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Thème

Mesures, choix du moteur électrique associer au convertisseur électronique applique au véhicule électrique

Devant le jury composé de :

……….………	Président
……….……..	Examinateur
……………...	Examinateur
Mr. ZINE Bachir	Encadreur

Présenté par :

- REGOUTA Fathi
- MESSAOUDI Mohammed Seddik
- HAMIDANI Moncef
- ZEGHIB Mohammed Ayoub

2021-2022

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Measurements, choice of the electric motor associated with the electronic converter applied to the electric vehicle

In front of the jury composed of:

……….………	President
……….……..	Examiner
……………...	Examiner
Mr. ZINE Bachir	Framer

Presented by :

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Finally, we would like to thank all those who have contributed to the realization of my work from near or far.

Dedication

We dedicate this modest thesis to our parents who were able to support us throughout our studies, sometimes comfort us in difficult times, and who without them we could not have done this work.

We dedicate this modest work:

To our brothers and sisters

To all our family's.

To all our loyal friends.

To all our teachers since childhood.

To the entire 2022 promotion.

our dedication also goes to those who have participated directly or indirectly in the culmination of our efforts.

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List of Abbreviations and Symbols

List of Abbreviations

Abbreviation	Definition
EV	Electric vehicle
GMs	General Motors
DC	Direct current
AC	Alternating current
Li-Ion	Lithium-ion
Ni-MH	Nickel-Metal Hybride
BMS	Battery management systems
BLDC	Brushless DC
PMSM	Permanent Magnet Synchronous Motor
BEV	Battery Electric Vehicle
HEV	Hybrid Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
FCVs	Fuel cell vehicles
IM	Induction motor
d	Direct along the axis
q	Quadrature along the axis
o	Homopolar
Pa	Absorbed power
Pu	Output Power

List of Symbols

Symbol	Definition	Unite
V	actual battery voltage	[V]
E_0	battery constant voltage	[V]
K	polarization resistance	[Ω]
Q	battery capacity	[ah]

it	actual battery charge	[ah]
A	exponentiel zone amplitude	[V]
B	exponential zone time constant inverse	[ah-1]
R	battery internal resistance	[Ω]
i	actual battery current	[A]
C	exponential voltage	[V]
v_{dc}	DC voltage	[V]
i	Current	[A]
C	Capacity	[F]
L	Inductance	[H]
R	Resistance	[Ω]
R_L	Inductance Resistance	[Ω]
$[P(\boldsymbol{P}_{0bs})]$	the Park matrix	
M	Stator-rotor mutual cyclic inductance	[H]
Idr, Iqr	d-axis and q-axis components of the rotor current vectors Ir.	[A]
R_r	rotor resistance	[Ω]
R_s	stator resistance	[Ω]
ωs , ωr	stator and rotor Electrical Heartbeat	[rad / s]
ϕs , ϕr	stator and rotor fluxes linkage	[Wb]
Is, Ir	Stator and rotor currents	[A]
Ωs	stator angular electrical frequency	[rad / s]
Ce	Electromagnetic torque	[Nm]
P	Pole number	
J	moment of inertia	
Cr	mechanical torque	[Nm]
N_1,N_2	Speed before and after add transmission	[tr / min]
p	power	[w]
i	Transmission ratio	
T	conversion factor	

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The company that welcomed us to work on our project

Company. I: Hard Facing Petroleum Industry

The owner of the foundation : Ahmed AmmarYousefi

Accommodation card :12 workers

The number of machines :10 huge machines

Services:

1. Special metal welding
2. cold welding
3. Repair of all drilling equipment

product:

1. Sprockets
2. Edges
3. pivot columns

albelt
Bande Transporteuse

Company. II:ALBELT: For the manufacture of conveyor belts

The owner of the foundation : AlaaedineYousefi

Accommodation card :12 workers

Services:

1. Conveyor belts for wage factories and cement factories
2. Manufacture of food belts such as semolina and oven
3. Manufacture of airport belts and sports equipment

General Introduction

General Introduction

The electric vehicle attaches great importance to the stress levels that technology places on the environment this factor has prompted automotive technology to invent electric vehicles that are environmentally friendly, they are not based on petroleum which is used for the internal combustion engine , Electric vehicles have a significantly lower footprint depending on the fuel source.

The motor is the beating heart of the vehicle, so it must be chosen carefully so that it does not emit noise or gas emissions, and this is what we find in the electric engine and is not present in the internal combustion engine, and it must be of great torque in order for the vehicle to move in all the pleasures, down or up as well as the speed must be too big to be controlled.

The choice of the electric motor in an electric vehicle is an essential element in such a way as to influence the autonomy and even the cost of the vehicle.

This thesis is divided into three chapters, in the first chapter, we dealt with generalities about the history of the electric vehicle and its various components. The second chapter presents the modeling of the various components of the vehicle. The third chapter deals with measurements and selection of the appropriate motor and inverter ,and it also deals with all results and simulations based on our theoretical and practical experiences.

Chapter I:

General information on electric vehicles

I.1.Introduction

In this chapter we dealt with a history of the electric vehicle ,it is Components and its various engines, and the various inverters associated with the engine applied to the electric vehicle**.**

I.2.History of the electric vehicle

Thomas constructed the first battery-powered electric vehicle (EV) in 1834. In Davenport, it's actually a tricycle. It had a non-rechargeable battery and was only used for a brief period of time. Robert Davidson also produced a non-rechargeable battery-powered electric locomotive four years later.

Sir David Salomons succeeded in developing a rechargeable battery-powered electric car in 1874, after the creation of the lead-acid battery. In 1886, 12 years later, Frank Sprague installed the first electric cart system. Electric automobiles quickly gained popularity after that. The automobile industry plays the most important role in motive transportation. In 1900, out of 4,200 cars sold in the United States, 38% were electric, 22% were ICEVs, and 40% were steam-powered vehicles. During that time, The wealthy elite's favored means of transportation was electric automobiles. It was about the same price as a Rolls-Royce today. Several businesses in America, the United Kingdom, and France produced electric automobiles in the last decade of the nineteenth century, therefore the EV is not new and has been around for over 166 years [1].

Figure I.1. Morris & Salom's Electrobat. (Courtesy of The Horseless Age; Courtesy of Scientific American; Photo courtesy of History of the Electric Automobile by Ernest H. Wakefield.)[1].

Since it built and manufactured batteries particularly for its own EVs, the BGS EV of 1900 held the world's electric distance record of around 290 km per charge. It's worth noting that the first car to break the 100 km/h barrier was an electric vehicle, Belgian Camille Jenatzy's 'Jamais Contente' (Never Satisfied). On May 1, 1899, a bullet-shaped electric racing vehicle achieved the global speed record of 110 km/h. After the period of horseless carriages, EVs entered the era of commercial growth. There were wire-spoken wheels, pneumatic tires, soft springs, and luxurious upholstery. In the United States, about 34000 electric cars had been registered by 1912. Between 1899 until 1916, Baker Electric Company was a well-known electric vehicle manufacturer in the United States. From 1901 through 1920, the British Electromobile Company of London produced rear-wheel-drive electric vehicles featuring rear-wheel motors, inclined wheel steering, and pneumatic tires. Between 1907 and 1938[1].

FigureI.2. Charging of electric car in Detroit, year 1919[2]

Automakers are driving the development and marketing of electric vehicles. Many automobile manufacturers, notably in America, Japan, and Europe, have produced their own electric vehicles or are engaged in electric vehicle initiatives. GM, Ford, Chrysler, U.S. Electric, and Solicteria have all worked hard to manufacture electric vehicles in response to California laws. Toyota, Nissan, Honda, Mazda, Daihatsu, Mitsubishi, Suzuki, Isuzu, and Subaru, to name a few, all have their own electric car assessment or marketing projects. Similarly, a number of European governments, including France, Germany, Italy, and the United Kingdom, have launched initiatives focused at the emerging electric car sector. Some of the active European automakers are PSA Peugeot Citroen Group, Renault, BMW, Mercedes-Benz, Audi, Volvo, Opel, Volkswagen, Fiat, and Bedford. Electric car demos are also attended by power utilities and battery manufacturers, in addition to automakers. Both firms hope to profit from the introduction of rechargeable electric cars powered by batteries. They usually collaborate with car companies to develop their own electric vehicles, or they just purchase electric vehicles to test and explain. Energy and environmental authorities are also actively involved in developing electric car technologies and pushing their commercialization due to the inherent benefits of electric vehicles in terms of energy efficiency, energy diversification, and environmental friendliness. Last but not least, colleges and research laboratories are always attempting to improve electric vehicle technology so that it can compete with ICEVS. GM's engagement with electric vehicles dates back to 1916, when GMC Truck produced a small number of Lead-acid batteries power electric trucks (Rajashekara, 1994)[1].

FigureI.3. GM **EV1.** (Photo courtesy of General Motors)[1]

Table I.1. Chronology of the electric vehicle with some models[3]

years	builder/inventor	autonomy	Speed
1881	Charles jean taud	100 m	
1894	Henry.G.morris & pedro. G.salomon	40 Km	32Km/h
1899	Camille jenatzy		100Km/h
1911	Detroit electric	130 Km	
1940	Paul Arzens	100 Km	70Km/h
1941	Jean Albert Gregoire	250 Km	42Km/h
1941	Peugeot	250 Km	42Km/h
1947	Nissan Toyota electric	65 Km	35Km/h
1959	Renault	60 km	60Km/h
1967	Ford	40 to 60km	64Km/h
1984	Peugeot	140 Km	100Km/h
1985	Renault	120 Km	80Km/h
1997	Toyota		
2003	Renault	140 Km	
2010	BMW		

Figure I.4. Renault electric cars fleet (Kangoo, Fluence, Twizy i Zoe)[4]

I.3.Electric Vehicle Components

The components and functions of electric vehicles are determined by the vehicle type. There are at least four different types of electric vehicles now on the market and in use around the world. Various common major electric vehicle components, parts, or elements, such as traction batteries, inverters (DC-DC converters), traction motors, on-board chargers, and controllers, will be discussed in this chapter. The various sorts of electric vehicle components influence how the vehicle functions. The components and functions of electric cars (vehicles) can be explained using the diagram below[5].

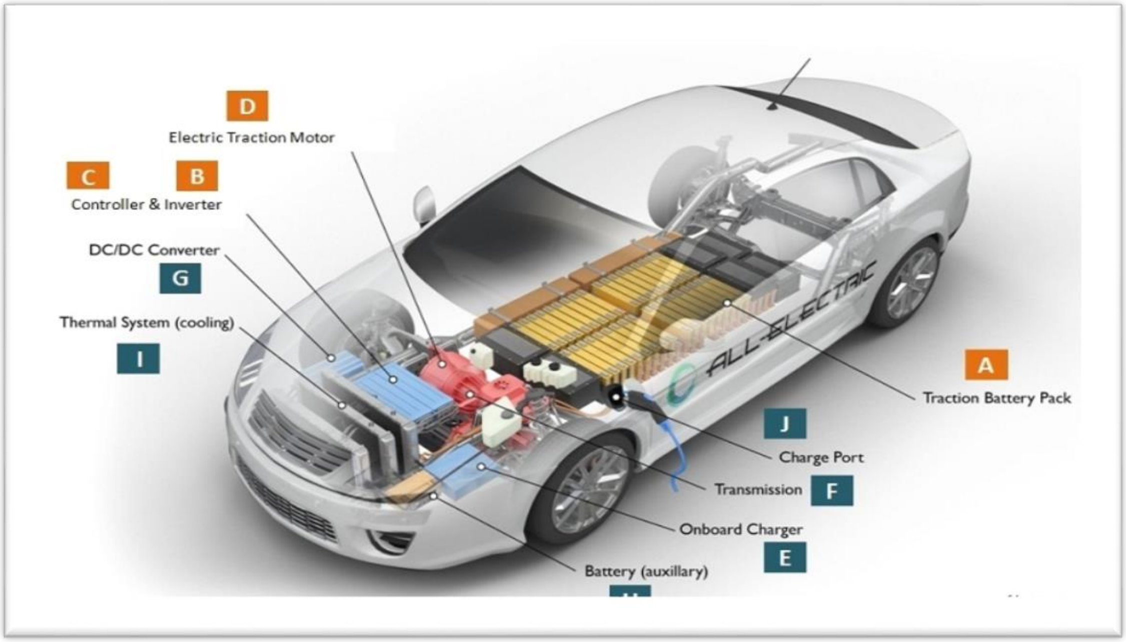


Figure I.5. Electric Vehicle Components[6]

I.3.1.Basic Main Components of Electrical Vehicle

The basic main elements of electric cars installed in almost all types of electric cars are as follows:

I.3.1.A.Traction Battery Pack(A)

An EV traction battery is rechargeable energy storage that supplies power to the electric motor very quickly, giving EVs high performance and rapid acceleration.

To better understand a traction battery, and the challenges of extinguishing one should it ignite, let's look at how EV traction battery packs are constructed[7].

Figure I.6. Traction Battery Pack[5]

There are various types of electric car batteries. The most widely used is the type of lithium-ion batteries.

Table I.2. General parameters of the electric battery component[8]

	Li-Ion	$Na\text{-}NiCl_2$	Ni-MH	Li-S	Unit
Maximum Charge	75	84	85	80	Ah
Nominal Voltage	323	289	288	305	V
Stored Energy	24.2	24.2	24.2	24.2	kWh
Maximum Voltage / Minimum Voltage	339/308	304/275	302/274	320/290	V
Initial Charge	100	100	100	100	%
Number of Cells per Cell-Row	12	12	20	26	-
Number of Cell-Row	17	30	20	1	-
Internal Resistance charge / discharge	1/1	1/1	1/1	1/1	Ω
Operating Temperature	33	270	36	30	℃
Specific Heat Transition	0.4	6	0.4	0.08	W/K
Specific Heat Capacity	795	950	677	1650	J/Kg*K
Mass of the Battery	318	457	534	173	Kg
Battery Price	300	500	400	250	€

I.3.1.B.Power Inverter(B)

A power inverter, is an electronic device or circuitry that converts DC to AC. The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source. A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process[9].

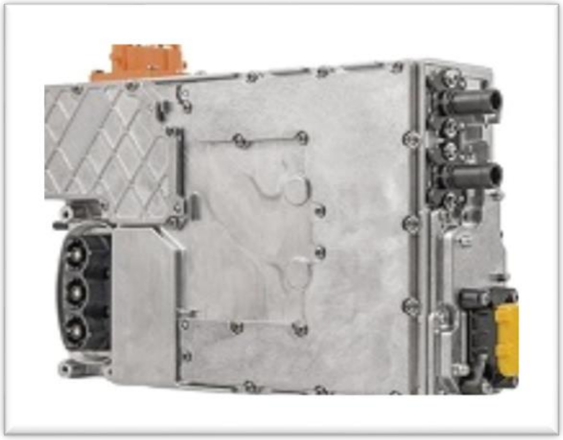


Figure I.7. Power Inverter[5]

I.3.1.C.Controller(C)

The electric vehicle controller, similar to a carburetor in a gasoline-powered vehicle, is an electronics package that operates between the batteries and the motor to control the electric vehicle's speed and acceleration. The controller regulates the energy flow from the battery by converting the direct current from the battery to alternating current (for AC motors only). The controller, unlike the carburetor, will also reverse the motor rotation (allowing the vehicle to reverse) and convert the motor to a generator (so that the kinetic energy of motion can be used to recharge the battery when the brake is applied)[10].

Figure I.8. Controller[5]

In a nutshell, this device controls the speed of the electric traction motor and the torque it produces by managing the flow of electrical energy given by the traction battery. The operation of electric vehicles will be determined by this component[5].

I.3.1.D.Electric Traction Motor(D)

Because DC motors are extremely simple to design and deliver great torque at low speeds, they were a popular choice for transportation applications in the early twentieth century [11]. However, because of their reliance on carbon commutators, they were unreliable, generated significant friction at high speeds, had a low specific power density, and were overtaken by the AC traction motor due to their comparatively large bulk.

Figure I.9. Electric Traction Motor[5]

I.3.2.Other Electric Car Components

I.3.2.A.Charger(E)

Chargers obtain electricity from outside sources such as the utility grid or solar power plants to charge batteries. AC power is converted to DC power, which is then stored in the battery. Electric car chargers are divided into two categories:

- On-board charger: this is a charger that is built into the automobile.
- Off-board charger: the charger isn't in the car or isn't installed.

Table I.3. chargers characteristics [12]

Chargers	Benefits and Key Challenges
On-board charger	❖ Less energy (kw) transfer ❖ Problem of battery heating is not concerned ❖ Pilot signal J1172 is used for operation ❖ Weight on electric vehicle(EV) is added

	❖ Slow charging ❖ Charge at low-power levels ❖ On board rectification is used to manage battery management systems(BMS) ❖ Size and weight restriction due to EV design (more charging components) ❖ Recharge at any place within electrical outlet ❖ Protocols concerning communication is not up to standards of industry regarding charger interaction ❖ Needed things by on-board BMS are supplied voltage, a maximum capacity of current, and an phase configuration of charging station
Off-board charger	❖ Higher transfer of energy (kw) ❖ Need to address battery heating issue ❖ Weight on EV is removed ❖ More better BMS systems ❖ No flexibility to recharge at various places ❖ Power output limitation is concerned with the capability of batteries to accept charge ❖ Fast charging ❖ Charge at higher-power levels ❖ More better contractual opportunities for utility companies and charging site owners ❖ More complexities and higher cost ❖ Combining BMS into charging the station is also cost intensive and complex ❖ Responsibility for an incorrect charging operation goes to charging stations ❖ Less complex BMS systems for charging ❖ Identification of malfunctioning of battery pack cells is not possible for off-board BMS

I.3.2.B.Transmission(F)

A transmission is a component in a vehicle that transfers mechanical power from the engine to the wheel's spinning. Electric cars are typically equipped with a single-speed transmission; however, top manufacturers in the EV transmission industry are introducing innovative multi-speed transmissions with enhanced performance and energy conversion efficiency. In terms of acceleration, top speed, gradeability with driving range, and other factors, electric vehicles with multi-speed transmission systems outperform single-speed transmission systems [13].

