Pour des conditions d'emploi différentes, on appliquera le(s) coefficient(s) de correction de la puissance avant de prédéterminer notre moteur.

Dimension drawings
Foot-mounted cast iron motors, 280 - 315

D-end

N-end
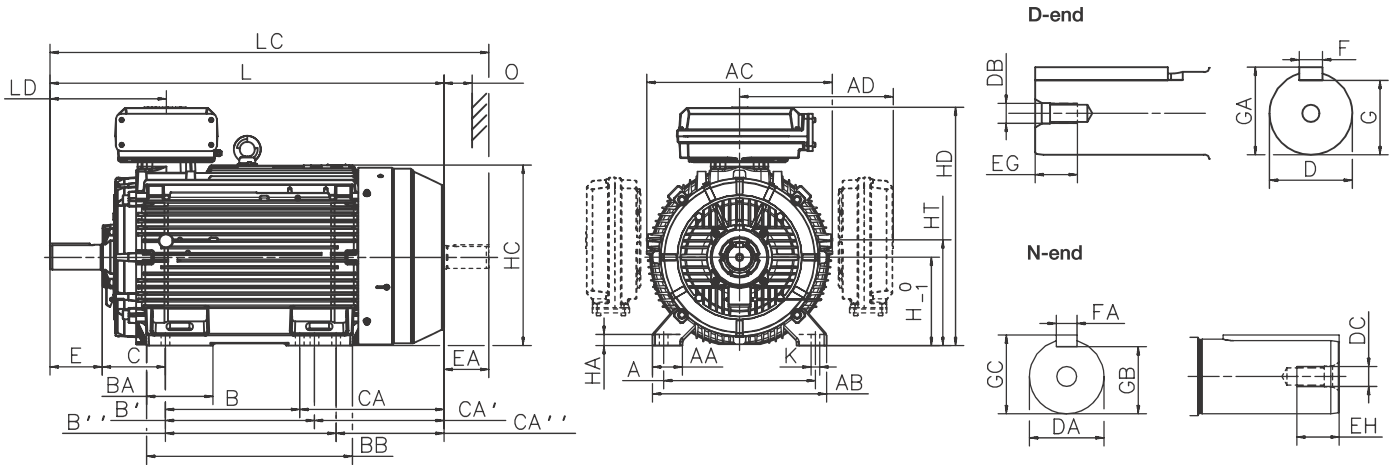
Mounting options IM B3 (IM 1001), IM B6 (IM 1051), IM B7 (IM 1061), IM B8 (IM 1071), IM V5 (IM 1011), IM V6 (IM 1031)

Motor size	Poles	A	AA	AB	AC	AD [1]	AD [2]	B	B'	B"	BA	BB	C	CA	CA'	CA"	D	DA	DB	DC	E
280 SM_	2	457	84	530	577	481	-	368	419	-	147	506	190	400	349	-	65	60	M20	M20	140
	4-12	457	84	530	577	481	-	368	419	-	147	506	190	400	349	-	75	65	M20	M20	140
280 ML_	2	457	84	530	577	-	504	419	457	-	193	608	190	400	349	-	65	60	M20	M20	140
	4-12	457	84	530	577	481	504	419	457	-	193	608	190	400	349	-	75	65	M20	M20	140
315 SM_	2	508	100	590	654	545	-	406	457	-	180	558	216	420	369	-	65	60	M20	M20	140
	4-12	508	100	590	654	545	-	406	457	-	180	558	216	420	369	-	80	75	M20	M20	170
315 ML_	2	508	100	590	654	545	-	457	508	-	212	669	216	480	429	-	65	60	M20	M20	140
	4-12	508	100	590	654	545	-	457	508	-	212	669	216	480	429	-	90	75	M24	M20	170
315 LK_	2	508	100	590	654	562	576	508	560	710	336	851	216	635	583	433	65	60	M20	M20	140
	4-12	508	100	590	654	562	576	508	560	710	336	851	216	635	583	433	90	75	M24	M20	170

Motor size	Poles	EA	EG	EH	F	FA	G	GA	GB	GC	H	HA	HC	HD [1] top-m.	HD [2] top-m.	HT	K	L	LC	LD top-m.	LD side-m.	O
280 SM_	2	140	40	40	18	18	58	69	53	64	280	31	564	762	-	337.5	24	1088	1238	336	539	100
	4-12	140	40	40	20	18	67.5	79.5	58	69	280	31	564	762	-	337.5	24	1088	1238	336	539	100
280 ML_	2	140	40	40	18	18	58	69	53	64	280	31	564	-	785	337.5	24	1189	1340	336	590	100
	4-12	140	40	40	20	18	67.5	79.5	58	69	280	31	564	762	785	337.5	24	1189	1340	336	590	100
315 SM_	2	140	40	40	18	18	58	69	53	64	315	40	638	852	-	375	28	1174	1322	356	585	115
	4-12	140	40	40	22	20	71	85	67.5	79.5	315	40	638	852	-	375	28	1204	1352	386	615	115
315 ML_	2	140	40	40	18	18	58	69	53	64	315	40	638	852	-	375	28	1285	1433	356	640	115
	4-12	140	48	40	25	20	81	95	67.5	79.5	315	40	638	852	-	375	28	1315	1463	386	670	115
315 LK_	2	140	40	40	18	18	58	69	53	64	315	40	638	852	880	359	28	1491	1639	356	721	115
	4-12	140	48	40	25	20	81	95	67.5	79.5	315	40	638	852	880	359	28	1521	1669	386	751	115

Tolerances	
A, B	± 0.8
C, CA	± 0.8
D	ISO k6 < Ø 50 mm
	ISO m6 > Ø 50 mm
F	ISO h9
H	+ 0 -0.5
N	ISO j6

Footnotes

[1] Terminal box 370
[2] Terminal box 750

Dimension drawings
Flange- and foot & flange mounted cast iron motors, 280 - 315
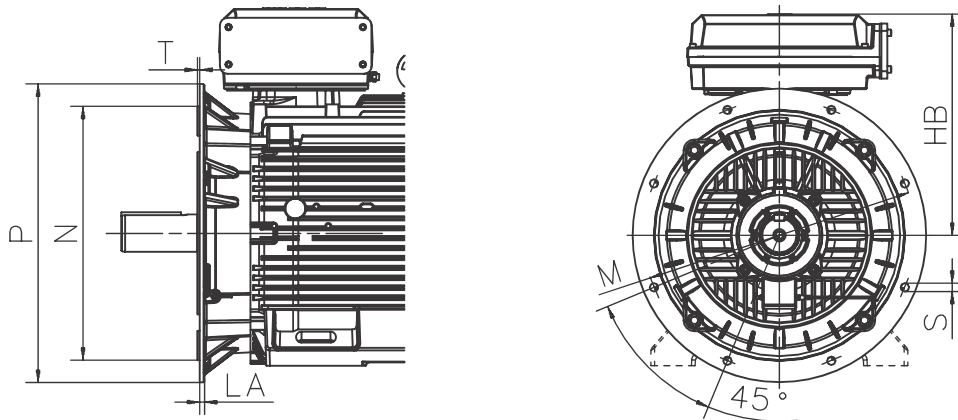
Mounting options IM B5 (IM 3001)V1, (IM 3011), V3 (IM 3031), IM B14 (IM 3601), V18 (IM 3611), V19 (IM 3631), IM B35 (IM 2001), IM V15 (IM 2011), IM V36 (IM 2031)

Motor size	Poles	HB [1]	HB [2]	LA	M	N	P	S	T
280 SM_	2	482	-	23	500	450	550	18	5
	4-12	482	-	23	500	450	550	18	5
280 ML_	2	-	505	23	500	450	550	18	5
	4-12	482	505	23	500	450	550	15	5
315 SM_	2	537	-	25	600	550	660	23	6
	4-12	537	-	25	600	550	660	23	6
315 ML_	2	537	-	25	600	550	660	23	6
	4-12	537	-	25	600	550	660	23	6
315 LK_	2	537	565	25	600	550	660	23	6
	4-12	537	565	25	600	550	660	23	6

Tolerances		Footnotes
A, B	± 0.8	[1] Terminal box 370
D	ISO j6	[2] Terminal box 750
F	ISO h9	
H	+0 - 0.1	
N	ISO j6 (280 SM_)	
	ISO js6 (315_)	
C	± 0.8	

Terminal box
Terminal box dimensions

For motor sizes 71 to 132 the terminal box is integrated in motor frame and the dimensions for terminal boxes can be found in the motor dimension drawings in ABB Library.