Because of government attempts to promote the use of electric cars and the necessity for fuel-efficient automobiles, electric vehicle (EV) transmission is expected to increase significantly in the coming years[13].

Table I.4. EV transmissions characteristics [14]

EV Transmissions	Medium duty 2-speed	Medium duty 4-speed	Medium duty 6-speed	heavy duty 4-speed
Housing	aluminum	aluminum	Cast iron	aluminum
Max. Torque capacity	700 Nm	1200 Nm	1150 Nm	2600 Nm
Max. input speed	6000 rpm	5000 rpm	4000 rpm	5000 rpm
Dry weight	81 kg	109 kg	273 kg	195 kg
Typical GCW	18 tons	18 tons	27 tons	43 tons
Total length	582 mm	420 mm	590 mm (with SPL90 yoke)	650 mm (with flange)
Oil capacity	4.6 liters	7.3 liters	9.2 liters	8 liters
Maintenance intervals	3 years, 300,000km (bus/vocational)	4 years, 300,000km oil change	3 years, 288,000km oil change (bus/vocational)	TBD
PTO	N/A	N/A	6-bolt PTO	Rear PTO
Typical EV application	Shuttle bus, school bus, city bus, logistics	City delivery, beverages, tourist bus, shuttle bus,	City delivery, beverages, tourist bus, shuttle bus,	Beverages, tourist bus, logistics, yard

		school bus, city bus, logistics, yard tractor	school bus, city bus, logistics, yard tractor, municipal	tractor, municipal, drayage.

I.3.2.C.DC/DC Converter(G)

This is an electric car component that converts higher-voltage DC power from the traction battery pack to the lower-voltage DC electricity required to operate vehicle accessories and replenish the auxiliary battery [5].

Figure I.10. (Delphi DC/DC Converter)

I.3.2.D.The battery(H)

The auxiliary battery in an electric car provides electricity to power vehicle accessories[5].

Figure I.11. lithium-ion battery

I.3.2.E.Thermal System – Cooling(I)

The temperature range of the engine, electric motor, power electronics, and other components is maintained by this system [5].

I.3.2.F.Charge Port(J)

The charging port allows the vehicle to charge the traction battery pack by connecting to an external power source[5].

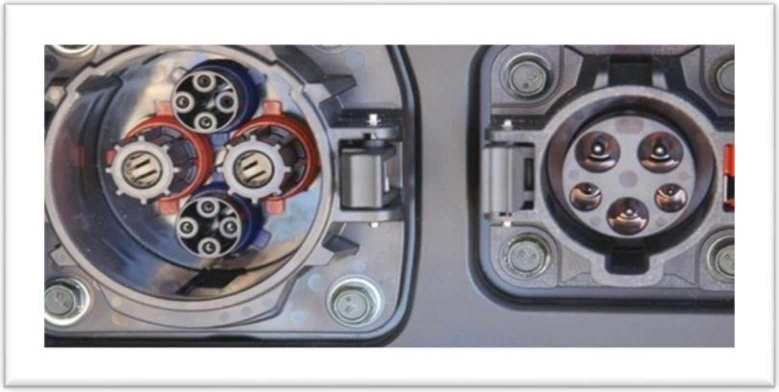


Figure I.12. DC Fast Charging

I.4.The different electric vehicle motors

I.4.1. DC Series Motor

The DC Series motor's high starting torque makes it a good choice for traction applications. In the early 1900s, it was the most extensively utilized motor for traction applications. This motor's benefits include easy speed control and the ability to tolerate a rapid rise in load. All of these features make it an excellent traction motor. A DC series motor's main disadvantage is the heavy maintenance required owing to brushes and commutators. Railways in India employ these motors. This motor belongs to the DC brushed motors category[15].

I.4.2. Brushless DC Motors

Commutation in a BLDC motor is done electronically, with rotor position feedback determining when to switch the current. Figure I.13 depicts the structure. A Hall sensor or a rotary encoder is generally used for feedback.

The stator windings work along with the rotor's permanent magnets to provide a relatively uniform flux density in the air gap. This allows a steady DC voltage to drive the stator coils (thus the name brushless DC), which simply changes from one stator coil to the next to provide a trapezoidal AC voltage waveform[16].

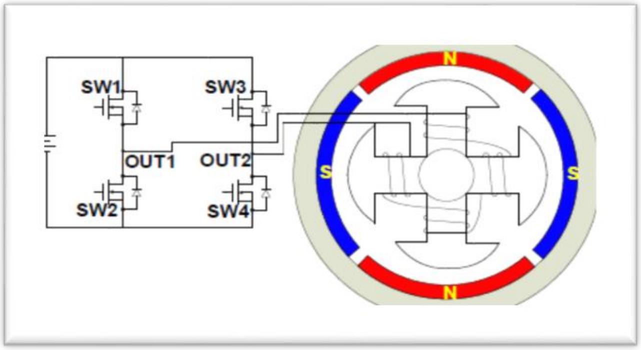


Figure I.13. The brushless DC motor[16]

BLDC motors further have two types:

I.4.2.A. Out-runner type BLDC Motor:

The permanent magnet is situated inside the rotor, and the rotor is located outside of the stator. The rotor's inner surface now has a segmented permanent magnet attached. The stator and permanent magnet locations are reversed from the inner rotor type. Because of the increased moment of inertia and poor acceleration and deceleration response, a cup-shaped rotor is not well-suited to agile movements, but it still provides excellent speed stability[17].

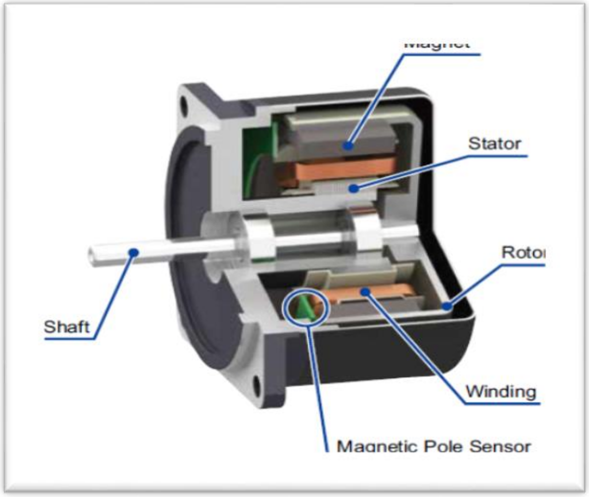


Figure I.14. The BLDC Out-runner type [17]

I.4.2.B. In-runner type BLDC Motor:

The rotor is at the center of the motor, and the stator windings surround it in this design. Rotor magnets do not insulate heat inside the rotor because it is positioned in the core, hence heat is easily dissipated. Because of this, inner rotor built motors create a lot of torque and are widely employed[18].

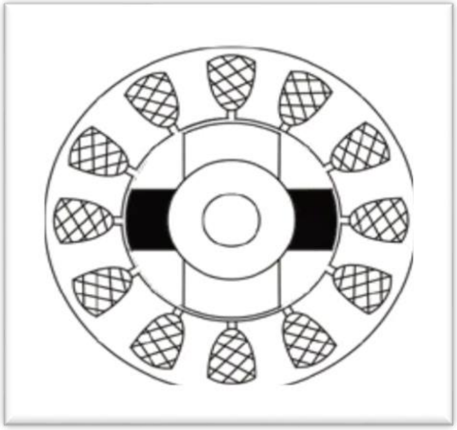


Figure I.15. The BLDC In-runner type[18]

I.4.3. Permanent Magnet Synchronous Motor (PMSM)

Variable speed industrial drives are increasingly using permanent magnet synchronous motors (PMSMs). Improvements in permanent magnet (PM) materials, particularly rare earth magnets, have substantially advanced new research and applications. While methods for analyzing and designing typical AC electrical machines are maturing, more study is needed to develop a systematic methodology for PMSM analysis, design, and control [19].

PM motors have become a more appealing solution for electrical drives than induction motors. Because of advancements in semiconductor drives, controlling PM motors has become easier and more cost-effective, with the ability to operate the motor across a wide speed range while retaining high efficiency and power factor. Rare earth magnets are becoming more affordable, making these motors more popular[19].

Figure I.16. The permanent Magnet Synchronous motor [15]

I.4.4. Three Phase AC Induction Motors

A three phase induction motor has a stator and rotor, much like any other electric motor. The stator has a three-phase winding (also known as stator winding), whereas the rotor has a short-circuited winding (called rotor winding). Three phase power is only used to power the stator winding. Through electromagnetic induction, the rotor winding obtains its voltage and power from the externally electrified stator winding, hence the name. The induction motor can be regarded as a "transformer type" a.c. machine in which electrical energy is turned into mechanical energy since it is a transformer with a revolving secondary[20].

Table I.5. Examples International car

	RENAULT ZOE R110	TESLA MODEL X P100D	TOYOTA BZ4X
Max power	80 KW	500 KW	150KW
Max torque	225 Nm	967 Nm	265 Nm
Max speed	135 km/h	250 km/h	160km/h
0-100km/h	11.4 s	3.1 s	8.4 s

I.5. Various converters associated with the motor applied to the electric vehicle

Battery electric cars (BEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell vehicles (FCVs) all benefit from power electronics interfaces. Furthermore, maximizing energy conversion from the chemical energy of the battery to electrical energy via the power electronic circuit, and then to mechanical energy via the electrical machine, must be prioritized. BEVs, HEVs, and PHEVs use a variety of power electronics converters, as shown in Figure I.17, which shows the architecture of a series hybrid electric vehicle[21].

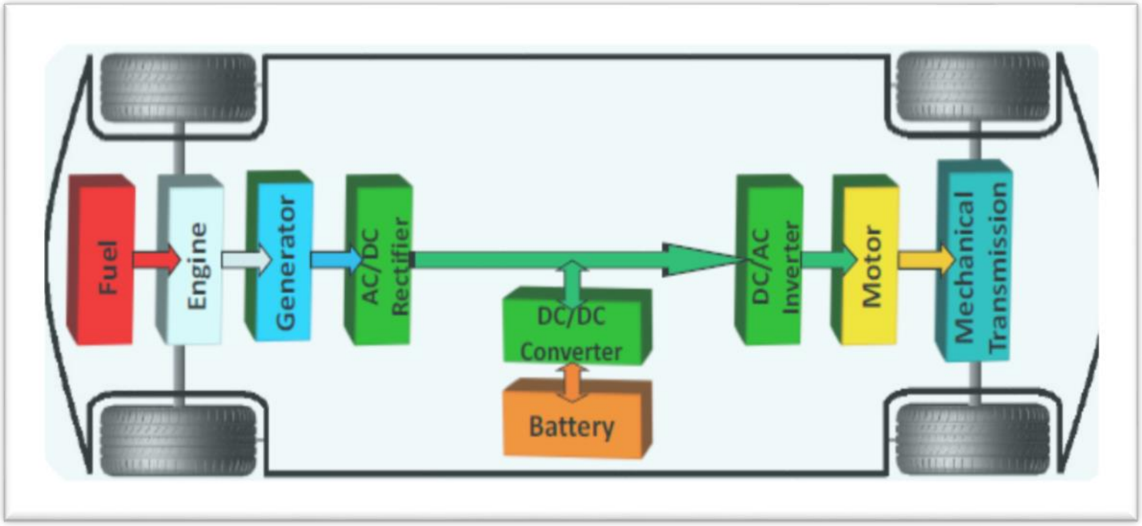


Figure I.17. Various types of power electronics converters used in a typical series hybrid vehicle design system[21]

There are three power converters types located in the power train electrification systems that are used in the vehicle propulsion system:

I.5.1. DC/DC converters for electric vehicles

The various EV power supply options reveal that at least one DC/DC converter is required to connect the FC(Fuel Cell), Battery, or Super capacitors module to the DC-link.

In electrical engineering, a DC to DC converter is a type of power converter that changes a source of direct current (DC) from one voltage level to another by momentarily holding the input energy and then releasing it to the output at a different voltage. In the literature, several alternative forms of DC/DC power converters have been proposed[22,23].

The most common DC/DC converters can be grouped as follows:

I.5.1.A. Non-isolated converters

Non-isolated converters are often utilized when the voltage needs to be stepped up or down by a small ratio. And when the output and input have no dielectric separation. There are five fundamental types of converters in this non-isolated group: buck, boost, buck-boost, Cuk, and charge-pump converters. The buck converter is used to reduce voltage, whereas the boost converter is used to increase it. Buck-boost and Cuk converters are capable of both up and down steps. In low-power applications, the charge-pump converter can be utilized for voltage step-up or inversion[24].

I.5.1.B. Isolated converters

A high frequency transformer is typically utilized in this sort of converter. An isolated converter is required in applications where the output must be fully separated from the input. Half-bridge, full-bridge, fly-back, forward, and push-pull DC/DC converters are among the various types of converters in this category[25,26]. All of these converters may be used in both directions and have a high stepping down and stepping up voltage ratio.

I.5.2. The AC/DC/AC Converter

The AC/DC/AC converter is a device that uses electricity to separate the two frequencies. The power circuit is made up of two identical three-phase bridges, one capacitor, and inductors. The AC/DC/AC converter may be separated into a rectifier and an inverter in acceleration mode, as shown in Figure I.18. The modeling and operation of the two modules are briefly described in this section[27].

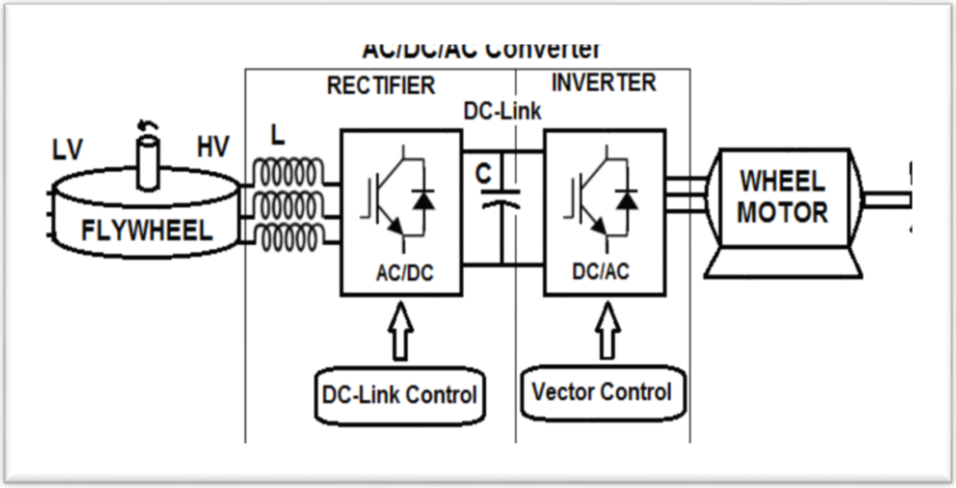


Figure I.18. The AC/DC/AC converter in acceleration mode[27]

I.5.2.A. Rectifier

To achieve a desired voltage in the DC-link for varied flywheel speeds and varying wheel motor loads, a forced-commutated three-phase controlled rectifier is required [28]. Figure I.19 is a schematic of a transistor-based forced-commutated rectifier.

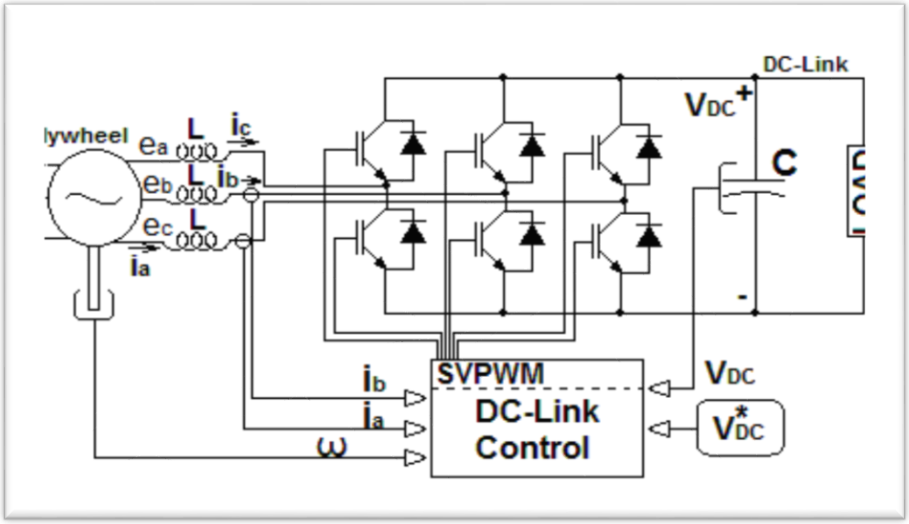


Figure I.19. Forced-commutated three-phase controlled rectifier [27].

The AC/DC converter must behave like a voltage boost in order to work as a forced-commutated rectifier. In other words, the DC-Link voltage must be larger than the peak DC voltage generated by the rectifying diodes in passive mode[27].

I.5.2.B. Inverter

The inverter scheme is shown in Figure I.20. The AC/DC converter, previously explained, is represented by a DC voltage source.

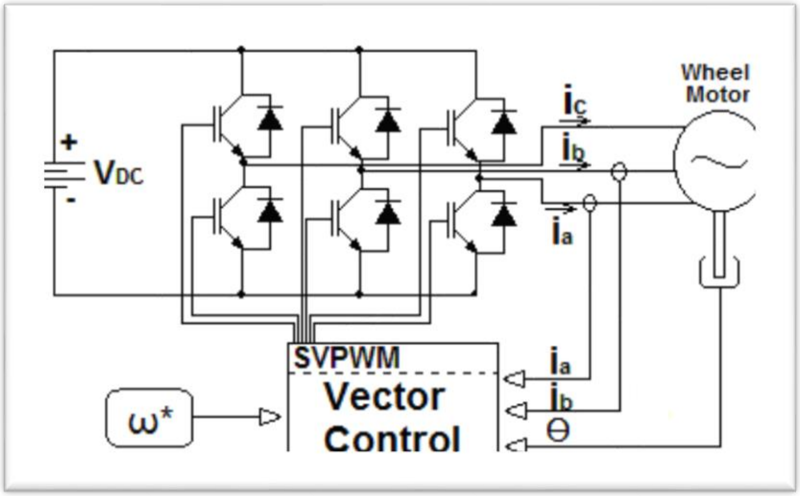


Figure I.20. Inverter[27]

The inverter is responsible for driving the wheel motor, controlling its angular speed for different load torques. Since the wheel motor is a synchronous permanent magnetic machine (PMSM)[29].

Table I.6. Comparison of the converters[30]

Converters	**Constructi-onal features**	**Applicat-ion**	**List of Compon-ents**	**Cost (£)**	**Effici-ency**	**Advantages**	**Drawbacks**
Bi-directional AC-DC converter	The filters are used alongside the rectifier circuit	Charging module, V2G andG2V, conditions output current and input voltage.	Emi filter, output filter	420 to 460	88 % to 92 %	A rectifier circuit is used that increases the efficiency.	Super junction devices reduce efficiency, Lyapunov based functions make the structure complicated
Bi-	Cascaded	Charging	Four	400	92 %	Four	Absence of

directional DC-DC converter	topology of inductors and capacitors is available	module, V2G and G2V	switches, two capacitors	to 450	to 94.5 %	switches enable the utilization of a cascade topology that controls output voltages	Soft switching means that switching losses are present
Full bridge LLC resonant converter	"A DC chopper along with a resonant tank and a rectifier and load is connected to a transformer "	ZVS is achieved	Four switches, four diodes, two inductors one capacitor	600 to 660	90 % to 93.3 %	Uses a chopper circuit in serie with a resonant tank that amplifies the waveforms	Quality factor is independent of voltage gain, magnetizing inductor has no impact on voltage gain
Half bridge LLC resonant converter	AC-DC rectifier is placed in series to FB LLC rectifier	ZVS is achieved	Four switches four diodes, two inductors one capacitor AC- DC rectifier	500 to 650	92 % to 94.6 %	It mainly acts as a rectifier	Increases the weight of charging panel by 10 % to 15 %
Full bridge	The	Charging	DC	480	94 %	Has the	High cost

converter	construction is a very simple	module, V2G and G2V, accepts a wide range of frequency, ZVS and ZVC is derived, Fast charging, Wireless power transfer	chopper, LLC resonant tank, rectifier, transformer	to 570	to 96 %	capability to support V2G and G2V technologies. Can be used in the EH fast charger module of EVs	compared to other traditional converters, Huge gap between constant current and voltage modes

I.6.conclusion

In this chapter, we dealt with the history of the electric vehicle as well as its various components, and it is now of interest to the whole world because it is not harmful to the environment because of the electric motor.

In the second chapter, we will discuss modeling the components of the vehicle.

Chapter II:

Modeling of vehicle components

II.1.Introduction

Dealt in this chapter modeling of vehicle components which consists of battery modeling (quote different models and choose the preferred model), Three-Phase and single-phase Inverter modeling and Modeling of the IM in the two-phase plane d q and last Modeling of the three-phase induction motor.

II.2.Battery modeling

II.2.1. Overview

The majority of known battery simulation models may be categorized into three categories:

- Electrochemical
- Electrical
- Experimentation

The first two models are unsuitable for simulating battery dynamics accurately [31]. Specially designed electric-circuit based models, on the other hand, may be used to accurately anticipate battery charge and discharge while taking state of charge into consideration. There are very slight variances in models depicting different battery kinds, and only the data from battery manufacturers' datasheets are used. Because there are so many various characteristics for comparing different types of batteries, just the mathematics of charging and discharging are examined at the time of writing this article. This model is simple to modify and develop, for example, a reaction to temperature, At a later stage of development, charging algorithms based on price and the battery ageing phenomena can be implemented[32].

Because the EV battery pack—a collection of 16 to 24 6-volt (or 12-volt equivalent) individual lead-acid and lithium batteries—represents the single highest replacement cost item, as well as possibly the single highest initial cost item, it's worth spending some time learning about batteries so you can choose and use them wisely[33].

II.2.2. Model Description

The following is the general equation for the battery model in use:

$$V = E_0 - K\frac{Q}{Q-it}it - K\frac{Q}{Q-it}i - R \cdot i + C, \tag{II.1}$$

where

V – actual battery voltage (V)

E_0– battery constant voltage (V)

K – polarization resistance (Ω)

Q – battery capacity (Ah)

it – actual battery charge (Ah)

A – exponentiel zone amplitude (V)

B – exponential zone time constant inverse (Ah-1)

R – battery internal resistance (Ω)

i – actual battery current (A)

C – exponential voltage (V)

The manufacturer's datasheet should have open access to all of the parameters mentioned above. However, the battery's discharge curve should be used to calculate polarization resistance K, exponential zone amplitude A, and exponential zone time constant inverse K.

Figure II.1 depicts the necessary parameters for computations[32].

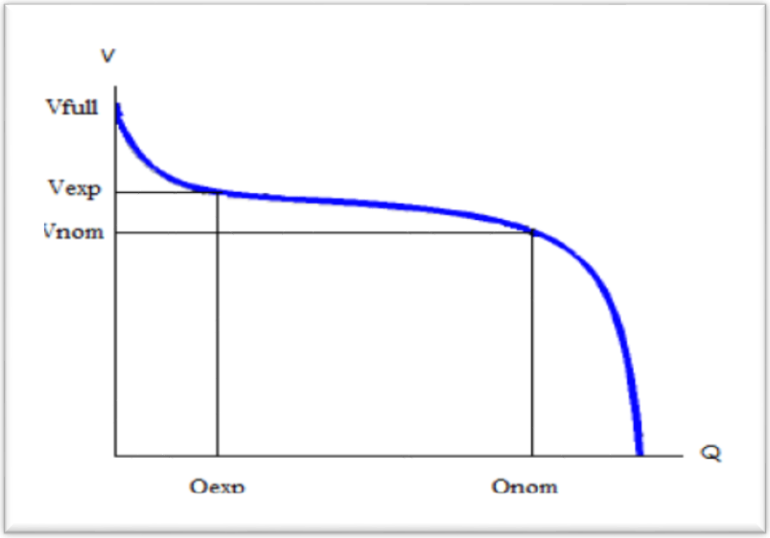


Figure II.1. Example discharge curve[32]

The equations are as follows:

$$A = V_{Full} - V_{exp} \quad \text{(II.2)}$$

$$\mathrm{B} = \frac{3}{\mathrm{Q_{exp}}} \quad \text{(II.3)}$$

To calculate E0, the following equation must be used [34]:

$$E_0 = V_{full} + K + R \cdot i - A \quad \text{(II.4)}$$

Due to the different nature of the chemical materials, used in different types of batteries, equations for the simulation of these batteries also differ:

- Lead Acid

Discharge

$$V \equiv E_0 - K\frac{Q}{Q-it}it - K\frac{Q}{Q-it}t - R \cdot i + C \tag{II.5}$$

Where

$$C = B \cdot |i| \cdot (-C + A) \tag{II.6}$$

Charge

$$V \equiv E_0 - K\frac{Q}{Q-it}it - K\frac{Q}{it-0.1 \cdot Q}t - R \cdot i + C \tag{II.7}$$

Where

$$C = B \cdot |i| \cdot (-C) \tag{II.8}$$

- Li-Ion

Discharge

$$V \equiv E_0 - K\frac{Q}{Q-it}it - K\frac{Q}{Q-it}t - R \cdot i + C \tag{II.9}$$

Where

$$C = A \cdot e^{(-B \cdot it)} \tag{II.10}$$

Charge

$$V \equiv E_0 - K\frac{Q}{Q-it}it - K\frac{Q}{it-0.1 \cdot Q}t - R \cdot i + C \tag{II.11}$$

where C is defined by (II.9).

$$C = A \cdot e^{(-B \cdot it)} \tag{II.12}$$

- Ni-Mh

Discharge mode is defined by (II.5) and (II.6), Charging is given in equations (II.8) and (II.13).

$$V \equiv E_0 - K\frac{Q}{Q-it}it - K\frac{Q}{it-0.1 \cdot Q}t - R \cdot i + C \tag{II.13}$$

II.2.3. Load Parameters

Because it is a popular application and also a good testing ground for batteries owing to its dynamic character, electric car drive was chosen for the simulated load of the battery because it fits both criteria for practical application of the test result and a suitable simulation environment.

The dynamic behavior of an electric automobile in motion is similar to that of an internal combustion engine [35]. Acceleration and deceleration, as well as lengthy periods of constant speed driving or waiting, are common. A typical load cycle of an electric vehicle under natural settings is shown in Table II.1. [32].

TABLE II.1. BATTERY LOAD CYCLES [32]

Multiple of discharge current C	Time (s)
3	60
2	60
-1.5	10
1	60
3.8	25
1	50
4	50
3.2	120
-2	20
0	25

The cycle is designed to keep repeating until the battery charge level drops below a certain threshold. The automobile would then be driven to a charging station and fully charged using the appropriate charge current. After that, the method is repeated until the simulation timer expires. The maximum charge and discharge levels, as well as the appropriate current values, are specified in the manufacturer's datasheet. Batteries function at normal temperature, according to this study, and electrochemical activity inside the batteries do not generate any heat. In addition, no aging effects are taken into consideration in the present version of the model[32].

All of the simulated batteries share the same input signals, but they are set and constrained by their nominal and maximum or minimum required parameters. In addition, the outputs of all three batteries are compared[32].

II.2.4. Comparing Lithium-ion and Lead Acid Batteries

A quick examination of lithium-ion lead acid (LiNCM) at pack point is presented in Table II.2. It's important to understand that parameter values in both chemistries vary widely, therefore this table is merely a simplified representation of a complicated comparison.

Table II.2. Battery Technology Comparison [36, 37, 38] .

	Flooded lead acid	VRLA lead acid	Lithium-ion (LiNCM)
Energy Density (Wh/L)	80	100	250
Specific Energy (Wh/kg)	30	40	150
Regular Maintenance	Yes	No	No
Initial Cost ($/kWh)	65	120	600
Cycle Life	1,200 @ 50%	1,000 @ 50% DoD	1,900 @ 80% DoD
Typical state of charge window	50%	50%	80%
Temperature sensitivity	Degrades significantly above 25°C	Degrades significantly above 25°C	Degrades significantly above 45°C
Efficiency	100% @20-hr rate 80% @4-hr rate 60% @1-hr rate	100% @20-hr rate 80% @4-hr rate 60% @1-hr rate	100% @20-hr rate 99% @4-hr rate 92% @1-hr rate

This table highlights the fact that different standard charging windows have different chemistries. As a result, a lead acid battery will have a higher nameplate energy efficiency than a lithium-ion battery in order to have the same amount of energy accessible.

II.3. Three-Phase and single-phase Inverter modeling

II.3.1. Single-Phase Inverter

Figure II.2 shows a single-phase full bridge inverter with LC filter and resistive load.

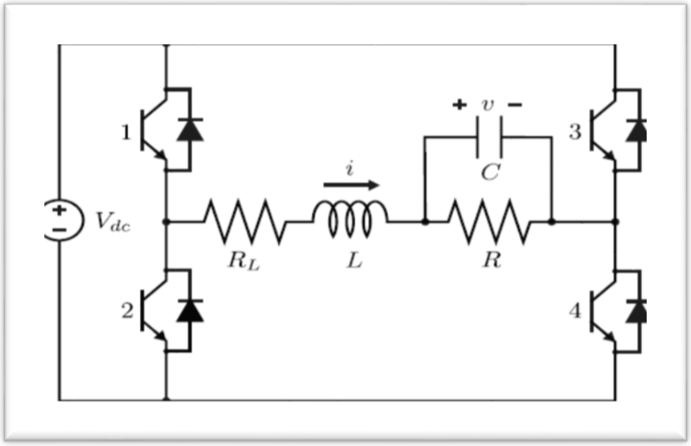


Figure II.2. Single-phase inverter [39]

Either the top or lower switch can be turned on for each switch branch. The full model's state equations are as follows:

$$\frac{di(t)}{dt} = \frac{V_{dc}}{L}(q_+(t) - q_-(t)) - \frac{R_L}{L} i(t) - \frac{1}{L} u(t) \tag{II.14}$$

$$\frac{du(t)}{dt} = \frac{1}{C} i(t) - \frac{1}{RC} u(t) \tag{II.15}$$

- v_{dc} : DC Voltage
- i: Current
- C: Capacity
- L: Inductance
- R : Resistance
- R_L: Inductance resistance

Where q+(t) is equal to 1 when switch 1 is on and switch 2 is off and equal to 0 when switch 1 is off and switch 2 is on and where q-(t) is equal to 1 when switch 3 is on and switch 4 is off and equal to 0 when switch 3 is off and switch 4 is on. By representing i(t) with i, u(t) with v, q(t)+ with q+, and q(t)- with q-, the following state equations for the generalized averaging method (GAM) model are found[39]:

$$\frac{di}{dt} = \frac{V_{dc}}{L}(q_+ - q_-) - \left(\frac{R_L}{L} I + T\right) i - \frac{1}{L} v \tag{II.16}$$

$$\frac{\mathrm{dv}}{\mathrm{dt}} = \frac{1}{C}\mathrm{i} - \left(\frac{1}{RC}\,\mathrm{I} + \mathrm{T}\right)\mathrm{v} \qquad \text{(II.17)}$$

II.3.2. Three-Phase Inverter

The three-phase grid-tie inverter is shown in Figure II.3.

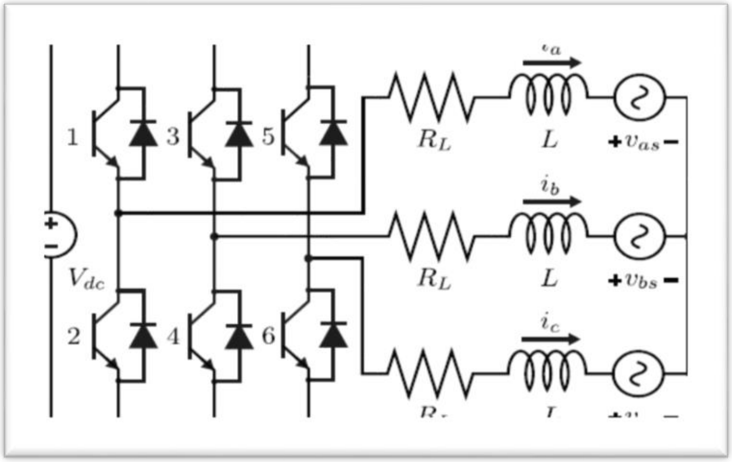


Figure II.3. Three-phase inverter [39]

The state equations for the detailed model are given by:

$$\frac{\mathrm{dia(t)}}{\mathrm{dt}} = \frac{\mathrm{V_{dc}}}{\mathrm{L}}\left(\frac{2}{3}\,\mathrm{q_a(t)} - \frac{1}{3}\,\mathrm{q_b(t)} - \frac{1}{3}\mathrm{q_c(t)}\right) - \frac{\mathrm{R_L}}{L}\mathrm{ia(t)} - \frac{\mathrm{uas}}{L} \qquad \text{(II.18)}$$

$$\frac{\mathrm{dib(t)}}{\mathrm{dt}} = \frac{\mathrm{V_{dc}}}{\mathrm{L}}\left(\frac{2}{3}\,\mathrm{q}_b\mathrm{(t)} - \frac{1}{3}\,\mathrm{q_a(t)} - \frac{1}{3}\mathrm{q_c(t)}\right) - \frac{\mathrm{R_L}}{L}\mathrm{ib(t)} - \frac{\mathrm{ubs}}{L} \qquad \text{(II.19)}$$

$$\frac{\mathrm{dic(t)}}{\mathrm{dt}} = \frac{\mathrm{V_{dc}}}{\mathrm{L}}\left(\frac{2}{3}\,\mathrm{q}_c\mathrm{(t)} - \frac{1}{3}\,\mathrm{q_a(t)} - \frac{1}{3}\mathrm{q_b(t)}\right) - \frac{\mathrm{R_L}}{L}\mathrm{ic(t)} - \frac{\mathrm{ucs}}{L} \qquad \text{(II.20)}$$

qa(t) is to 1 when switch 1 is on and switch 2 is off and equal to 0 when switch 1 is closed and switch 2 is on, qb(t) is equal to 1 when switch 3 is on and switch 4 is closed and equal to 0 when switch 3 is off and switch 4 is on, and qc(t) is equal to 1 when switch 5 is on and switch 6 is off and equal to 0 when switch 5 is closed and switch 6 is on. By representing $i_y(t)$ with i_y, $u_{ys}(t)$ with v_{ys}, $q_y(t)$ with q_y, where y $\in\{a, b, c\}$, the following state equations for the GAM model are found[39]:

$$\frac{\mathrm{dia}}{\mathrm{dt}} = \frac{\mathrm{V_{dc}}}{\mathrm{L}}\left(\frac{2}{3}\,\mathrm{q_a} - \frac{1}{3}\,\mathrm{q_b} - \frac{1}{3}\mathrm{q_c}\right) - \left(\frac{\mathrm{R_L}}{L}\mathrm{I} + \mathrm{T}\right)\mathrm{ia} - \frac{1}{L}\,\mathrm{v_{as}} \qquad \text{(II.21)}$$

$$\frac{\mathrm{dib}}{\mathrm{dt}} = \frac{\mathrm{V_{dc}}}{\mathrm{L}}\left(\frac{2}{3}\,\mathrm{q}_b - \frac{1}{3}\,\mathrm{q_a} - \frac{1}{3}\mathrm{q_c}\right) - \left(\frac{\mathrm{R_L}}{L}\mathrm{I} + \mathrm{T}\right)\mathrm{ib} - \frac{1}{L}\,\mathrm{v_{bs}} \qquad \text{(II.22)}$$

$$\frac{\mathrm{d}i_c}{\mathrm{d}t} = \frac{V_{dc}}{L}\left(\frac{2}{3}\,q_c - \frac{1}{3}\,q_a - \frac{1}{3}\,q_b\right) - \left(\frac{R_L}{L}I + T\right)i_c - \frac{1}{L}\,v_{cs} \tag{II.23}$$

II.4. Modeling of the IM in the frame d q

The coefficients of the differential equations are changeable due to the existence of continuous trigonometric terms in the matrix of mutual inductances [Msr], and the analytical resolution of the system faces almost insurmountable obstacles. The stator and rotor windings are transformed into two orthogonal two-phase windings dq using the PARK transformation to yield a system of equations with constant coefficients. The transition of electrically and magnetically equivalent windings is known as conversion. The transformation of real windings abc into orthogonal windings d-q is shown in Figure II.4. [40].