To match the correct terminal box with motor sizes 160 - 450, find the motor type and correspondent terminal box type on the previous page. The box types and heir dimensions are presented on this page.
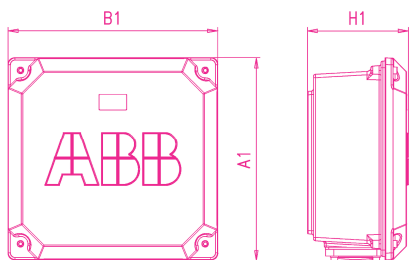
Terminal box types 160, 260 and 350
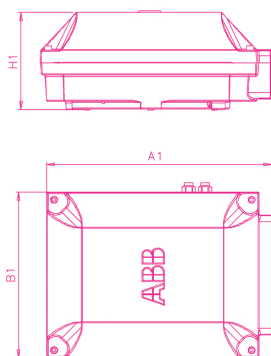
Terminal box types 210 and 370
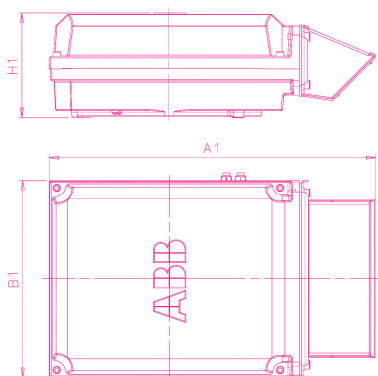
Terminal box type 750 + adapter
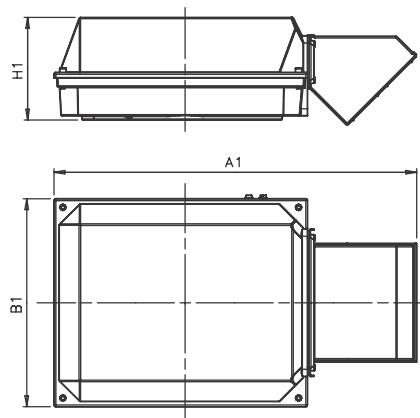
Terminal box type 1200 + adapter

Terminal box types acc. to current capacity	A1	B1	H1
160	257	257	145
260	257	257	136
350	300	311	150
210	416	306	177
370	451	347	200
750, top-mounted	686	413	219
750, side-mounted	525	413	219
1200 (variant code 295)*	1000	578	285
1200 (variant code 444)	1195	578	285
1200 (variant code 296)	1250	578	285

* Standard terminal box for motor size 450. See Optional adapters for more information.

Dimensions for terminal box inlets
Corresponds to motor sizes 160 and above
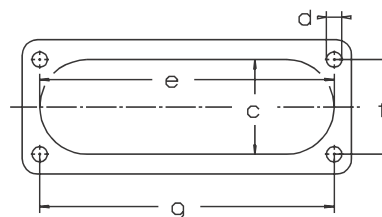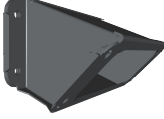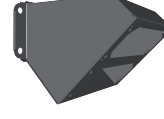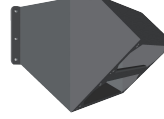
Flange opening	c mm	e mm	f mm	g mm	d thread type
B	71	194	62	193	M8
C	62	193	62	193	M8
D	100	300	80	292	M10
E	115	370	100	360	M12

Optional adapters
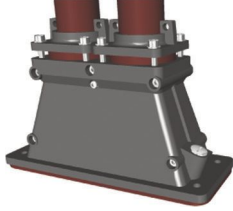
To allow easy termination of cables entering the terminal box from above or below, an angle adapter is recommended.These are available for motor sizes 280 and above and can also be used to allow the mounting of several cable sealing end units or gland plates. For exact suitability on a certain motor size, refer to the 'terminal box opening' column in section Standard terminal box.

Adapter						
Variant code	292	293	294	295	296	444
Suited for motor sizes	280	315, 355	315 LKC IE2, 355 SM_ 2-4 poles, 400 - 450	315 LKC IE2, 355 SM_ 2-4 poles, 400 - 450	315 LKC IE2, 355 SM_ 2-4 poles, 400 - 450	315 LKC IE2, 355 SM_ 2-4 poles, 400 - 450
Opening to terminal box	C	D	E	E	E	E
Flange or opening for end unit	C	D	D	2 x D	3 x D	2 x E
Material	Steel	Steel	Steel	Steel	Steel	Steel
Notes			Included in type 750 terminal box when 750 is the standard size.	Included in type 1200 terminal box when 1200 is the standard size.	Only possible on type 1200 terminal box	Only possible on type 1200 terminal box

Cable sealing end units

As an alternative to flanges and cable glands, cable sealing end units can be used. These allow more space for spreading the cores for easy termination.
Cable sealing end units have rubber-sealed entries for one of two main cables. In addition, there are two plugged M20 holes for auxiliary cables.

End unit			
Variant code	277	278	279
Suited for motor sizes	280	315, 355, except 315 LKC IE2, 355 SM_ 2-4 poles	315, 355, except 315 LKC IE2, 355 SM_ 2-4 poles
Opening to terminal box	C	D	D
Cable outer diameter	1 - 2 cables, 48 - 60 mm	1 - 2 cables, 48 - 60 mm	1 - 2 cables, 60 - 80 mm
Cable entry for auxiliary cable	2 x M20 plugged holes	2 x M20 plugged holes	2 x M20 plugged holes
Additional optional variants	EMC cable gland (704); Standard gland with clamping device (231)	EMC cable gland (704); Standard gland with clamping device (231)	EMC cable gland (704); Standard gland with clamping device (231)

Silencer for motor sizes 280 - 450
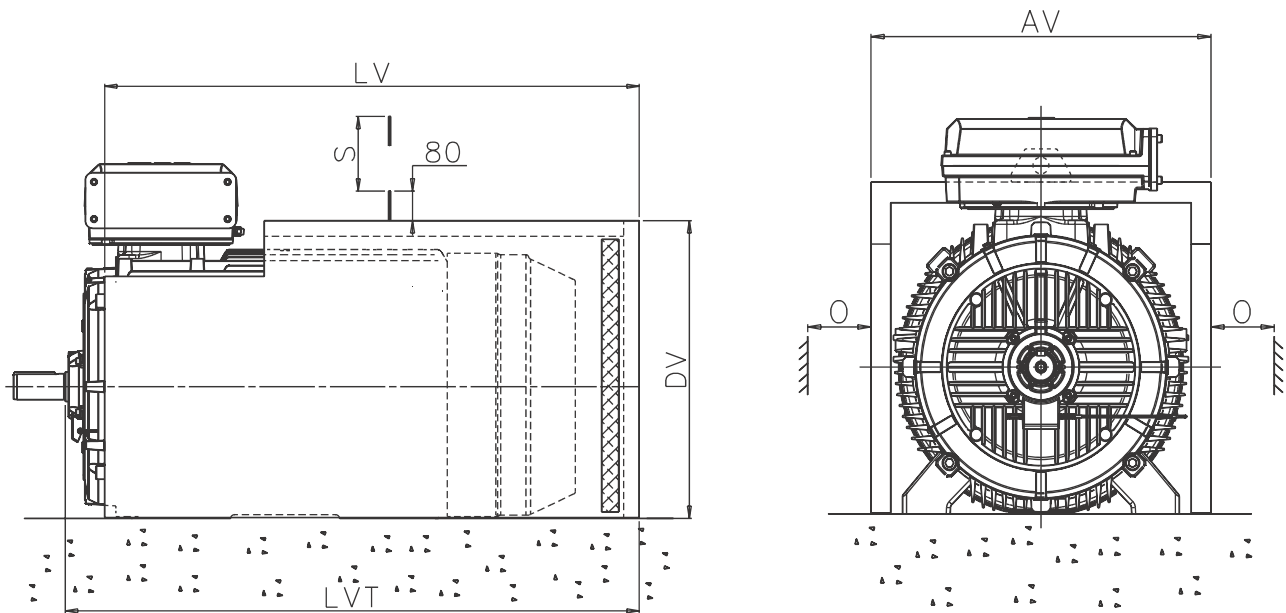
Both foot-mounted and flange-mounted motors can be fitted with a silencer to reduce noise level by about 5 - 6 dB(A). The silencer is painted blue and made of 2 mm steel sheet. The sound absorbing material is 40 mm thick polyurethane foam. On the rim there is a rubber strip for sealing on the floor. The silencer fits loosely over the motor.

The variant code for ordering a silencer is 055.

Motor size	AV	LV	LVT	DV	O[1]	S[2]	Weight kg
280 SM_	681	1010	1090	616	50	762	38
315 SM_	760	1094	1191	697	60	852	47
315 ML_	760	1205	1302	697	60	852	51
315 LK_	760	1411	1508	697	60	852	58
355 SM_	850	1335	1441	777	65	958	62
355 ML_	850	1440	1546	777	65	958	67
355 LK_	850	1690	1796	777	65	958	77
400 L_	938	1750	1873	866	75	1045	88
400 LK_	938	1750	1873	866	75	1045	88
450 L_	1050	2110	2230	990	80	1045	120

[1] Clearance for motor cooling.
[2] Clearance for removal of silencer.
Note: The dimensions are only valid for standard foot-mounted motors.

Slide rails for motor sizes 280 - 400
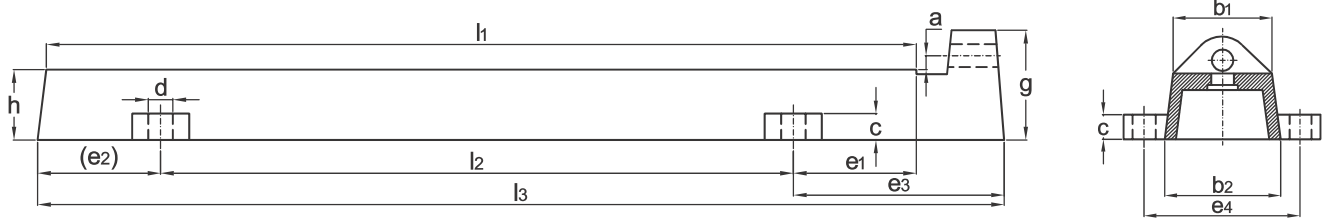
Slide rails for motor sizes 280 - 315.
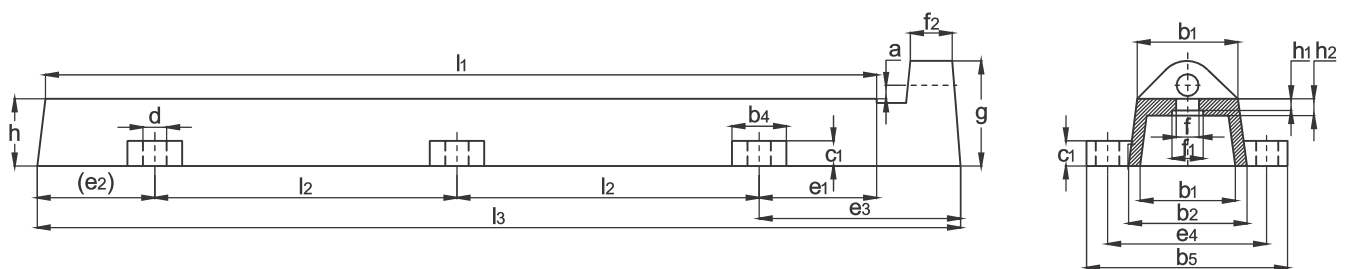
Slide rails for motor sizes 355 - 400.

Note: Slide rails that do not fulfill the DIN standard are available for motor size 450 on request.

A set of slide rails includes two complete rails with screws for mounting the motor on the rails. Screws for mounting the rails on the foundation are not included. Slide rails have unmachined lower surfaces and should be supported in a suitable manner before tightening down.

Slide rails can be ordered with article numbers shown in the table.

Motor														Bolts	Horizontal	Weight
size	Article no.	l1	l2	l3	a	h	b1	b2	c	d	e1	e2	e3	e4	to feet	bolts	kg/2 pc
280	3GZF334730-55	800	600	900	16	75	100	120	35	28	100	100	200	165	M20x90	M24x300	50
315	3GZF334730-56	1000	720	1100	16	80	120	140	40	28	140	140	240	190	M24x100	M24x300	80
355 - 400	3GZF334730-57	1250	485	1350	16	80	120	140	35	28	140	140	240	190	M24x100	M24x300	90

Wall-mounted drives
ACS800-01, up to 200 kW

Compact and complete drive

The ACS800-01 offers all that you need in a single, extremely small, wall-mounted package making it a compact and complete drive. The standard degree of protection is IP21. Optional IP55 allows equal performance without additional derating. Power ratings start from 0.55 kW heavy-duty rating and go up to 200 kW continuous load rating. There are five different mechanical frame sizes covering the power range. Each frame size is optimized in performance, size and weight.

Everything inside

From the smallest to the biggest ACS800-01 there is an extensive range of built-in features and options. Standard features include a choke for harmonic filtering and drive protection, extensive and flexible I/O, user-friendly control panel with Startup assistant feature and a silent, long lifetime cooling fan. Brake chopper is included as standard in the two smallest frame sizes R2 and R3 as well as in the 690 V R4 frame. In other frames the chopper is an built-in option. External options include EMC filters and extension modules for additional I/O, fieldbus and pulse encoder.

Main standard hardware features

– Wall mounting
– IP21 protection degree
– Compact design
– Harmonic filtering choke inside
– Input rectifier protection
– Brake chopper (in frame sizes R2-R3; R4 only 690 V)
– Long lifetime cooling fan and capacitors
– Extensive, programmable I/O with galvanically isolated inputs
– Three I/O and fieldbus extension slots inside
– Alphanumeric, multilingual control panel with startup assistant feature
– Large power terminals allowing use of a wide range of cable sizes

Options for ACS800-01

Built-in options:

– IP55 protection degree
– Brake chopper (in frame sizes R4-R6)
– EMC filter for 1st environment, restricted distribution according to EN 61800-3 (category C2)
– EMC filter for 2nd environment, unrestricted distribution according to EN 61800-3 (category C3)
– Analog and digital I/O extension modules
– Fieldbus modules
– Pulse encoder interface module

External options:

– Brake resistor
– Output filters
– Safe torque-off (STO)

Marine type approved design as an option.