Direct along the axis (d).

Quadrature (transverse) along the axis (q).

Homopolar (o).

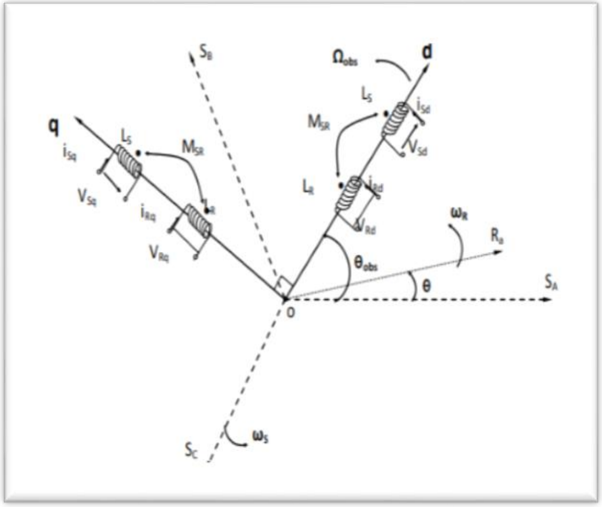


Figure II.4. Rotating axis reference (d– q)

Where: $\theta_{0bs} = \int \omega_{0bs}\mathrm{d}t$: is any observation position between the two-phase axis systems with respect to the three-phase axis system.

The application of the Park transformation to an induction motor corresponds to a transformation of the three coils (static and rotoric) into two equivalent coils that take up the same consideration or aspects in terms of flux, torque, current, or month and produce an image that is perfectly proportional to them[41].

For the transition from the three-phase system to the two-phase system, we have the following equivalents[42]:

-The voltage equivalent:$[V_{dq}0]=[P(\boldsymbol{P}_{0bs})][V_{abs}]$

-The current equivalent: $[i_{dq}0]=[P(\boldsymbol{P}_{0bs})][i_{abs}]$-

-The flux equivalent: $[\Phi_{dq}0]=[P(\boldsymbol{P}_{0bs})][\Phi_{abs}]$

Or :

$[P(\boldsymbol{P}_{0bs})]$: Is the Park matrix

In the case of an inverse passage, we have:

$$\begin{gathered}[V_{abs}]=[P(\boldsymbol{P}_{0bs})]^{-1}[V_{dq}0]\\ [i_{abs}]=[P(\boldsymbol{P}_{0bs})]^{-1}[i_{abs}]\\ [\Phi_{abs}]=[P(\boldsymbol{P}_{0bs})]^{-1}[\Phi_{abs}]\end{gathered}\tag{II.24}$$

The modified direct and inverse Park transformation matrix is then written:

$$[P(\theta_{abs})]=\sqrt{\frac{2}{3}}\begin{bmatrix}\cos(\theta_{abs}) & \cos(\theta_{abs}-\frac{2л}{3}) & \cos(\theta_{abs}+\frac{2л}{3})\\ -sin(\theta_{abs}) & -sin(\theta_{abs}-\frac{2л}{3}) & -sin(\theta_{abs}+\frac{2л}{3})\\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}}\end{bmatrix}\tag{II.25}$$

The factor ($\sqrt{\frac{2}{3}}$): is there to conserve the instantaneous electrical power[43].

$$[P(\theta_{abs})]^{T}=\sqrt{\frac{2}{3}}\begin{bmatrix}\cos(\theta_{abs}) & -sin(\theta_{abs}) & \frac{1}{\sqrt{2}}\\ \cos(\theta_{abs}-\frac{2л}{3}) & -sin(\theta_{abs}-\frac{2л}{3}) & \frac{1}{\sqrt{2}}\\ \cos(\theta_{abs}+\frac{2л}{3}) & -sin(\theta_{abs}+\frac{2л}{3}) & \frac{1}{\sqrt{2}}\end{bmatrix}\tag{II.26}$$

When the angle $\boldsymbol{P}_{0bs}$ is assigned the value zero, the Park transformation is called the Clarke transformation and the passage matrix is written as follows:

$$[C] = \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} \tag{II.27}$$

II.4.1. Electrical equation[44]:

$$\begin{bmatrix} V_{sd} \\ V_{sq} \end{bmatrix} = \begin{bmatrix} R_s & 0 \\ 0 & R_s \end{bmatrix} \begin{bmatrix} i_{sd} \\ i_{sq} \end{bmatrix} + \frac{d}{dt} \begin{bmatrix} \varphi_{sd} \\ \varphi_{sq} \end{bmatrix} + \begin{bmatrix} 0 & -w_s \\ -w_s & 0 \end{bmatrix} \begin{bmatrix} \varphi_{sq} \\ \varphi_{sd} \end{bmatrix} \tag{II.28}$$

$$\begin{bmatrix} V_{rd} \\ V_{rq} \end{bmatrix} = \begin{bmatrix} R_r & 0 \\ 0 & R_r \end{bmatrix} \begin{bmatrix} i_{rd} \\ i_{rq} \end{bmatrix} + \frac{d}{dt} \begin{bmatrix} \varphi_{rd} \\ \varphi_{rq} \end{bmatrix} + \begin{bmatrix} 0 & -(w_s - w_r) \\ w_s - w_r & 0 \end{bmatrix} \begin{bmatrix} \varphi_{rq} \\ \varphi_{rd} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \tag{II.29}$$

II.4.2. Magnetic equation :

$$\begin{bmatrix} \varphi_{sd} \\ \varphi_{sq} \end{bmatrix} = \begin{bmatrix} L_s & 0 \\ 0 & L_s \end{bmatrix} \begin{bmatrix} i_{sd} \\ i_{sq} \end{bmatrix} + \begin{bmatrix} M & 0 \\ 0 & M \end{bmatrix} \begin{bmatrix} i_{rd} \\ i_{rq} \end{bmatrix} \tag{II.30}$$

$$\begin{bmatrix} \varphi_{rd} \\ \varphi_{rq} \end{bmatrix} = \begin{bmatrix} L_r & 0 \\ 0 & L_r \end{bmatrix} \begin{bmatrix} i_{rd} \\ i_{rq} \end{bmatrix} + \begin{bmatrix} M & 0 \\ 0 & M \end{bmatrix} \begin{bmatrix} i_{sd} \\ i_{sq} \end{bmatrix} \tag{II.31}$$

With:

$L_s = l_s - M$, $L_r = l_r - M$; Self-cyclic inductance of stator and rotor respectively.

$M = \frac{3}{2} M_0$: Stator-rotor mutual cyclic inductance

II.4.3. Mechanical equation :

$$C_{em} = p \frac{M}{L_r} \left(\varphi_{rd} i_{sd} - \varphi_{rq} i_{sq} \right) \tag{II.32}$$

$$J \frac{d}{dt} \Omega = C_{em} - C_r - f\Omega_r \tag{II.33}$$

II.5. Modeling of the three-phase induction motor

The induction motor is represented by 6 windings 3 in the stator and 3 in the rotor as follows:

Vsa = Vm * cos(2лft) Vra = Vm * cos(2лft)= 0

$$Vsb = Vm * \cos(2\text{л}ft - \frac{2\text{л}}{3}) \qquad Vrb = Vm * \cos(2\text{л}ft - \frac{2\text{л}}{3}) = 0 \qquad (II.34)$$

$$Vsc = Vm * \cos(2\text{л}ft - \frac{4\text{л}}{3}) \qquad Vrc = Vm * \cos(2\text{л}ft - \frac{4\text{л}}{3}) = 0$$

- Vsa, Vsb and Vsc (V): a-axis, b-axis and c-axis components of the stator voltage vector Vs.

- Vra, Vrb and Vrc (V): a-axis, b-axis and c-axis components of the stator voltage vector Vr.

II.5.1. Electrical equation

Using well-documented motor models [45], the appropriate electrical model of the three-phase induction motor was developed. The stator and rotor voltage equations in matrix form:

$$[Vs]=[Rs]*[Is]+\frac{d[\phi s]}{dt} \qquad [Vr]=[Rr]*[Ir]+\frac{d[\phi r]}{dt} \qquad (II.35)$$

The voltage equations of the magnetically connected stator and rotor circuits may be stated as follows, using the relevant subscripts as bs, cs, ar, br, and cr:

$$Vas=Rs*Ias+\frac{d\phi as}{dt} \qquad Var=Rr*Iar+\frac{d\phi ar}{dt}=0$$

$$Vbs=Rs*Ibs+\frac{d\phi bs}{dt} \qquad Vbr=Rr*Ibr+\frac{d\phi br}{dt}=0 \qquad (II.36)$$

$$Vcs=Rs*Ics+\frac{d\phi cs}{dt} \qquad Vcr=Rr*Icr+\frac{d\phi cr}{dt}=0$$

This mathematical model is a system of six differential equations with time-dependent coefficients that are challenging to solve even with the help of a numerical tool. The three-phase to two-axis voltage transformation is used to solve this problem. The formula for converting a three-phase system (a, b, c) to a two-phase system (d, q) is:

$$Vsd=\sqrt{\frac{2}{3}}(Vsa-\frac{1}{2}Vsb-\frac{1}{2}Vsc) \qquad (II.37)$$

$$Vsq=\sqrt{\frac{2}{3}}(Vsa-\frac{\sqrt{3}}{2}Vsb-\frac{\sqrt{3}}{2}Vsc) \qquad (II.38)$$

The two-phase voltage [Vds, Vqs, Vdr, Vqr] is the input, while the current vector [ids, iqs, idr, iqr] is the output vector in the electrical model. Because of the short-circuited cage rotor winding, Vdr=0 and Vqr=0, the rotor voltage vector is generally zero [46].

By rewriting the previous equations in a stationary from d-q (_),we obtain the model of the electrical part of the asynchronous motor[47] :

$$\mathrm{Vds}=\mathrm{Rs}*\mathrm{Ids}-\omega s*\phi qs+\frac{d\phi ds}{dt}$$

$$\mathrm{Vqs}=\mathrm{Rs}*\mathrm{Iqs}+\omega s*\phi ds+\frac{d\phi qs}{dt} \quad \text{(II.39)}$$

$$\mathrm{Vdr}=\mathrm{Rr}*\mathrm{Idr}-\omega r*\phi qr+\frac{d\phi dr}{dt}=\mathbf{0}$$

$$\mathrm{Vqr}=\mathrm{Rr}*\mathrm{Iqr}+\omega r*\phi dr+\frac{d\phi qr}{dt}=\mathbf{0}$$

The rotor of the asynchronous sguirrel cage motor being closed on itself (short-circuited),we take Vand legal to zero.

- Idr, Iqr (A): d-axis and q-axis components of the rotor current vectors Ir.

- Rr (Ω): rotor resistance.

- Rs (Ω): stator resistance.

- ωs , ωr :(rad / s): stator and rotor Electrical Heartbeat.

- ϕs , ϕr : stator and rotor fluxes linkage.

II.5.2. Magnetic Equation

The flux connections of the stator and rotor windings may be represented in terms of winding inductances and current in matrix notation as shown in the reference [48]:

$$[\phi s]=[\mathrm{Ls}]*[\mathrm{Is}]+[\mathrm{Msr}]*[\mathrm{Ir}]$$

$$[\phi r]=[\mathrm{Lr}]*[\mathrm{Ir}]+[\mathrm{Msr}]*[\mathrm{Is}] \quad \text{(II.40)}$$

- Ls (H): stator inductance.

- Lr (H): rotor inductance.

- M (H): Mutual Inductance between the stator and the rotor.

- Is, Ir: Stator and rotor currents.

II.5.3. Equations of power and torque

The conversions keep instantaneous power. The last power will be written:

$$Pi=[Rs*Isd^2 + Rs*Isq^2] + [\frac{d\phi sd}{dt}*Isd + \frac{d\phi sq}{dt}*Isq] + \omega s[\phi sd*Isq - \phi sq*Isd] \qquad (II.41)$$

The first component may be clearly identified in joule losses; the second term relates to electromagnetic power; and the third term reflects the electrical power converted into mechanical power. The electromagnetic torque Ce is given by in the two-axis stator reference frame:

$$Pe=Ce*\ \Omega s = \omega s(\phi sd*Isq - \phi sq*Isd)$$

$$Ce= \frac{Pe}{\Omega s}= \frac{\omega s}{\Omega s}*(\phi sd*Isq - \phi sq*Isd) \qquad (II.42)$$

$$Ce= P*(\phi sd*Isq - \phi sq*Isd)$$

$$Ce= P*M(Isq*Ird - Isd*Irq)$$

- Ωs (rad / s): stator angular electrical frequency

- Ce (Nm): Electromagnetic torque

- P: Pole number

II.5.4. Mechanical Equation

Mechanical part of induction motor can be described by (II.43), where is angular rotor velocity, J- moment of inertia, Cr - mechanical torque, Ce - electromagnetic torque [49].

$$J*\frac{d\Omega r}{dt} = Ce - Cr \qquad (II.43)$$

II.5.5. Induction motor slip and efficiency of asynchronous motor

The motor slip between the rotor and the swivel field is written as follows::

$$g=\frac{\Omega s-\Omega}{\Omega s} \qquad (II.44)$$

The machine's efficiency fluctuates depending on the amount of electricity it has:

$$\eta=\frac{Pa}{Pu} \qquad (II.45)$$

- Pa: Absorbed power

- Pu: Output Power

II.6. Modeling of the DC-DC converter (Buck-Boost Chopper)

This chopper, also known as a DC to DC converter, is a new form of chopper that may increase or decrease the input DC voltage at the same time. The output voltage difference between measured and reference values [50] is used to modify the duty cycle. Figure II.5 depicts the Buck-Boost chopper and control mechanism.

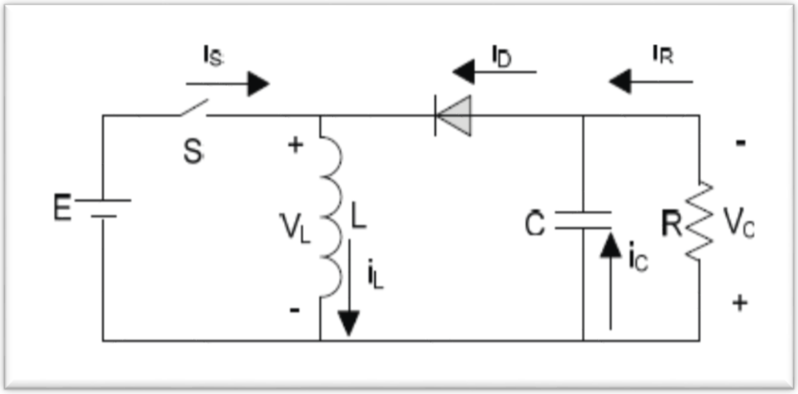


Figure II.5. The Buck-Boost converter

The averaging state-space approach is a generic analytic tool that may be used to create a continuous model from basic circuits or complicated systems. There are two separate switching states for the converter in Figure II.5. [50] :

A. *S* conducts (0 < *t* < *dT*):

$$\text{a:}\begin{cases}\frac{dV_c}{d_t}=\frac{1}{C}\left[0-\frac{V_c}{R}\right]\\ \frac{di_L}{d_t}=\frac{1}{L}[V_{in}]\end{cases} \tag{II.46}$$

$$\begin{pmatrix}\frac{dV_c}{d_t}\\ \frac{di_L}{d_t}\end{pmatrix}=\begin{pmatrix}\frac{1}{RC} & 0\\ 0 & 0\end{pmatrix}\begin{pmatrix}V_c\\ i_L\end{pmatrix}+\begin{pmatrix}0\\ \frac{1}{L}\end{pmatrix}V_{in} \tag{II.47}$$

B. *S* is off state (*dT* < *t* < *T*):

$$\text{b:}\begin{cases}\frac{dV_c}{d_t}=\frac{1}{C}\left[i_L-\frac{V_c}{R}\right]\\ \frac{di_L}{d_t}=\frac{1}{L}[-V_{in}]\end{cases} \tag{II.48}$$

$$\begin{pmatrix} \frac{dV_C}{d_t} \\ \frac{di_L}{d_t} \end{pmatrix} = \begin{pmatrix} \frac{-1}{RC} & \frac{1}{C} \\ \frac{-1}{L} & 0 \end{pmatrix} \begin{pmatrix} V_c \\ i_L \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \end{pmatrix} V_{in} \tag{II.49}$$

The state-space averaging approach is a generic analytic tool that may be used to build a continuous model from either basic circuits or complicated systems. If the switching frequency is high enough, these separate models may be averaged across a switching period to provide an approximate but continuous model of the converter that captures its average behavior during a switching period:

$$\begin{pmatrix} \frac{dV_C}{d_t} \\ \frac{di_L}{d_t} \end{pmatrix} = \begin{pmatrix} \frac{-1}{RC} & \frac{1}{C} \\ \frac{-1}{L} & 0 \end{pmatrix} \begin{pmatrix} V_c \\ i_L \end{pmatrix} + \begin{pmatrix} \frac{-i_L}{C} \\ \frac{V_C+V_{in}}{L} \end{pmatrix} d \tag{II.50}$$

II.7. Conclusion

In this part, we dealt with the modeling of the various components of the electric vehicle, through which we can simulate through different programs, such as the Matlab.