ACS800-01 size	Nominal ratings		No-overload use	Light-overload use		Heavy-duty use		Frame size	Air flow	Heat dissipation
	$I_{cont.max}$ A	I_{max} A	$P_{cont.max}$ kW	I_{2N} A	P_N kW	I_{2hd} A	P_{hd} kW		m³/h	W
Three-phase supply voltage 380 V, **400 V** or 415 V										
-0003-3	5.1	6.5	1.5	4.7	1.5	3.4	1.1	R2	35	100
-0004-3	6.5	8.2	2.2	5.9	2.2	4.3	1.5	R2	35	120
-0005-3	8.5	10.8	3	7.7	3	5.7	2.2	R2	35	140
-0006-3	10.9	13.8	4	10.2	4	7.5	3	R2	35	160
-0009-3	13.9	17.6	5.5	12.7	5.5	9.3	4	R2	35	200
-0011-3	19	24	7.5	18	7.5	14	5.5	R3	69	250
-0016-3	25	32	11	24	11	19	7.5	R3	69	340
-0020-3	34	46	15	31	15	23	11	R3	69	440
-0025-3	44	62	22	41	18.5	32	15	R4	103	530
-0030-3	55	72	30	50	22	37	18.5	R4	103	610
-0040-3	72	86	37	69	30	49	22	R5	250	810
-0050-3	86	112	45	80	37	60	30	R5	250	990
-0060-3	103	138	55	94	45	69	37	R5	250	1190
-0075-3	145	170	75	141	75	100	45	R5	405	1440
-0070-3 *	141	164	75	132	55	97	45	R6	405	1440
-0100-3	166	202	90	155	75	115	55	R6	405	1940
-0120-3	202	282	110	184	90	141	75	R6	405	2310
-0135-3	225	326	110	220	110	163	90	R6	405	2810
-0165-3	260	326	132	254	132	215	110	R6	405	3260
-0205-3	290	351	160	285	160	234	132	R6	405	4200
Three-phase supply voltage 380 V, 400 V, 415 V, 440 V, 460 V, 480 V or **500** V										
-0004-5	4.9	6.5	2.2	4.5	2.2	3.4	1.5	R2	35	120
-0005-5	6.2	8.2	3	5.6	3	4.2	2.2	R2	35	140
-0006-5	8.1	10.8	4	7.7	4	5.6	3	R2	35	160
-0009-5	10.5	13.8	5.5	10	5.5	7.5	4	R2	35	200
-0011-5	13.2	17.6	7.5	12	7.5	9.2	5.5	R2	35	250
-0016-5	19	24	11	18	11	13	7.5	R3	69	340
-0020-5	25	32	15	23	15	18	11	R3	69	440
-0025-5	34	46	18.5	31	18.5	23	15	R3	69	530
-0030-5	42	62	22	39	22	32	18.5	R4	103	610
-0040-5	48	72	30	44	30	36	22	R4	103	810
-0050-5	65	86	37	61	37	50	30	R5	250	990
-0060-5	79	112	45	75	45	60	37	R5	250	1190
-0070-5	96	138	55	88	55	69	45	R5	250	1440
-0105-5	145	170	90	141	90	100	55	R5	405	2150
-0100-5 *	124	164	75	115	75	88	55	R6	405	1940
-0120-5	157	202	90	145	90	113	75	R6	405	2310
-0140-5	180	282	110	163	110	141	90	R6	405	2810
-0165-5	225	326	132	220	132	163	110	R6	405	3260
-0205-5	260	326	160	254	160	215	132	R6	405	3800
-0255-5	290	351	200	285	200	234	160	R6	405	4500

* Type not available any more

ACS800-01 size	Nominal ratings		No-overload use	Light-overload use		Heavy-duty use		Frame size	Air flow	Heat dissipation
	$I_{cont.max}$ A	I_{max} A	$P_{cont.max}$ kW	I_{2N} A	P_N kW	I_{2hd} A	P_{hd} kW		m³/h	W
Three-phase supply voltage 525 V, 550 V, 575 V, 600 V, 660 V or **690** V										
-0011-7	13	14	11	11.5	7.5	8.5	5.5	R4	103	300
-0016-7	17	19	15	15	11	11	7.5	R4	103	340
-0020-7	22	28	18.5	20	15	15	11	R4	103	440
-0025-7	25	38	22	23	18.5	19	15	R4	103	530
-0030-7	33	44	30	30	22	22	18.5	R4	103	610
-0040-7	36	54	30	34	30	27	22	R4	103	690
-0050-7	51	68	45	46	37	34	30	R5	250	840
-0060-7	57	84	55	52	45	42	37	R5	250	1010
-0070-7	79	104	75	73	55	54	45	R6	405	1220
-0100-7	93	124	90	86	75	62	55	R6	405	1650
-0120-7	113	172	110	108	90	86	75	R6	405	1960
-0145-7	134	190	132	125	110	95	90	R6	405	2660
-0175-7	166	245	160	155	132	131	110	R6	405	3470
-0205-7	190	245	160	180	160	147	132	R6	405	4180

0009693

Symbols

Nominal ratings

$I_{cont.max}$ continuous rms output current. No overload capability at 40 °C (104 °F).

I_{max} maximum output current. Available for 10 s at start, otherwise as long as allowed by drive temperature.

Typical ratings:

No-overload use

$P_{cont.max}$ typical motor power. The power ratings apply to most IEC 60034 motors at the nominal voltage, 230 V, 400 V, 500 V or 690 V.

Light-overload use (10% overload capability)

I_{2N} continuous rms current. 10% overload is allowed for one minute every 5 minutes.

P_N typical motor power. The power ratings apply to most IEC 60034 motors at the nominal voltage, 230 V, 400 V, 500 V or 690 V.

Heavy-duty use (50% overload capability)

I_{2hd} continuous rms current. 50% overload is allowed for one minute every 5 minutes.

P_{hd} typical motor power. The power ratings apply to most IEC 60034 motors at the nominal voltage, 230 V, 400 V, 500 V or 690 V.

Sizing

The current ratings are the same regardless of the supply voltage within one voltage range. To achieve the rated motor power given in the table, the rated current of the drive must be higher than or equal to the rated motor current.

Note 1: The maximum allowed motor shaft power is limited to $1.5 \cdot P_{hd}$, $1.1 \cdot P_N$ or $P_{cont.max}$ (whichever value is greatest). If the limit is exceeded, motor torque and current are automatically restricted. The function protects the input bridge of the drive against overload. If the condition exists for 5 minutes, the limit is set to $P_{cont.max}$.

Note 2: The ratings apply at an ambient temperature of 40 °C (104 °F). At lower temperatures the ratings are higher (except I_{max}).

Frame size R6 (IP55, UL type 12) -0205-3 and -0255-5 units
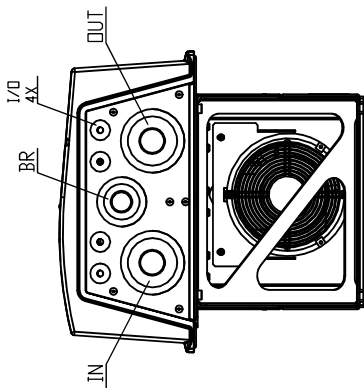
GROMMET WIRE RANGE:

I/O	10 – 14 [0.39 – 0.55]
BRAKE	30..45 [1.18 – 1.77]
IN, OUT	40..60 [1.57 – 2.36]

424.18 [16.70]

420 [16.53]

994 [39.11]

16 [.63]
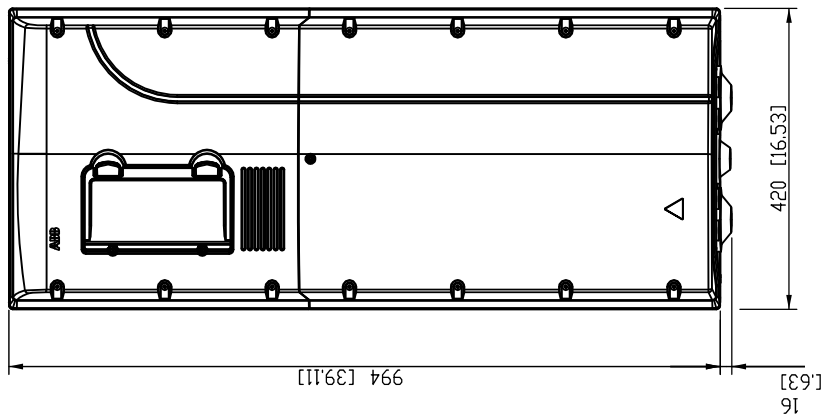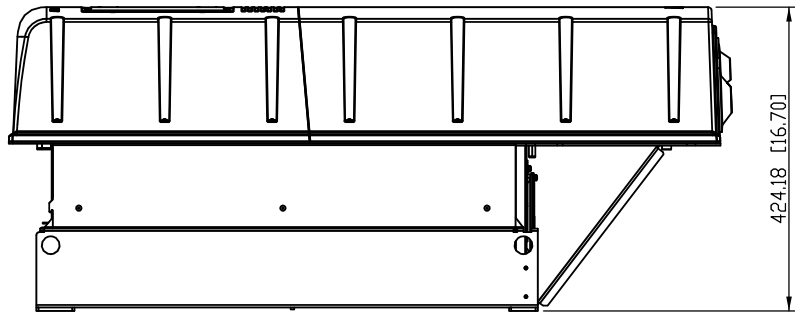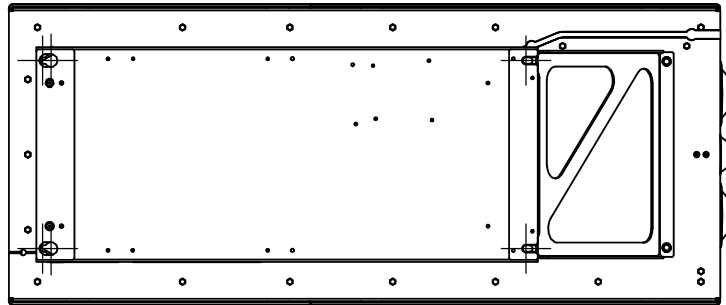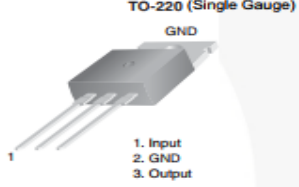
3AUA000057578

Annexe 9 : datasheet des composants
et programme de la carte ARDUINO

7805

TO-220 (Single Gauge)
GND

1. Input
2. GND
3. Output

Ordering Information[1]

Product Number	Output Voltage Tolerance	Package	Operating Temperature	Packing Method
LM7805CT	±4%	TO-220 (Single Gauge)	-40°C to +125°C	Rail
LM7806CT				
LM7808CT				
LM7809CT				
LM7810CT				
LM7812CT				
LM7815CT				
LM7818CT				
LM7824CT				
LM7805ACT	±2%		0°C to +125°C	
LM7809ACT				
LM7810ACT				
LM7812ACT				
LM7815ACT				

Note:
1. Above output voltage tolerance is available at 25°C.

PC817

■ Electro-optical Characteristics

$(T_a=25°C)$

	Parameter		Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Input	Forward voltage		V_F	$I_F=20mA$	–	1.2	1.4	V
	Peak forward voltage		V_{FM}	$I_{FM}=0.5A$	–	–	3.0	V
	Reverse current		I_R	$V_R=4V$	–	–	10	μA
	Terminal capacitance		C_t	$V=0, f=1kHz$	–	30	250	pF
Output	Collector dark current		I_{CEO}	$V_{CE}=50V, I_F=0$	–	–	100	nA
	Collector-emitter breakdown voltage		BV_{CEO}	$I_C=0.1mA, I_F=0$	[5] 80	–	–	V
	Emitter-collector breakdown voltage		BV_{ECO}	$I_E=10μA, I_F=0$	6	–	–	V
Transfer characteristics	Collector current		I_C	$I_F=5mA, V_{CE}=5V$	2.5	–	30.0	mA
	Collector-emitter saturation voltage		$V_{CE(sat)}$	$I_F=20mA, I_C=1mA$	–	0.1	0.2	V
	Isolation resistance		R_{ISO}	DC500V, 40 to 60%RH	$5×10^{10}$	$1×10^{11}$	–	Ω
	Floating capacitance		C_f	$V=0, f=1MHz$	–	0.6	1.0	pF
	Cut-off frequency		f_c	$V_{CE}=5V, I_C=2mA, R_L=100Ω, –3dB$	–	80	–	kHz
	Response time	Rise time	t_r	$V_{CE}=2V, I_C=2mA, R_L=100Ω$	–	4	18	μs
		Fall time	t_f		–	3	18	μs

[5] From the production Date code "J5" (May 1997) to "P7" (July 2002), however the products were screened by $BV_{CEO}≥70V$.

■ Absolute Maximum Ratings

$(T_a = 25°C)$

	Parameter	Symbol	Rating		Unit
Input	Forward current	I_F	50		mA
	*1 Peak forward current	I_{FM}	1		A
	Reverse voltage	V_R	6		V
	Power dissipation	P	70		mW
Output	Collector-emitter voltage	V_{CEO}	*4 80		V
	Emitter-collector voltage	V_{ECO}	6		V
	Collector current	I_C	50		mA
	Collector power dissipation	P_C	150		mW
Total power dissipation		P_{tot}	200		mW
*2 Isolation voltage		$V_{iso (rms)}$	5.0		kV
Operating temperature		T_{opr}	−30 to +100		°C
Storage temperature		T_{stg}	−55 to +125		°C
*3 Soldering temperature		T_{sol}	260		°C

*1 Pulse width≤100μs, Duty ratio : 0.001
*2 40 to 60%RH, AC for 1minute, f=60Hz
*3 For 10s
*4 Up to Date code "P7" (July 2002) V_{CEO} : 35V.

ATMEGA2560

NOTE:
Shaded parts only available
in the 100-pin version.

Complete functionality for
the ADC, T/C4, and T/C5 only
available in the 100-pin version.
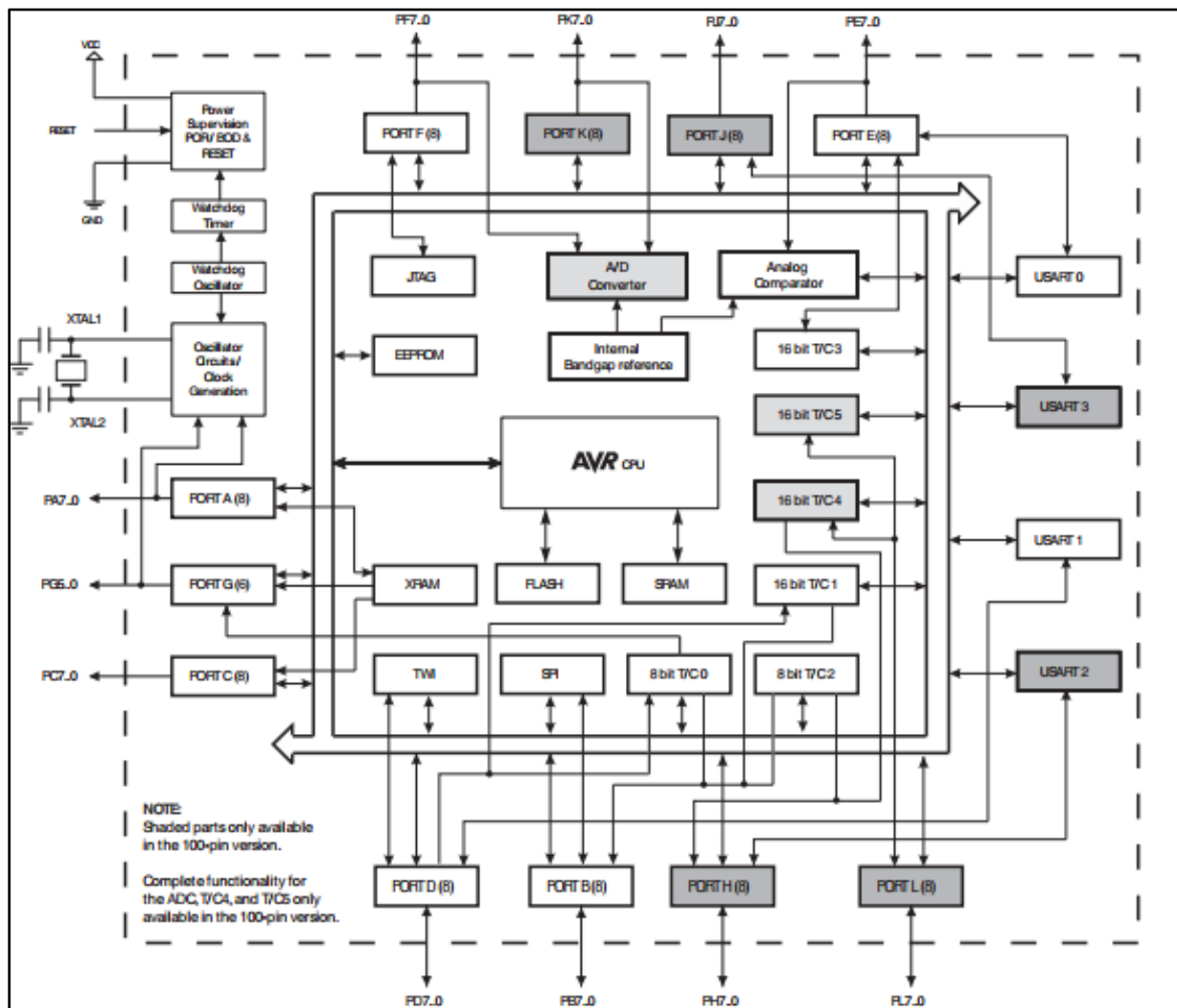
Symbol	Definition	Min.	Max.	Units
V_B	High side floating supply voltage (IR2110)	-0.3	525	
	(IR2113)	-0.3	625	
V_S	High side floating supply offset voltage	V_B - 25	V_B + 0.3	
V_{HO}	High side floating output voltage	V_S - 0.3	V_B + 0.3	
V_{CC}	Low side fixed supply voltage	-0.3	25	
V_{LO}	Low side output voltage	-0.3	V_{CC} + 0.3	V
V_{DD}	Logic supply voltage	-0.3	V_{SS} + 25	
V_{SS}	Logic supply offset voltage	V_{CC} - 25	V_{CC} + 0.3	
V_{IN}	Logic input voltage (HIN, LIN & SD)	V_{SS} - 0.3	V_{DD} + 0.3	
dV_S/dt	Allowable offset supply voltage transient (figure 2)	—	50	V/ns
P_D	Package power dissipation @ T_A ≤ +25°C (14 lead DIP)	—	1.6	
	(14 lead DIP w/o lead 4)	—	1.5	
	(16 lead DIP w/o leads 5 & 6)	—	1.6	W
	(16 lead SOIC)	—	1.25	
R_{THJA}	Thermal resistance, junction to ambient (14 lead DIP)	—	75	
	(14 lead DIP w/o lead 4)	—	85	
	(16 lead DIP w/o leads 5 & 6)	—	75	°C/W
	(16 Lead SOIC)	—	100	
T_J	Junction temperature	—	150	
T_S	Storage temperature	-55	150	°C
T_L	Lead temperature (soldering, 10 seconds)	—	300	