In the next chapter, we will learm about the measurements and the selection of the electric motor associated with the inverter.

Chapter III:

Measurements, choice of electric motor associated with the inverter

III.1.Introduction

In this chapter We will discuss measurements, choice of electric motor associated with the inverter the simulation of three-phase asynchronous motor as well as the inverter needed for this motor ,we will also talk about (transformer, speed variator, battery and accessories of our vehicle).

III.2.Discrete vehicle to achieve

Figure III.1. vehicle before modification

We chose the electric vehicle because it is environmentally friendly and does not pollute the air, we made some modifications to the chassis and wheels and changed the shock absorbers.

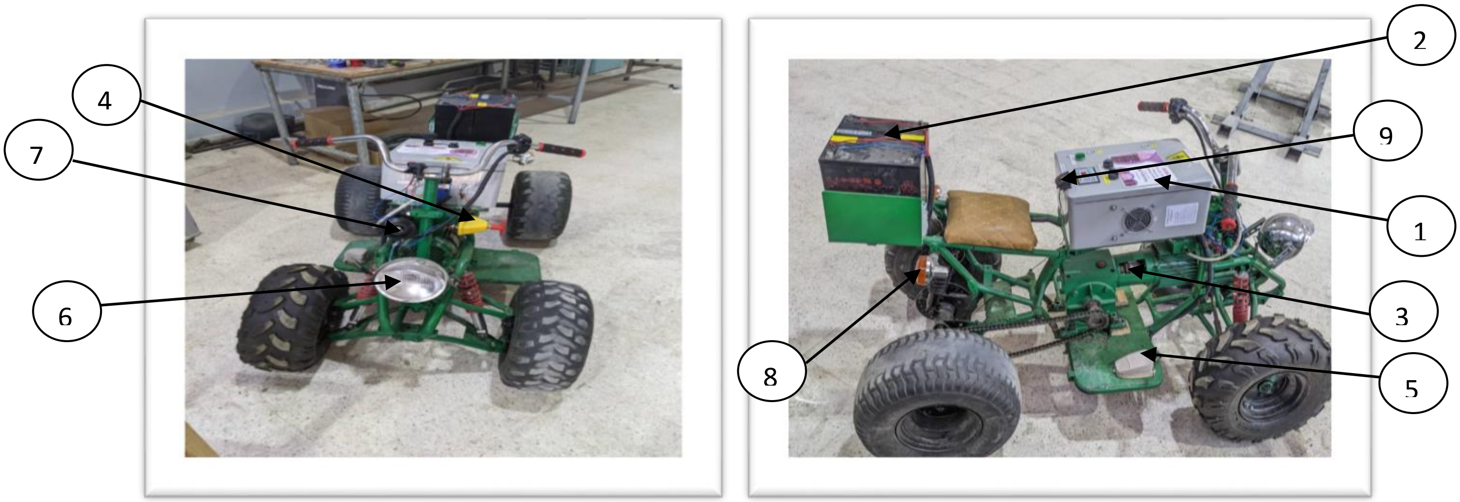


Figure III.2. vehicle after modification

1: The inverter

2: The battery

3: The electric motor

4: A circuit breaker

5: A foot pedal switch

6: A headlight

7: A horn

8: Indicators turn signal

9: Digital bike speed motor

III.2.1.The inverter

An inverter can be defined as a compact, rectangular electrical device used to convert direct current voltage (24 DC) to alternating current voltage (230 AC). DC applications include several small types of equipment such as solar power systems.

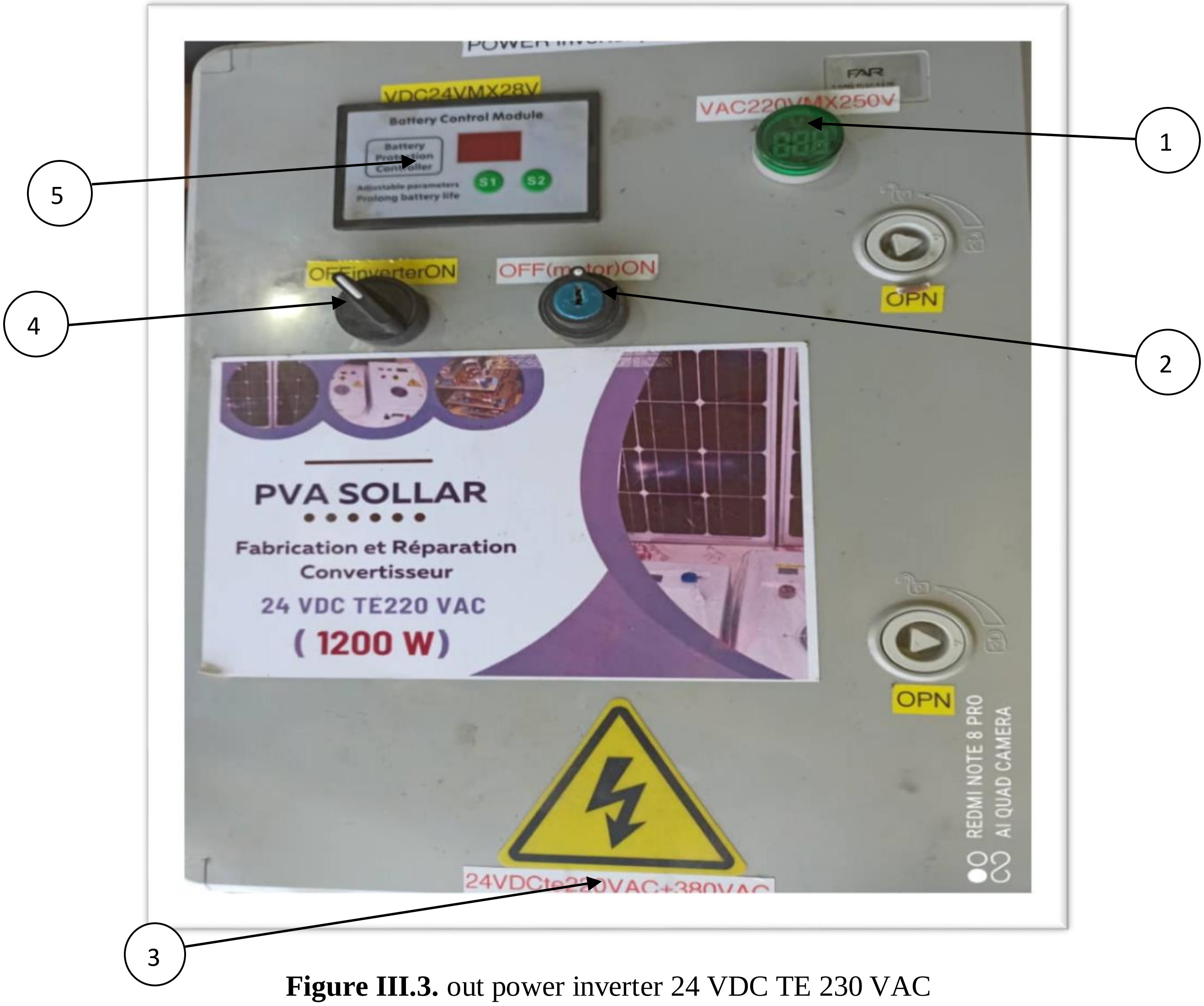


Figure III.3. out power inverter 24 VDC TE 230 VAC

1:lampe 230 v

2:rotary selector :three position (zero, one ,two)

- Position zero :OFF
- Position one: ON the motor rotates clockwise
- Position two: ON the motor rotates counterclockwise

3:output three phase 230v AC

4: rotary selector: two position (zero ,one)

- Position zero :OFF
- Position one: ON

5: battery control module :is in charge of monitoring and controlling the battery's charging condition ,as well as regulating the current and voltage delivered to it. It also regulates communication between the car's many components and the battery, as well as assisting in energy conservation by setting the battery to the lowest possible value during use.

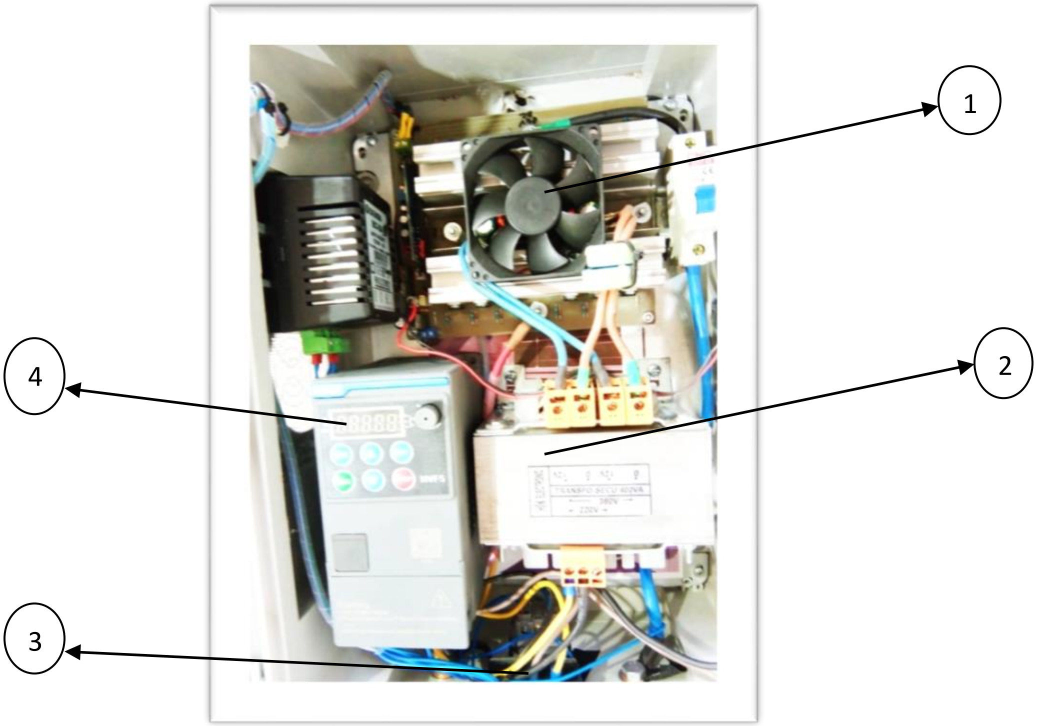


Figure III.4. in power inverter 24VDC TE230 VAC

1:inverter 24VDC/24VAC

2: Transformer 24 VAC /220VAC

3: output three phase 230VAC

4: CHNT inverter

III.2.1.A.Inverter 24VDC /24VAC

It is used to convert direct current voltage (DC24) to alternating current voltage (24 AC)

Figure III.5. inverter 24VDC/24VAC

III.2.1.B.Transformer 24 VAC /220VAC

The transformer is a conversion system that allows changing the voltage and intensity of 24V electric current into an electric current of 240 V, as shown in the equation

$$T = \frac{v_2}{v_1} \qquad \text{(III.1)}$$

$$\frac{240}{24} = 10 \qquad \text{(III.2)}$$

T:conversion factor

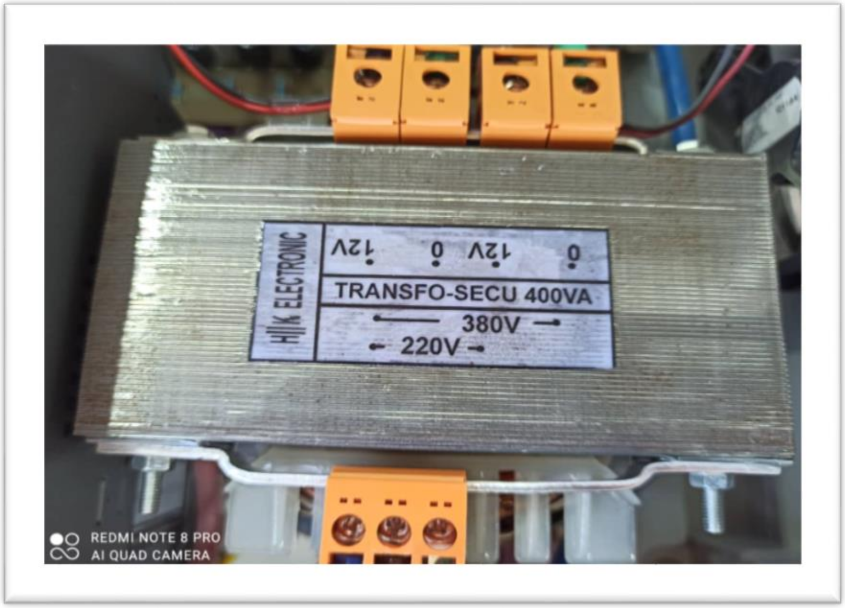
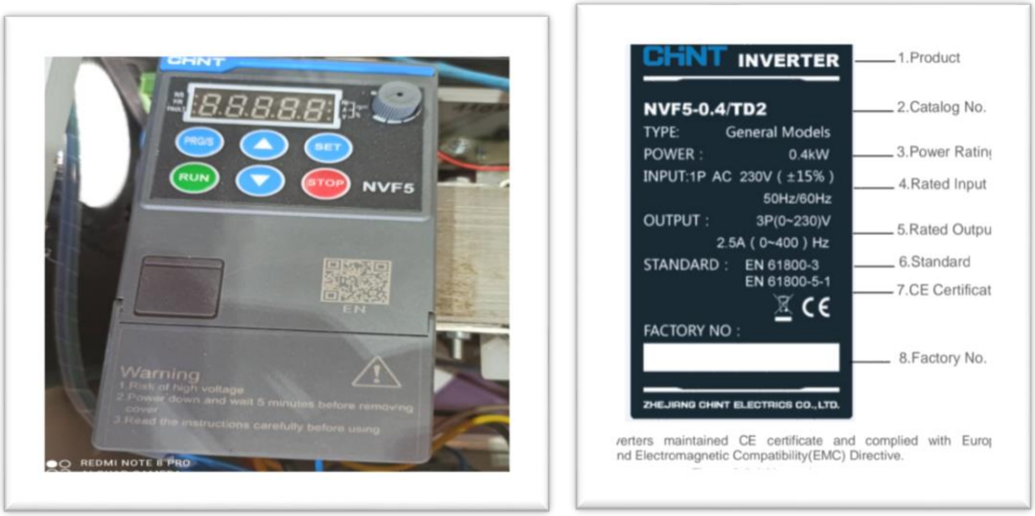


Figure III.6. transformer 24VAC/230VAC

III.2.1.C.speed variator

The variator or variable frequency drive is a converter from fixed frequency AC voltage (single-phase or three-phase) to variable-frequency AC voltage (three-phase).



CHNT INVERTER
NVF5-0.4/TD2
TYPE: General Models
POWER : 0.4kW
INPUT:1P AC 230V (±15%)
50Hz/60Hz
OUTPUT : 3P(0~230)V
2.5A (0~400) Hz
STANDARD : EN 61800-3
EN 61800-5-1
FACTORY NO :
ZHEJIANG CHINT ELECTRICS CO.,LTD.

verters maintained CE certificate and complied with Euro
nd Electromagnetic Compatibility(EMC) Directive.

Figure III.7. CHNT inverter NVF5-0.4/TD2

Table III.1 Key Function Description of the Keypad

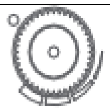
Key	Description	
PRG	Long press PRG/S key, if the LED flash state is changed, then you can loosen this function switch key	
	Shift function： In parameter edit state, bit left shift ； In main interface, switch display parameters	PRG function： Enter and exit parameters group in parameter edit state
RUN	Run Key	
STOP	Stop key when normal state； Reset fault key when fault state	
▲	Increase key（Change parameter group No .、parameters and so on）, When inverter is power on, you can use▲ key increase frequency reference directly. Setting frequency changing rate can be changed by parameter F0.12	
▼	Decrease key（Change parameter group No .、parameters and so on）, When inverter is power on, you can use▼ key decrease frequency reference directly. Setting frequency changing rate can be modified by parameter F0.12	
SET	Enter key（Save a change/Enter next level parameter menu）	
	When parameter F0.02 = 9, the potentiometer can be used on adjusting frequency. Also you can modify parameter F7.12 and F7.13 to adjust frequency range.	