IGBT 50N60

Symbol	Conditions	Characteristic Values (T_{VJ} = 25°C, unless otherwise specified)			
		min.	typ.	max.	
$V_{CE(sat)}$	I_C = 40 A; V_{GE} = 15 V; T_{VJ} = 25°C		2.5	3.1	V
	T_{VJ} = 125°C		3.0		V
$V_{GE(th)}$	I_C = 2 mA; V_{GE} = V_{CE}	4		8	V
I_{CES}	V_{CE} = 0.8 V_{CES}; V_{GE} = 0 V; T_{VJ} = 25°C			0.4	mA
	T_{VJ} = 125°C		3.0		mA
I_{GES}	V_{CE} = 0 V; V_{GE} = ± 20 V			500	nA
$t_{d(on)}$	Inductive load, T_{VJ} = 125°C V_{CE} = 500 V; I_C = 40 A V_{GE} = 0/15 V; R_G = 22 Ω		80		ns
t_r			100		ns
$t_{d(off)}$			380		ns
t_f			75		ns
E_{on}			3.6		mJ
E_{off}			2.1		mJ
C_{ies}	V_{CE} = 25 V; V_{GE} = 0 V; f = 1 MHz		4		nF
Q_{Gon}	V_{CE} = 500V; V_{GE} = 15 V; I_C = 40 A		150		nC
I_{RM}	I_F = 40 A; di_C/dt = -400 A/μs; T_{VJ} = 125°C V_{CE} = -500 V; V_{GE} = 15 V		58		A
t_{rr}			840		ns
R_{thJC}				0.42	K/W

Programme de la carte ARDUINO

```
/*
 * VTx - transistors
 * ------------------<<  + DC voltage (i.e. 250 V)
 *    |     |     |
 *    |     |     |
 *   VT1   VT2   VT3
 *    |     |     |
 *    *------------------a
 *    |     |     |
 *    |     *-------------b
 *    |     |     |
 *    |     |     *--------c
 *   VT4   VT5   VT6
 *    |     |     |
 *    |     |     |
 * ------------------<<   GND
*/
/*
 * transistor - pin
 */
#define VT1 6
#define VT2 7
#define VT3 8
#define VT4 9
#define VT5 10
#define VT6 11
#define RELAY 2
/*
 * max and min delay in microsecond
 * must be <16300
 * use for setup frequency
*/
#define MAX_FREQ 12150 // ~15 Hz
#define MIN_FREQ 1575  // ~100 Hz
/*
 * pin A0 - SET_FREQ frequency setup potentiometer
```

```
 * pin A1 - SET_K_ZAP filling factor setup potetiometer
*/
#define SET_FREQ A0
#define SET_K_ZAP A1
void setup()
{
// put your setup code here, to run once:
  pinMode(VT1, OUTPUT);
  pinMode(VT2, OUTPUT);
  pinMode(VT3, OUTPUT);
  pinMode(VT4, OUTPUT);
  pinMode(VT5, OUTPUT);
  pinMode(VT6, OUTPUT);
  pinMode(RELAY, OUTPUT);
//Serial.begin(9600);//???????????????!
  digitalWrite(RELAY, LOW); /*IR2132 off on setup time*/
  analogWrite(VT1, 255);/*all VTx close*/
  analogWrite(VT2, 255);/*on HINx, LINx (inputs IR2132) +5 V*/
  analogWrite(VT3, 255);
  analogWrite(VT4, 255);
  analogWrite(VT5, 255);
  analogWrite(VT6, 255);
  pinMode(SET_FREQ, INPUT);
  pinMode(SET_K_ZAP, INPUT);
  /*set 4-5kHz frequncy for PWM*/
  TCCR1B = TCCR1B & 0b11111000 | 0x02;
  TCCR2B = TCCR1B & 0b11111000 | 0x02;
  TCCR3B = TCCR1B & 0b11111000 | 0x02;
  TCCR4B = TCCR1B & 0b11111000 | 0x02;
//  delay(5000);
//  digitalWrite(RELAY, HIGH); /*turn on relay and wait 5 seconds*/
//  delay(5000);
}
int sw_time = 60;
int K_zap = 130;
//int time_start;
```

```c
void pwm_loop_fwd_a2(void)/*alpha/2 mode - transistors work 1/2 of
period. three of them simultaneously */
{
  int iteration;
  for (iteration = 1; iteration <= 6; iteration++)
  {
    switch ( iteration )
    {
      case 1:
        analogWrite(VT1, 255);/*all VTx close*/
        analogWrite(VT2, 255);/*on HINx, LINx (inputs IR2132) +5 V*/
        analogWrite(VT3, 255);
        analogWrite(VT4, 255);
        analogWrite(VT5, 255);
        analogWrite(VT6, 255);
        analogWrite(VT1, K_zap);/*open VTx on K_zap value 255 =
close, 0 = full open (inverse logic)*/
        analogWrite(VT3, K_zap);
        analogWrite(VT5, K_zap);
        delayMicroseconds(sw_time);
        break;
      case 2:
        analogWrite(VT1, 255);
        analogWrite(VT2, 255);
        analogWrite(VT3, 255);
        analogWrite(VT4, 255);
        analogWrite(VT5, 255);
        analogWrite(VT6, 255);
        analogWrite(VT1, K_zap);
        analogWrite(VT5, K_zap);
        analogWrite(VT6, K_zap);
        delayMicroseconds(sw_time);
        break;
      case 3:
        analogWrite(VT1, 255);
        analogWrite(VT2, 255);
        analogWrite(VT3, 255);
```

```
    analogWrite(VT4, 255);
    analogWrite(VT5, 255);
    analogWrite(VT6, 255);
    analogWrite(VT1, K_zap);
    analogWrite(VT2, K_zap);
    analogWrite(VT6, K_zap);
    delayMicroseconds(sw_time);
    break;
case 4:
    analogWrite(VT1, 255);
    analogWrite(VT2, 255);
    analogWrite(VT3, 255);
    analogWrite(VT4, 255);
    analogWrite(VT5, 255);
    analogWrite(VT6, 255);
    analogWrite(VT4, K_zap);
    analogWrite(VT2, K_zap);
    analogWrite(VT6, K_zap);
    delayMicroseconds(sw_time);
    break;
case 5:
    analogWrite(VT1, 255);
    analogWrite(VT2, 255);
    analogWrite(VT3, 255);
    analogWrite(VT4, 255);
    analogWrite(VT5, 255);
    analogWrite(VT6, 255);
    analogWrite(VT4, K_zap);
    analogWrite(VT2, K_zap);
    analogWrite(VT3, K_zap);
    delayMicroseconds(sw_time);
    break;
case 6:
    analogWrite(VT1, 255);
    analogWrite(VT2, 255);
    analogWrite(VT3, 255);
    analogWrite(VT4, 255);
```

```
        analogWrite(VT5, 255);
        analogWrite(VT6, 255);
        analogWrite(VT4, K_zap);
        analogWrite(VT5, K_zap);
        analogWrite(VT3, K_zap);
        delayMicroseconds(sw_time);
        break;
      default:
        delayMicroseconds(sw_time);
        break;
    }
  }
}
/*
A0 - SET_FREQ frequency setup
A1 - SET_K_ZAP setup K_zap
*/
int repeat_count = 200; /*count of repeats (because on small sw_time
high frequency and unstable working*/
int i;//for loop
void loop()
{
  /*set microseconds delay between I..IV phases of work => define
frequency */
  sw_time = map(analogRead(SET_FREQ), 0, 1023, 1, 100);
  /*on high frequency greater repeats, without arduino functions.
Need for frequency stability*/
  repeat_count = map(sw_time, 1, 100, 400, 100);
  /*calculate K_zap - filling coefficient
  * 255 = close transistor, 0 = full open transistor (inverse logic)
  */
  K_zap = map(analogRead(SET_K_ZAP), 0, 1023, 255, 1);
  if (K_zap > 220)//stop
  {
    analogWrite(VT1, 255);/*all VTx close*/
    analogWrite(VT2, 255);/*on HINx, LINx (inputs IR2132) +5 V*/
    analogWrite(VT3, 255);
```

```
    analogWrite(VT4, 255);
    analogWrite(VT5, 255);
    analogWrite(VT6, 255);
    delayMicroseconds(sw_time);
  }
  else //generation ~3-phase voltage
  {
//    time_start = millis();
    for (i = 1; i <= repeat_count; i++)
    {
      pwm_loop_fwd_a2();
       if (!(i % 10))
      {
        sw_time  =  map(analogRead(SET_FREQ),  0,  1023,  MIN_FREQ,
MAX_FREQ);
        K_zap = map(analogRead(SET_K_ZAP), 0, 1023, 255, 1);
      }
    }
//    time_start = millis() - time_start;
    //Serial.print("FREQUENCY: "); Serial.println(1000. / time_start
* repeat_count);
  }
  //Serial.println(sw_time);
  //Serial.println(K_zap);
  //Serial.println();
}
```

MICROCHIP PIC18F2455/2550/4455/4550

28/40/44-Pin, High-Performance, Enhanced Flash, USB Microcontrollers with nanoWatt Technology

Universal Serial Bus Features:

- USB V2.0 Compliant
- Low Speed (1.5 Mb/s) and Full Speed (12 Mb/s)
- Supports Control, Interrupt, Isochronous and Bulk Transfers
- Supports up to 32 Endpoints (16 bidirectional)
- 1 Kbyte Dual Access RAM for USB
- On-Chip USB Transceiver with On-Chip Voltage Regulator
- Interface for Off-Chip USB Transceiver
- Streaming Parallel Port (SPP) for USB streaming transfers (40/44-pin devices only)

Power-Managed Modes:

- Run: CPU on, Peripherals on
- Idle: CPU off, Peripherals on
- Sleep: CPU off, Peripherals off
- Idle mode Currents Down to 5.8 μA Typical
- Sleep mode Currents Down to 0.1 μA Typical
- Timer1 Oscillator: 1.1 μA Typical, 32 kHz, 2V
- Watchdog Timer: 2.1 μA Typical
- Two-Speed Oscillator Start-up

Flexible Oscillator Structure:

- Four Crystal modes, including High-Precision PLL for USB
- Two External Clock modes, Up to 48 MHz
- Internal Oscillator Block:
  - 8 user-selectable frequencies, from 31 kHz to 8 MHz
  - User-tunable to compensate for frequency drift
- Secondary Oscillator using Timer1 @ 32 kHz
- Dual Oscillator Options allow Microcontroller and USB module to Run at Different Clock Speeds
- Fail-Safe Clock Monitor:
  - Allows for safe shutdown if any clock stops

Peripheral Highlights:

- High-Current Sink/Source: 25 mA/25 mA
- Three External Interrupts
- Four Timer modules (Timer0 to Timer3)
- Up to 2 Capture/Compare/PWM (CCP) modules:
  - Capture is 16-bit, max. resolution 5.2 ns (T$_{CY}$/16)
  - Compare is 16-bit, max. resolution 83.3 ns (T$_{CY}$)
  - PWM output: PWM resolution is 1 to 10-bit
- Enhanced Capture/Compare/PWM (ECCP) module:
  - Multiple output modes
  - Selectable polarity
  - Programmable dead time
  - Auto-shutdown and auto-restart
- Enhanced USART module:
  - LIN bus support
- Master Synchronous Serial Port (MSSP) module Supporting 3-Wire SPI (all 4 modes) and I^{2}C™ Master and Slave modes
- 10-Bit, Up to 13-Channel Analog-to-Digital Converter (A/D) module with Programmable Acquisition Time
- Dual Analog Comparators with Input Multiplexing

Special Microcontroller Features:

- C Compiler Optimized Architecture with Optional Extended Instruction Set
- 100,000 Erase/Write Cycle Enhanced Flash Program Memory Typical
- 1,000,000 Erase/Write Cycle Data EEPROM Memory Typical
- Flash/Data EEPROM Retention: > 40 Years
- Self-Programmable under Software Control
- Priority Levels for Interrupts
- 8 x 8 Single-Cycle Hardware Multiplier
- Extended Watchdog Timer (WDT):
  - Programmable period from 41 ms to 131s
- Programmable Code Protection
- Single-Supply 5V In-Circuit Serial Programming™ (ICSP™) via Two Pins
- In-Circuit Debug (ICD) via Two Pins
- Optional Dedicated ICD/ICSP Port (44-pin, TQFP package only)
- Wide Operating Voltage Range (2.0V to 5.5V)

Device	Program Memory		Data Memory		I/O	10-Bit A/D (ch)	CCP/ECCP (PWM)	SPP	MSSP		EUSART	Comparators	Timers 8/16-Bit
	Flash (bytes)	# Single-Word Instructions	SRAM (bytes)	EEPROM (bytes)					SPI	Master I^{2}C™			
PIC18F2455	24K	12288	2048	256	24	10	2/0	No	Y	Y	1	2	1/3
PIC18F2550	32K	16384	2048	256	24	10	2/0	No	Y	Y	1	2	1/3
PIC18F4455	24K	12288	2048	256	35	13	1/1	Yes	Y	Y	1	2	1/3
PIC18F4550	32K	16384	2048	256	35	13	1/1	Yes	Y	Y	1	2	1/3