Table III.2 Combination key Function Description

Key	Description	
PRG/S + SET	Parameter Menu Mode Selection（F7.11） 1、 Simple Parameter Menu Mode（U-1）； 2、 Custom Parameter Menu Mode（U-2）； 3、 Engineering Parameter Menu Mode（U-3）	
PRG/S + ▲	The system is under the main interface	Lock Combinational Key
	In custom menu mode, in menu level one	Add custom parameters
PRG/S + ▼	The system is under the main interface	Unlock Combinational Key
	In custom menu mode, in next level menu	Delete custom parameters

Table III.3 Simple Parameter Menu List

Code	Name	Parameter Description	Default
F0.00	Motor Control Mode	0：Sensorless Vector Control 1：Reserve 2：V/F Mode	0
F0.14	Accelerate Time 1	（0.0～6500.0）s	Depend on Series
F0.15	Decelerate Time 1	（0.0～6500.0）s	Depend on Series
F2.00	Motor Type	0：AC Induction Motor 1：Reserve 2：Reserve	0
F2.01	Motor NP Power	550w	Depend on motor type
F2.02	Motor NP Voltage	230v	Depend on motor type
F2.03	Motor NP Current	1.8A	Depend on motor type
F2.05	F2.05	2 ～ 24	4
F2.06	Motor NP RPM	（0～60000）rpm	1380rpm
F5.01	DI1 Function Selection	1	Forward （FWD）
F5.02	DI2 Function Selection	2	Reverse （REV）

III.2.1.D.Inverter simulation

III.2.1.D.A.simulated measurements

We used the inverter to obtain an alternating electrical voltage and a sinusoidal starting voltage from a constant electrical voltage, and the results were as follows

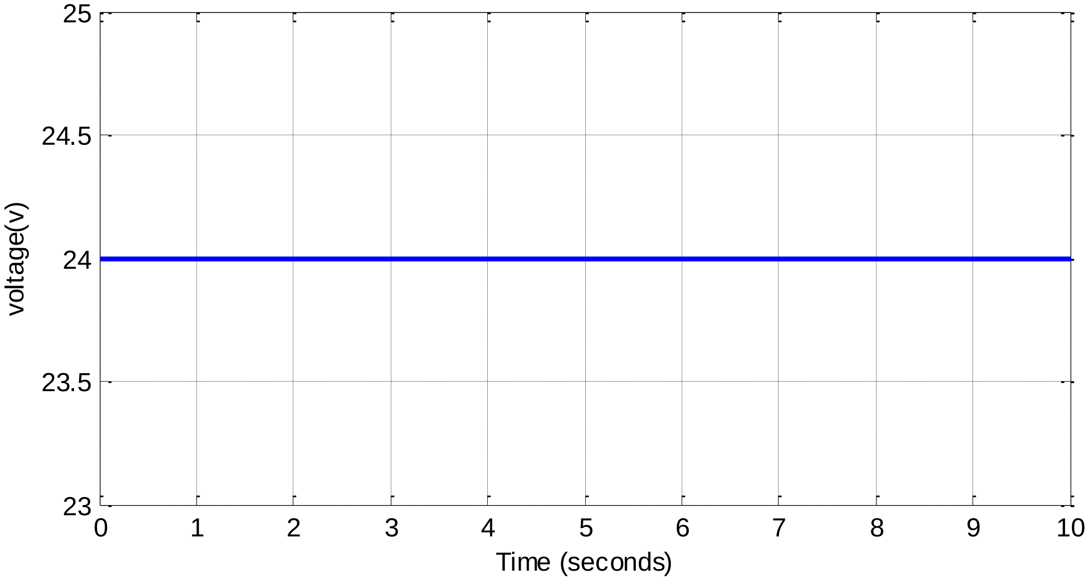


Figure III.8. the simulation result of the voltage inside to the inverter.

By figure III 8 as a result of the simulation of the voltage inside the inverter, we notice that the voltage is continuous and equal to 24 volts, and after converting it into the inverter ,we get the results in figure III 9.

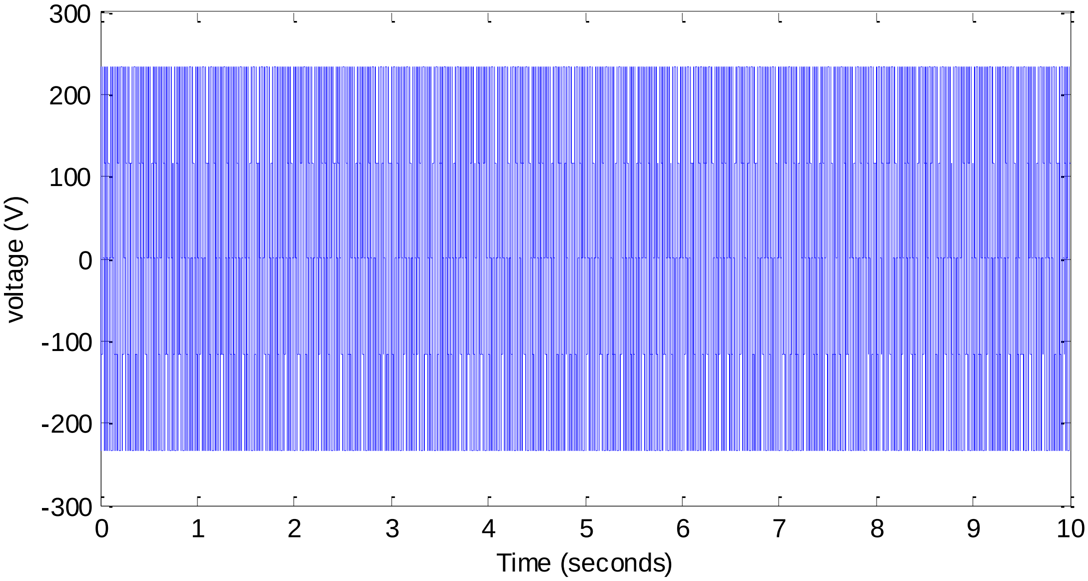


Figure III.9. the simulation result voltage obtained from the inverter.

By figure III.9 as a result of simulating the voltage obtained from the inverter ,we notice that the inverter has converted the voltage from DC to AC and became similar to the sinusoidal function and that is what is required for me to feed a three-phase motor.

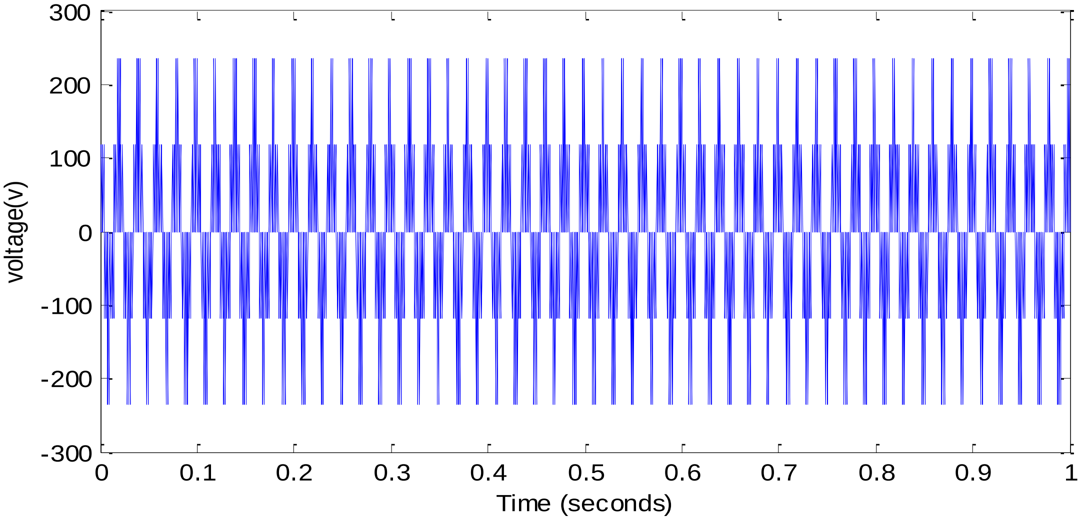


Figure III.10.zoom 1(s) of figure III.9.

III.2.1.D.B. Real measurements

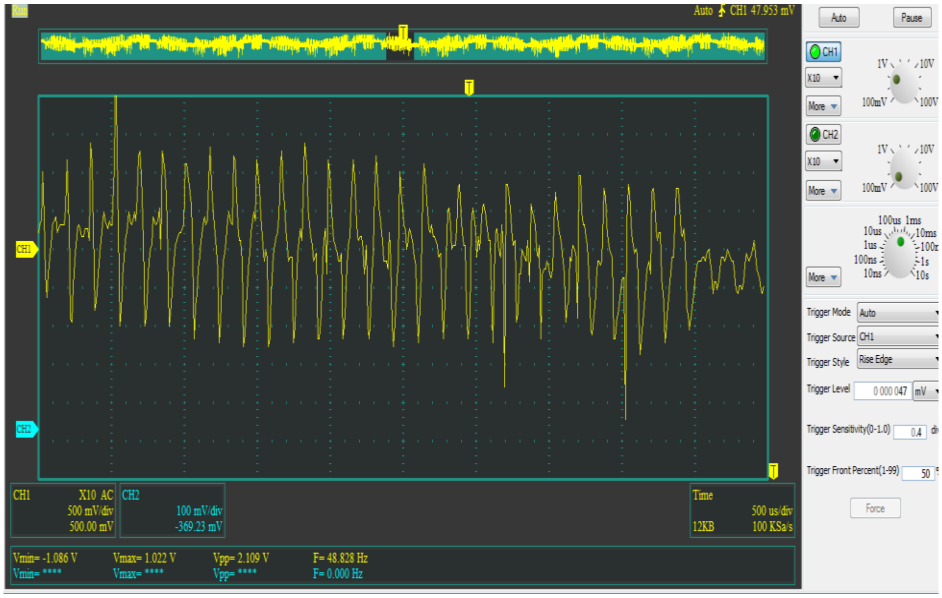
Figure III.11. Measurement tools

1: A computer

2: An oscilloscope

3: A Power supply

4: Voltage sensor



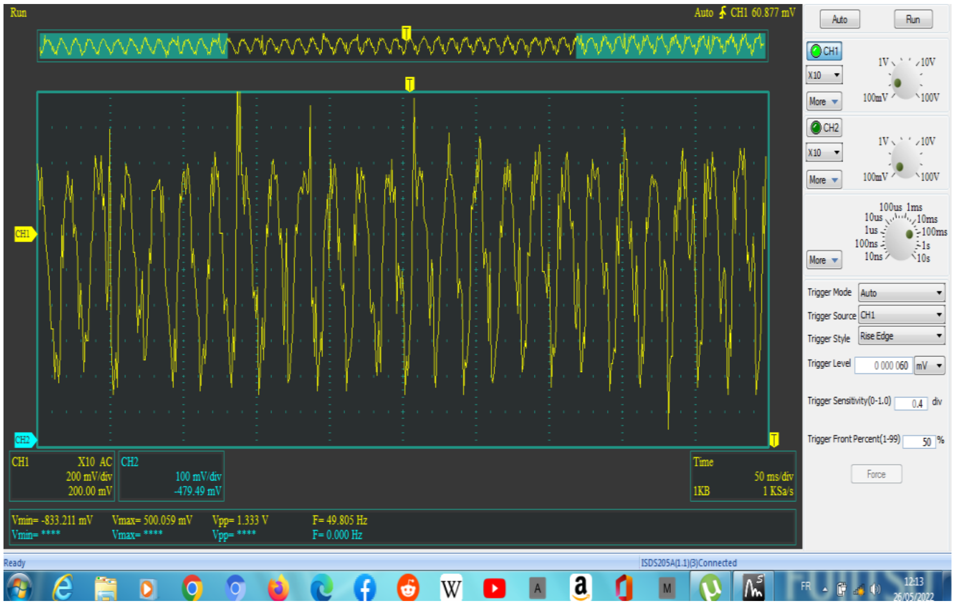
CH1 X10 AC
500 mV/div
500.00 mV
CH2
100 mV/div
-369.23 mV
Time
500 us/div
12KB 100 KSa/s

Vmin= -1.086 V Vmax= 1.022 V Vpp= 2.109 V F= 48.828 Hz
Vmin= **** Vmax= **** Vpp= **** F= 0.000 Hz

Trigger Mode: Auto
Trigger Source: CH1
Trigger Style: Rise Edge
Trigger Level: 0 000 047 mV
Trigger Sensitivity(0-1.0): 0.4 div
Trigger Front Percent(1-99): 50

Figure III.12. A curve representing the voltage of the output

From the figure III.12 we notice that the voltage is similar to the sinusoidal function , and from it we conclude that the speed variator does not work perfectly.



CH1 X10 AC
200 mV/div
200.00 mV
CH2
100 mV/div
-479.49 mV
Time
50 ms/div
1KB 1 KSa/s

Vmin= -833.211 mV Vmax= 500.059 mV Vpp= 1.333 V F= 49.805 Hz
Vmin= **** Vmax= **** Vpp= **** F= 0.000 Hz

Trigger Mode: Auto
Trigger Source: CH1
Trigger Style: Rise Edge
Trigger Level: 0 000 060 mV
Trigger Sensitivity(0-1.0): 0.4 div
Trigger Front Percent(1-99): 50 %

Ready
ISDS205A(1.1)(3)Connected

Figure III.13. A curve representing the voltage of the transformer

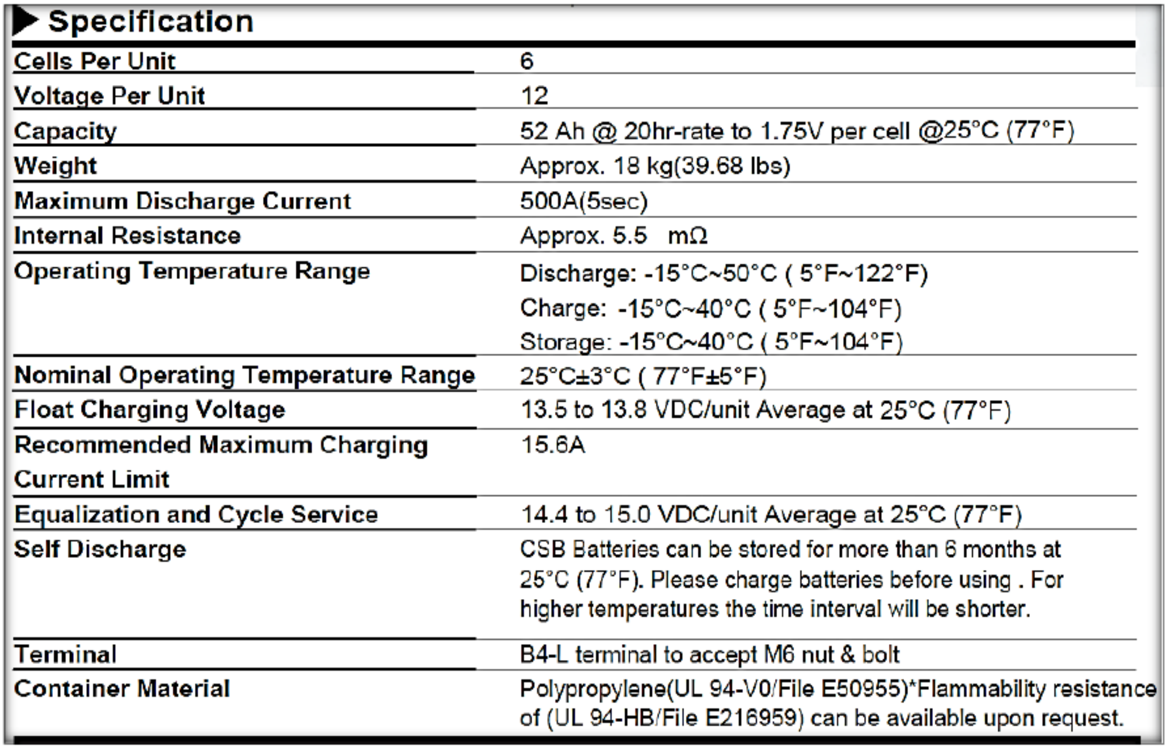
By figure III.13 as a result of measurements the voltage obtained from the transformer ,we notice that the voltage has became similar to the sinusoidal function and this is what is required to feed speed variator**.**

III.2.2. Battery

Figure III.14. GPL 12520 12V 52Ah Battery Picture

GPL 12520 is a general purpose battery up to 10 years in standby service or more than 260 cycles at 100% discharge in cycle service . As with all CSB batteries, all are rechargeable , highly efficient , leak proof and maintenance free.

Since the battery generates 12 volts, we connected two batteries in series to get 24 volts.



▶ **Specification**

Cells Per Unit	6
Voltage Per Unit	12
Capacity	52 Ah @ 20hr-rate to 1.75V per cell @25°C (77°F)
Weight	Approx. 18 kg(39.68 lbs)
Maximum Discharge Current	500A(5sec)
Internal Resistance	Approx. 5.5 mΩ
Operating Temperature Range	Discharge: -15°C~50°C (5°F~122°F) Charge: -15°C~40°C (5°F~104°F) Storage: -15°C~40°C (5°F~104°F)
Nominal Operating Temperature Range	25°C±3°C (77°F±5°F)
Float Charging Voltage	13.5 to 13.8 VDC/unit Average at 25°C (77°F)
Recommended Maximum Charging Current Limit	15.6A
Equalization and Cycle Service	14.4 to 15.0 VDC/unit Average at 25°C (77°F)
Self Discharge	CSB Batteries can be stored for more than 6 months at 25°C (77°F). Please charge batteries before using . For higher temperatures the time interval will be shorter.
Terminal	B4-L terminal to accept M6 nut & bolt
Container Material	Polypropylene(UL 94-V0/File E50955)*Flammability resistance of (UL 94-HB/File E216959) can be available upon request.

Figure III.15. Specifications in Our Battery Model

III.2.3.choice of electric motor

III.2.3.A.Three Phase Asynchronous Motor Measurements

An asynchronous motor is sometimes selected instead of an induction motor because of its operating characteristics.

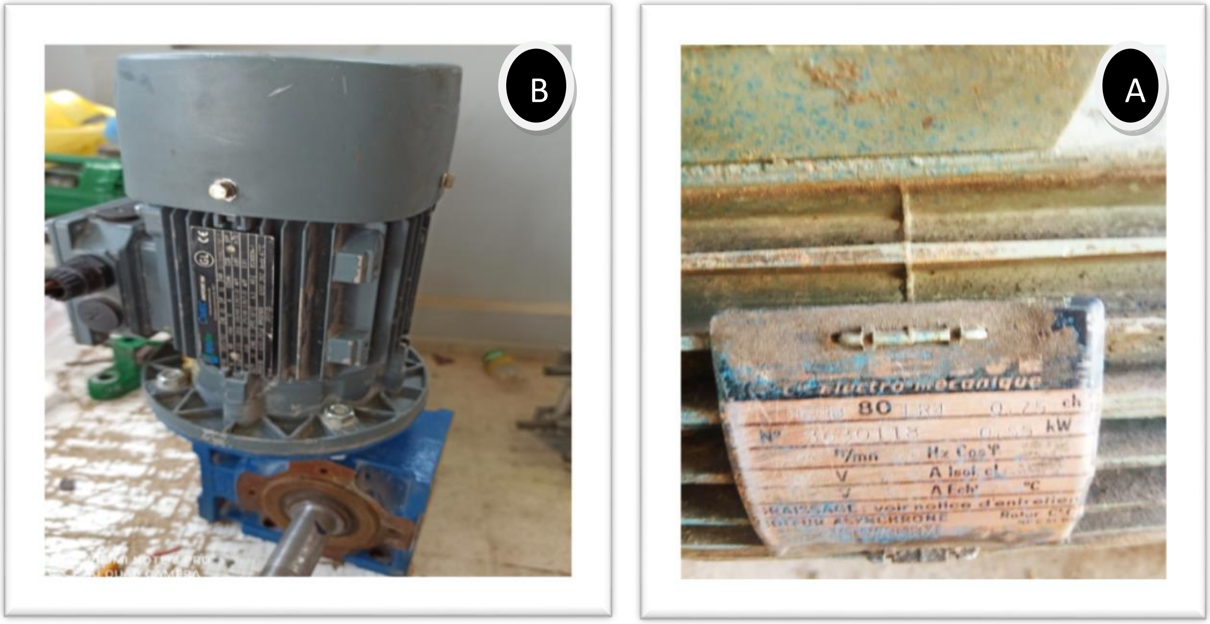


Figure III.16. Three Phase Asynchronous Motors

Table III.4 Nameplates of our motors

	Motor (A)	**Motor (B)**
Power [KW]	0.55	0.55
Frequency [Hz]	50	50
Speed [Tr/Min]	1380	2810
Voltage [V] (Δ/Y)	230/400	230/400
Current [A] (Δ/Y)	3/1.5	2.29/1.32

It is significantly more expensive and only used if it can be justified by the following considerations:

- **Speed**

Asynchronous motors run at synchronous speeds with no speed variation over the load range. If precise speed is necessary, they should be chosen.