PIC18F2455/2550/4455/4550

Pin Diagrams

28-Pin PDIP, SOIC

```
                                    ┌───────U───────┐
        MCLR/VPP/RE3  ──→   1 │o              │ 28   ←→  RB7/KBI3/PGD
            RA0/AN0  ←→    2 │               │ 27   ←→  RB6/KBI2/PGC
            RA1/AN1  ←→    3 │               │ 26   ←→  RB5/KBI1/PGM
    RA2/AN2/VREF-/CVREF  ←→    4 │               │ 25   ←→  RB4/AN11/KBI0
      RA3/AN3/VREF+  ←→    5 │  PIC18F2455   │ 24   ←→  RB3/AN9/CCP2(1)/VPO
   RA4/T0CKI/C1OUT/RCV  ←→    6 │  PIC18F2550   │ 23   ←→  RB2/AN8/INT2/VMO
RA5/AN4/SS/HLVDIN/C2OUT  ←→    7 │               │ 22   ←→  RB1/AN10/INT1/SCK/SCL
               VSS  ──→    8 │               │ 21   ←→  RB0/AN12/INT0/FLT0/SDI/SDA
          OSC1/CLKI  ──→    9 │               │ 20   ←──  VDD
     OSC2/CLKO/RA6  ←──   10 │               │ 19   ←──  VSS
    RC0/T1OSO/T13CKI  ←→   11 │               │ 18   ←→  RC7/RX/DT/SDO
RC1/T1OSI/CCP2(1)/UOE  ←→   12 │               │ 17   ←→  RC6/TX/CK
           RC2/CCP1  ←→   13 │               │ 16   ←→  RC5/D+/VP
             VUSB  ←→   14 │               │ 15   ←→  RC4/D-/VM
                                    └───────────────┘
```

40-Pin PDIP

```
                                    ┌───────U───────┐
        MCLR/VPP/RE3  ──→   1 │o              │ 40   ←→  RB7/KBI3/PGD
            RA0/AN0  ←→    2 │               │ 39   ←→  RB6/KBI2/PGC
            RA1/AN1  ←→    3 │               │ 38   ←→  RB5/KBI1/PGM
    RA2/AN2/VREF-/CVREF  ←→    4 │               │ 37   ←→  RB4/AN11/KBI0/CSSPP
      RA3/AN3/VREF+  ←→    5 │               │ 36   ←→  RB3/AN9/CCP2(1)/VPO
   RA4/T0CKI/C1OUT/RCV  ←→    6 │               │ 35   ←→  RB2/AN8/INT2/VMO
RA5/AN4/SS/HLVDIN/C2OUT  ←→    7 │               │ 34   ←→  RB1/AN10/INT1/SCK/SCL
       RE0/AN5/CK1SPP  ←→    8 │               │ 33   ←→  RB0/AN12/INT0/FLT0/SDI/SDA
       RE1/AN6/CK2SPP  ←→    9 │  PIC18F4455   │ 32   ←──  VDD
       RE2/AN7/OESPP  ←→   10 │  PIC18F4550   │ 31   ←──  VSS
               VDD  ──→   11 │               │ 30   ←→  RD7/SPP7/P1D
               VSS  ──→   12 │               │ 29   ←→  RD6/SPP6/P1C
          OSC1/CLKI  ──→   13 │               │ 28   ←→  RD5/SPP5/P1B
     OSC2/CLKO/RA6  ←──   14 │               │ 27   ←→  RD4/SPP4
    RC0/T1OSO/T13CKI  ←→   15 │               │ 26   ←→  RC7/RX/DT/SDO
RC1/T1OSI/CCP2(1)/UOE  ←→   16 │               │ 25   ←→  RC6/TX/CK
        RC2/CCP1/P1A  ←→   17 │               │ 24   ←→  RC5/D+/VP
             VUSB  ←→   18 │               │ 23   ←→  RC4/D-/VM
           RD0/SPP0  ←→   19 │               │ 22   ←→  RD3/SPP3
           RD1/SPP1  ←→   20 │               │ 21   ←→  RD2/SPP2
                                    └───────────────┘
```

Note 1: RB3 is the alternate pin for CCP2 multiplexing.

Programme de PIC18F2550

```c
// Projet : Variateur de vitesse avec affichage sur LCD
//*****************************************************

// LCD module connections
sbit LCD_RS at RB0_bit;
sbit LCD_EN at RB1_bit;
sbit LCD_D4 at RB4_bit;
sbit LCD_D5 at RB5_bit;
sbit LCD_D6 at RB6_bit;
sbit LCD_D7 at RB7_bit;
sbit LCD_RS_Direction at TRISB0_bit;
sbit LCD_EN_Direction at TRISB1_bit;
sbit LCD_D4_Direction at TRISB4_bit;
sbit LCD_D5_Direction at TRISB5_bit;
sbit LCD_D6_Direction at TRISB6_bit;
sbit LCD_D7_Direction at TRISB7_bit;
// End LCD module connections
float Vitesse = 0.0 ;
char TRMN[6] ;
float Vitesse_MAX = 1500.0;

void main()
{

    ADCON1=0b00001011 ; // AN0...AN3 analogique
    TRISA=0xFF;
    TRISB=0x00;
    Lcd_Init();                         // Initialize LCD
    Lcd_Cmd(_LCD_CLEAR);                 // Clear display
    Lcd_Cmd(_LCD_CURSOR_OFF);           // Cursor off
    ADC_Init();
    //ADCON1=0b00001110 ; // AN0 uniquement analogique
    LCD_Out(1,1,"PFE 2017-2018");
    LCD_Out(2,1,"VAR DE VITESSE");
    Delay_ms(1000);
    Lcd_Cmd(_LCD_CLEAR);

    while (1)
    {
       // Mesure vitesse
       Vitesse  = ADC_Read(0);
       Vitesse  = ((float)Vitesse )*(Vitesse_MAX/1024) ;
       inttostr(Vitesse,TRMN);
       //Affichage bruit
       LCD_Out(1,1,"Vitesse:");
       LCD_Out(2,1,Ltrim(TRMN));
       LCD_Out(2,10,"TR/MN");
       Delay_ms(2000);
       Lcd_Cmd(_LCD_CLEAR);                // Clear display
       Lcd_Cmd(_LCD_CURSOR_OFF);          // Cursor off
    }
}
```

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Help Guide

The following information is intended to help each student who will take this project from the institute library:

The purchase of components: SNE SOMETEL company

Address: Center Saïd - Avenue Habib Bourguiba MEGRINE TUNIS-SUD 2033 TUNISIE

Phone: (+216) 71 43 41 54 (LG)

Fax: (+216) 71 43 40 74

Mail: sales@snesometel.tn

Website: http://www.snesometel.tn

Realization and drilling of cards: HTL training center

Address: Bardo - Tunis

Phone: (+216) 50 789 454

Mail: sami.incib@gmail.com

Contact facebook: https://web.facebook.com/ncib.enit

The purchase of arduino and its accessories: Arduino Tunisia

Address: 22 avenue de la liberté- Bou Mhel El Bassatine.

Phone: (+216) 92 168 725/29308609

Website: http://www.seli.tn/

Download link QElectrotech Software:

http://www.01net.com/telecharger/windows/Loisirs/electronique/fiches/img100046.html

PSIM software download link:

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Résumé

𝒟ans le domaine des entrainements à vitesse variable, plusieurs types de commande peuvent

être utilisés dans une vaste gamme d'applications industrielles. Ce projet de fin de parcours porte sur la substitution d'un moteur à courant continu par un moteur asynchrone triphasé ABB 200 kW, ainsi que sa commande par un variateur de vitesse. Il est intéressant de soumettre ce moteur à des fréquences variables. Pour cette raison, j'ai fait une étude sur le moteur asynchrone à installer, sa modélisation, son variateur, la simulation des différents étages et enfin la réalisation pratique.

Summary

ℐn the field of variable speed drives, several types of controls can be used in a wide range of

industrial applications. This end-of-term project concerns the replacement of a DC motor by a three-phase asynchronous motor ABB 200 kW, as well as its control by a variable speed drive. It is interesting to subject this engine to varying frequencies. For this reason, I made a study on the asynchronous motor to install, its modeling, its variator, the simulation of the various stages and finally the practical realization.

ملخص

في مجال محركات الأقراص المتغيرة السرعة ، يمكن استخدام عدة أنواع من الضوابط في مجموعة واسعة من التطبيقات الصناعية. ويتعلق مشروع نهاية الفصل باستبدال المحرك DC بواسطة محرك غير متزامن من ثلاث مراحل ABB 200 kW ، بالإضافة إلى التحكم به بواسطة محرك متغير السرعة. من المثير للاهتمام أن يخضع هذا المحرك لترددات مختلفة. ولهذا السبب ، قمت بدراسة حول المحرك غير المتزامن لتركيبه ، ونمذجته ، ومغيره ، ومحاكاة المراحل المختلفة ، وأخيراً تحقيقه العملي.