- **Torque**

To increase the torque, we added a transmission for each motor, in order for the vehicle to run according to its weight.

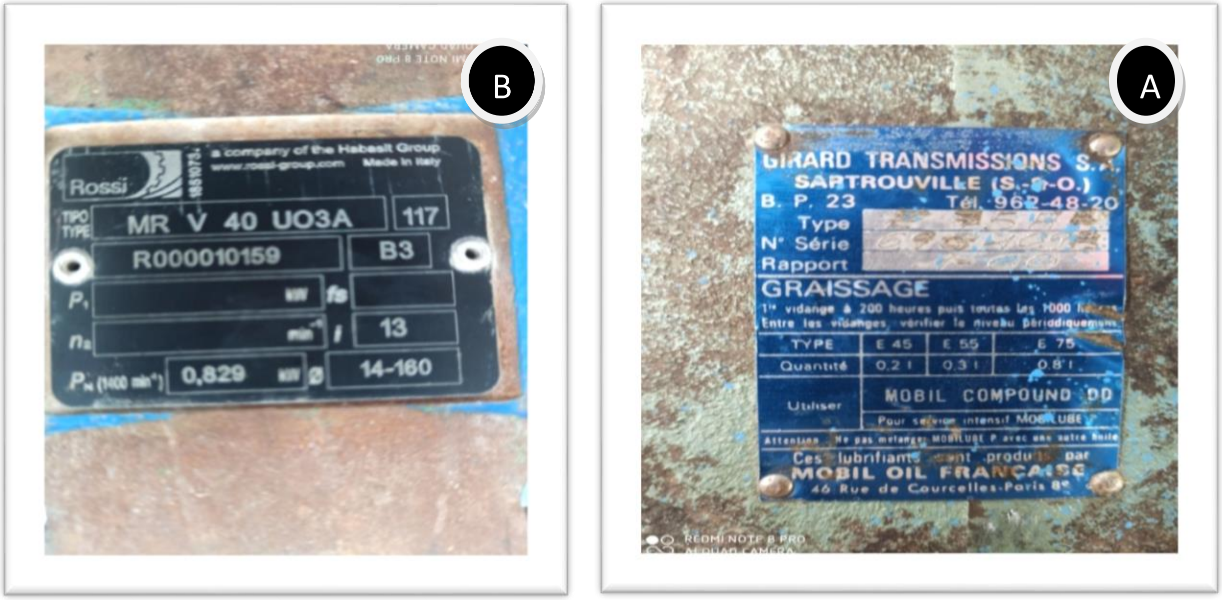


Figure III.17. Transmissions

This transmission multiplies the torque by coefficient and divides the speed by a coefficient, as shown in the following equations:

$$i = \frac{N_1}{N_2} = \frac{Ce_2}{Ce_1} \tag{III.3}$$

$$Ce = \frac{P}{ws} \tag{III.4}$$

$$\omega s = \frac{N \times 2\pi}{60} \tag{III.5}$$

Ce_1: Torque before add transmission

Ce_2: Torque after add transmission

N_1: Speed before add transmission

N_2: Speed after add transmission

i: Transmission ratio

ωs: speed

p: power

Table III.5 parameters of transmissions

	transmission (A)	**transmission (B)**
i	60	13
Ce1 (N.m)	4	2
Ce2 (N.m)	240	26
N1 (r/min)	1380	2810
N2 (r/min)	23	216

- **Lower Operating Costs**

Asynchronous motors are typically more energy efficient than induction motors, particularly in higher horsepower ranges.

A general rule of thumb is to use an asynchronous motor(A) when the horsepower requirement exceeds the motor's speed.

After we did an experiment with the two motors, we selected motor because its transmission is bigger than the transmission of the motor A, which gives us more torque so the chance of the vehicle traveling is greater.

III.2.3.B.Three Phase Asynchronous Motor simulation

III.2.3.B.A.simulation measurements

Table III.6 parameters of our motor (A)

Nominal power P[W]	550
voltage (line-line) U[V]	230
Frequency F[HZ]	50
Stator resistance Sr[OHM]	3.805
Stator inductance LS[H]	0.005839
Rotor resistance Rr[OHM]	2.695
Rotor inductance LR[H]	0.005839
Mutual inductance LM[H]	0.1722
Inertia J[Kg.m^2]	0.0131
friction factor F[N.m.S]	0.002985
pole pairs P	2

Figures III(18,19,20,21) show the simulated results for starting a three-phase asynchronous motor (A) for a me 10 seconds. speed ,electromagnetic torque, rotor current and rotor voltage respectively.

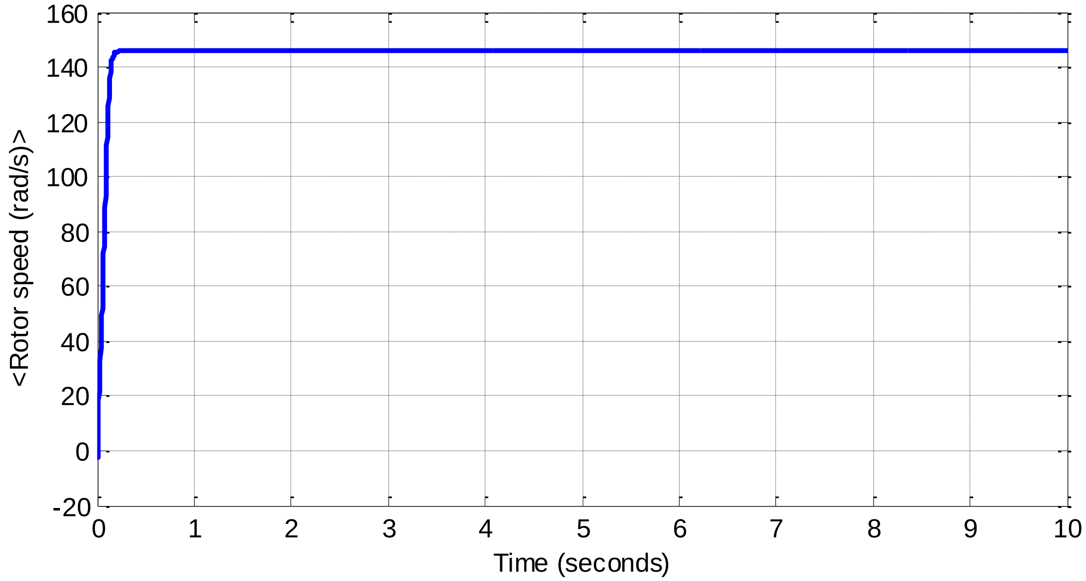


Figure III.18. simulation result for motor speed (A).

From figure III.18 we notice that the speed stabilized after 0. 2 seconds of running at a value of 145rad/s, and this value is equivalent to 1380r/min ,which is the actual equivalent value of motor (A).

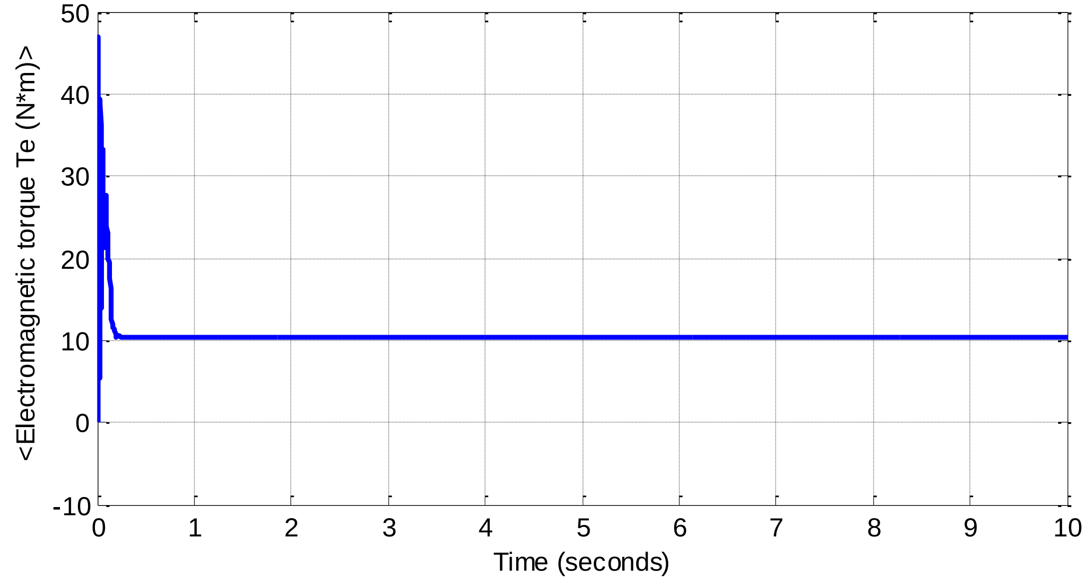


Figure III.19. simulation result for motor torque (A) .

From figure III.19 we notice that the torque is stabilized after 0.2 seconds of running at a value of 10 N.m ,which is the value of the motor's torque (A) when fed from network.

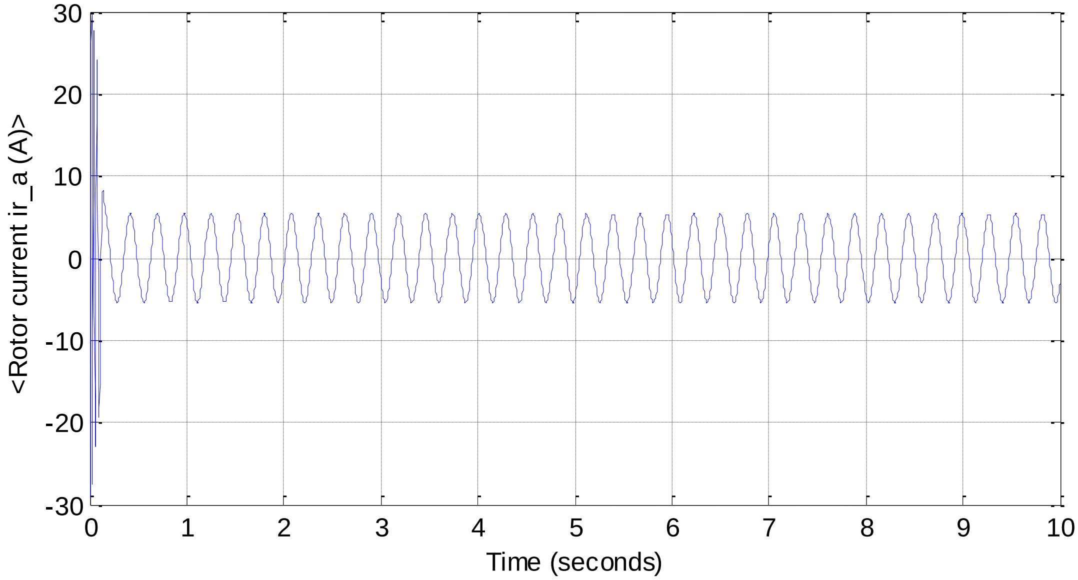


Figure III.20. simulation result for motor current (A).

From figure III.20, we notice that the current is a sinusoidal function when operating, it is high with a value of 30A as a maximum, value -30A as a minimum value and after 0.2 S it decreases to 4A as a maximum value and -4A as a minimum value, and it is fixed at this value if no load is applied to it.

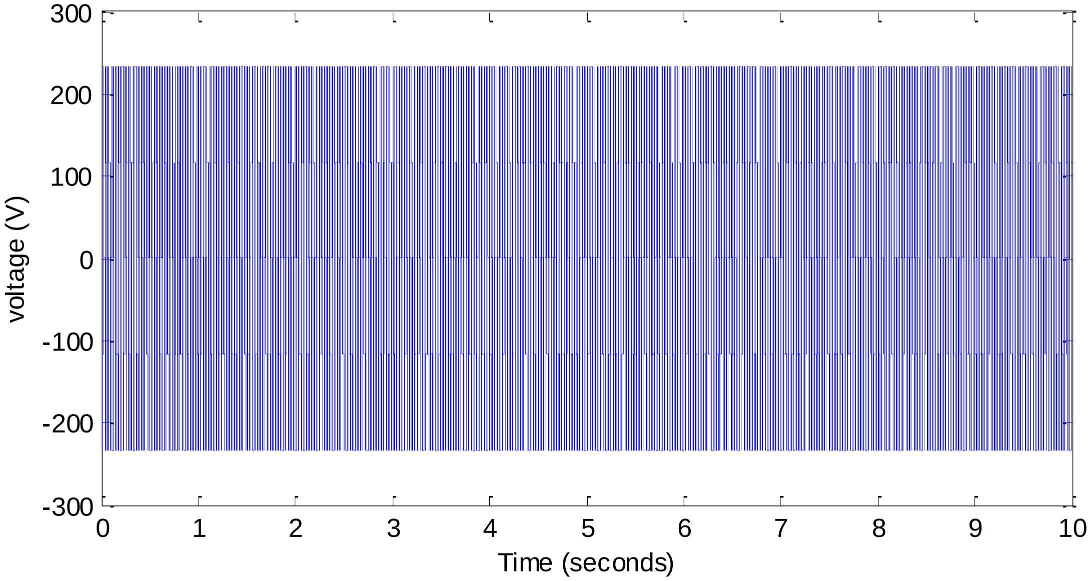


Figure III.21. simulation result for motor (A) and (B) tension.

From figure III.21, we notice that the voltage is alternating and its maximum value is 230V and this is what is required to feed our motors.

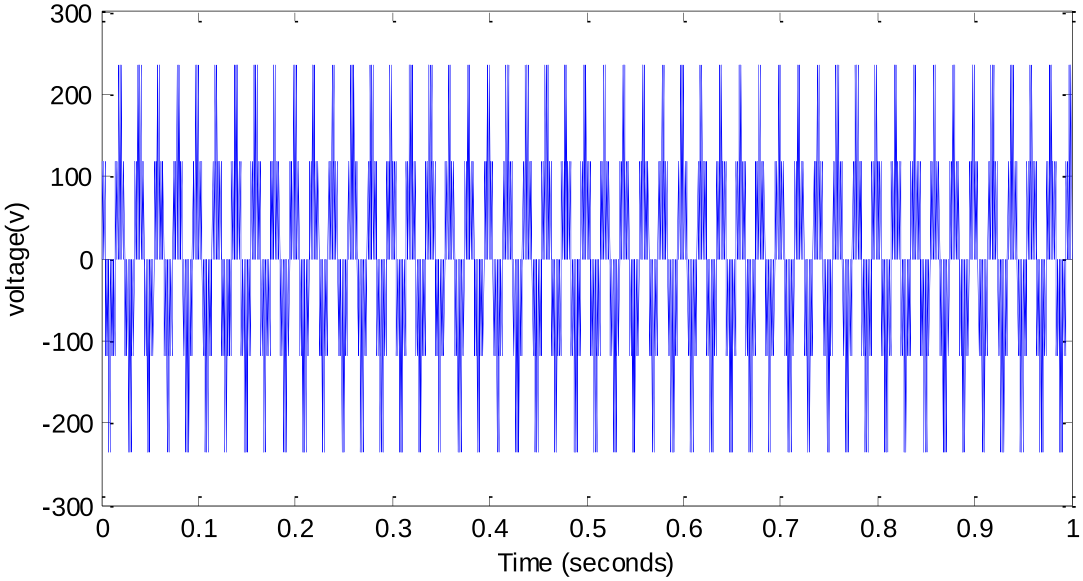


Figure III.22.zoom 1(s) of figure III21.

Table III.7 parameters of our motor (B)

Nominal power P[W]	550
voltage (line-line) U[V]	230
Frequency F[HZ]	50
Stator resistance Sr[OHM]	4.85
Stator inductance LS[H]	0.274
Rotor resistance Rr[OHM]	3.805
Rotor inductance LR[H]	0.247
Mutual inductance LM[H]	0.258
Inertia J[Kg.m^2]	0.031

friction factor F[N.m.S]	0
pole pairs P	2

Figures III(23,24,25) show the simulated results for starting a three-phase asynchronous motor (B) for a me 4 seconds. speed ,electromagnetic torque, current respectively.

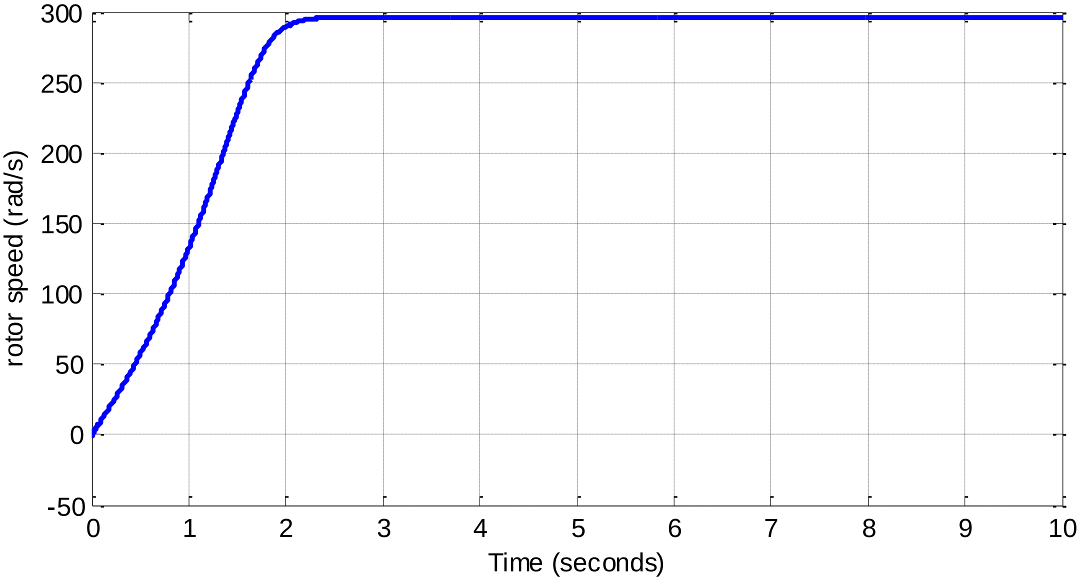


Figure III.23. simulation result for motor speed (B).

From figure III.23 we note that the speed stabilized after 2.5 seconds of running at a value of 295 rad/s, and this value is equivalent to 2810 r/min ,which is the actual equivalent value of motor (B).

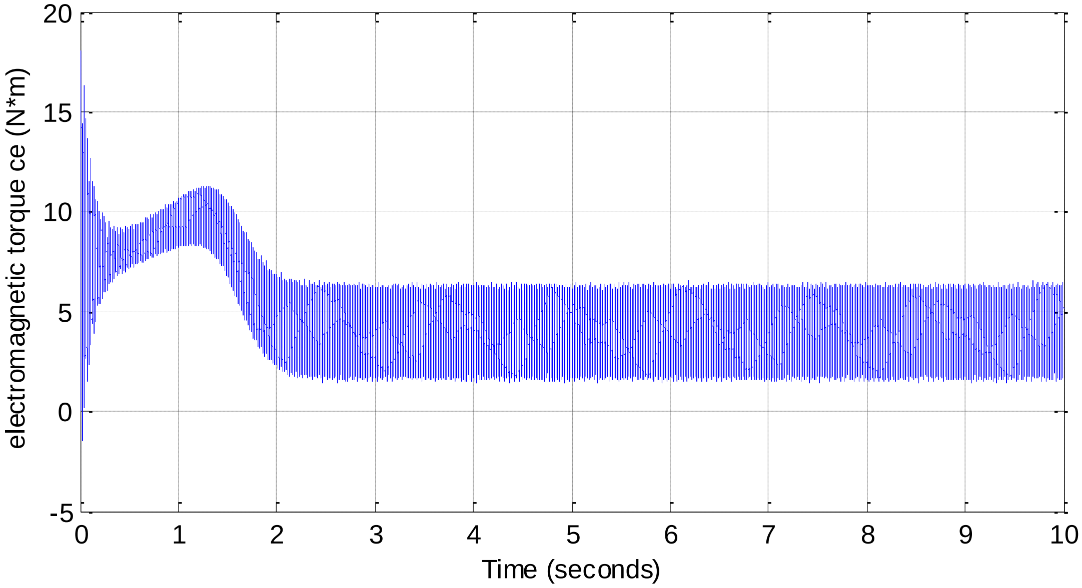


Figure III.24. simulation result for motor torque (B).

From figure III.24 we notice that the torque is stabilized after 2.5 seconds of operation with a value of 5 N.m ,which is the value of the torque of motor (B).

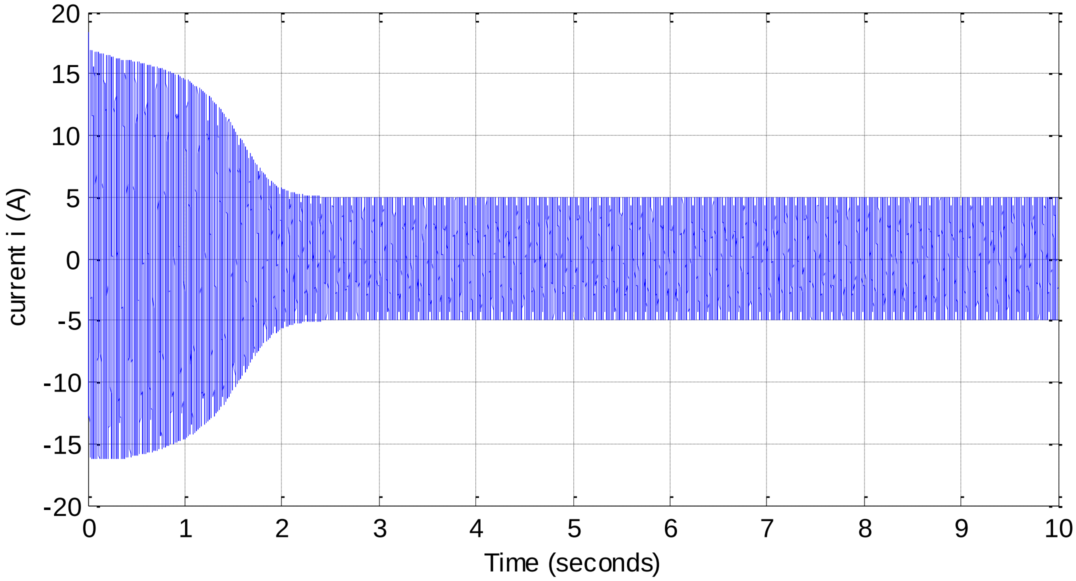


Figure III.25. simulation result for motor current (B).

From figure III.25, we notice that the current is a sinusoidal function when operating, it is high with a value of 15A as a maximum, value -15A as a minimum value and after 2.2 S it decreases to 4A as a maximum value and -4A as a minimum value, and it is fixed at this value if no load is applied to it.

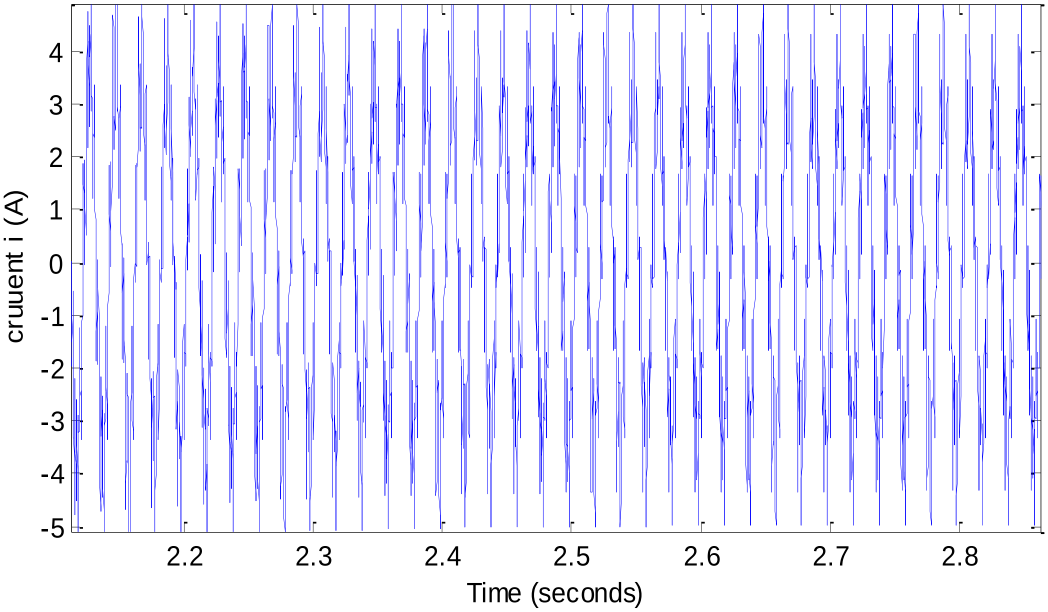
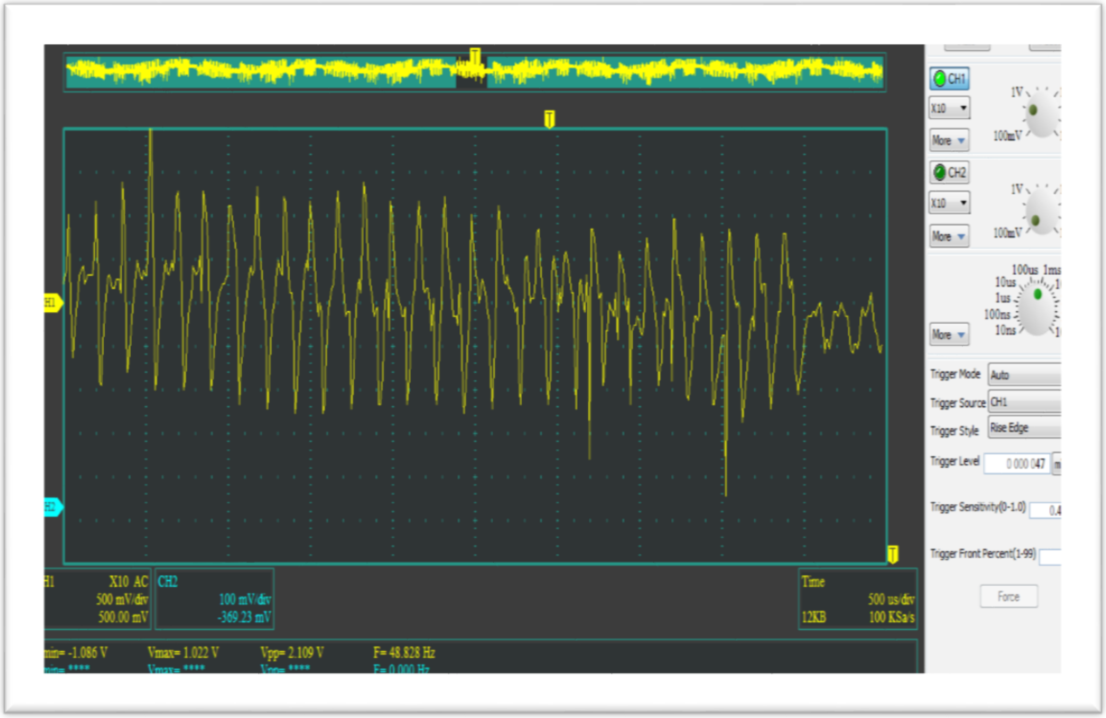


Figure III.26. zoom from 2(s) to 3(s) of figure III.25

III.2.3.B.B.real measurements



H1 X10 AC 500 mV/div 500.00 mV

CH2 100 mV/div -369.23 mV

Time 500 us/div

12KB 100 KSa/s

min= -1.086 V Vmax= 1.022 V Vpp= 2.109 V F= 48.828 Hz

min= **** Vmax= **** Vpp= **** F= 0.000 Hz

Trigger Mode Auto

Trigger Source CH1

Trigger Style Rise Edge

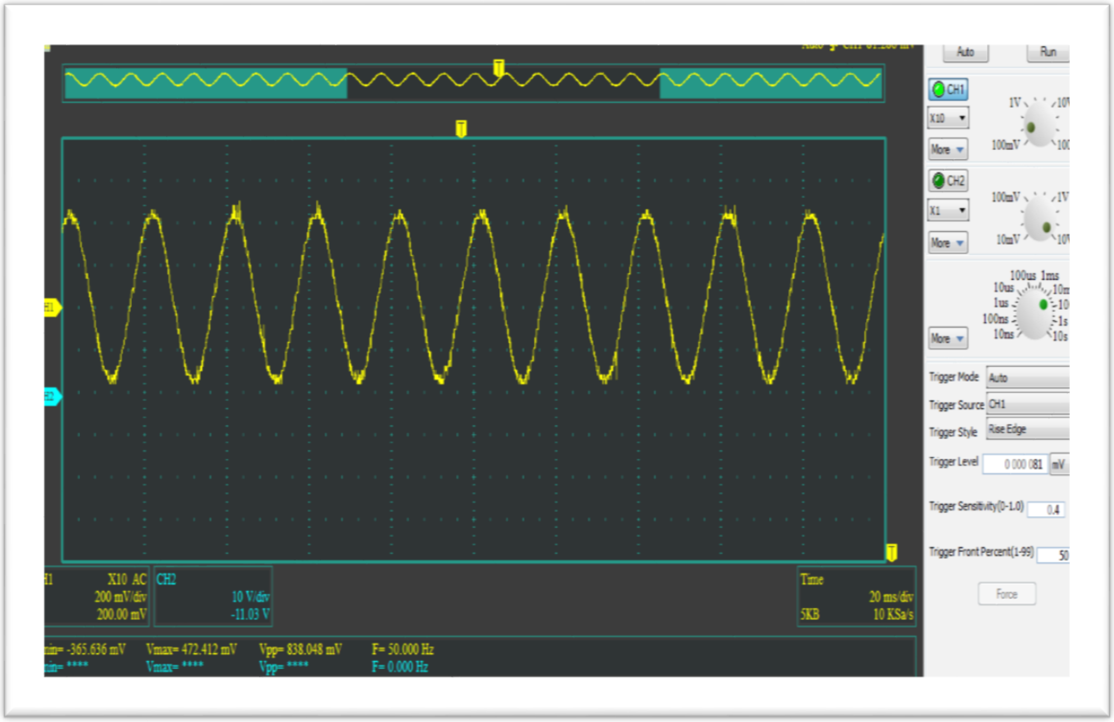
Trigger Level 0.000 047

Trigger Sensitivity(0-1.0) 0.4

Trigger Front Percent(1-99)

Figure III.27. tension motor result

From the figure III.27 we can see from the curve that the motor voltage is alternating and non-uniform.



```
CH1 X10 AC
200 mV/div
200.00 mV
CH2
10 V/div
-11.03 V
Time
20 ms/div
5KB 10 KSa/s
Vmin= -365.636 mV   Vmax= 472.412 mV   Vpp= 838.048 mV   F= 50.000 Hz
Vmin= ****          Vmax= ****         Vpp= ****         F= 0.000 Hz
```

Trigger Mode: Auto
Trigger Source: CH1
Trigger Style: Rise Edge
Trigger Level: 0 000 081 mV
Trigger Sensitivity(0-1.0): 0.4
Trigger Front Percent(1-99): 50

Figure III.28. current motor result

From the figure III.28 we can see from the curve that the motor current is alternating and regular**.**

III.2.4.Accessories

III.2.4.A.Circuit breaker

A car circuit breaker or battery circuit breaker is an important part of our vehicle. This is a safety device that is often mandatory for the racing car. It makes it possible to secure our car and therefore it is also essential for our own safety as well as that of our passengers.

Figure III.29. a circuit breaker

III.2.4.B.Foot pedal switch

A foot switch, often known as "stomp" switch, is activated by stepping on the actuator, which is usually a pushbutton or pedal.

Figure III.30. foot pedal switch

A benefit of using a foot switch is that it frees up a person's hands for other tasks while yet enabling complete control of switching by a human operator.

III.2.4.C. Indicator turn signal

Your car's turn signals are an important safety feature that helps you to express your intentions to other motorists. A growing number of people are neglecting to use their indicators, resulting in an increase in accidents.

Figure III.31. Indicator turn signal

III.2.4.D.Headlight

The main purpose of automotive headlights is to illuminate the road and allow for fatigue-free and safe driving. As a result, headlights and their light sources are important vehicle components for safety.

Figure III.32. Headlight

III.2.4.E.Horn

A horn is a sounding device that can be installed in cars, buses, and other types of vehicles. The horn is used by the driver to alert people to the approaching or presence of a vehicle, as well as to attract attention to potential hazards.

Figure III.**33**. a horn

III.2.4.F.Digital bike speed motor

The bicycle computer, or odometer, is a small electronic or mechanical device that measures the speed, distance traveled.

Figure III.**34**. Digital bike speed motor

III.3.Conclusion

In this third and final chapter ,which is the application part of this note ,in which we dealt with how to calculate and select the appropriate motor and inverter, and various other components for an electric vehicle.

General Conclusion

General Conclusion

The goal of this work is to choose an electric motor that does not pollute the environment, as opposed to an internal combustion engine that pollutes the environment. The engine is chosen according to the weight of the vehicle through torque, speed, current, tension or horsepower (calculated by power). The greater the weight, the greater the torque to move the vehicle, which is an essential step for determining the engine. Fit for vehicle.

The key to this study is to experimentally produce an electric vehicle in order to justify the choices of the electric motor based on the weight, torque and speed of this vehicle From the experimental and theoretical results during this thesis, we concluded that:

- the theoretical and experimental results of the voltage and the current of the motor to be chosen are not suitable, it is thanks to the parameters of the motor such as (the stator resistance, the rotor resistance, the stator inductance, the rotor inductance) which are not available
- The advantage of the engine to choose has a large torque, it allows the vehicle to roll in any trajectory (plane, incline).
- The inconvenience of the motor to choose is at low speed (about 1Km/h), it is that it allows to minimize the field of application of the vehicle (for example the rolling chassis of andicaput).
- The vehicle has great autonomy, it is almost more than 6 hours
- Simple to charge this vehicle's batteries from a single outlet power supply, and even automatically disconnects when the batteries are charged.

Perspectives :

- Use the wheel motors (2,3 and 4) motors, in order to increase the speed of this vehicle.
- Minimize the cost of electrical energy consumption during battery charging by using photovoltaic panels to drive the vehicle and even charge the batteries from solar energy.
- Use the solidworks software to designate the coke of this vehicle.

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Résumé :

Le véhicule électrique est un moyen de transport qui ne présente aucun danger pour la nature. Remplace donc le moteur à combustion interne par un moteur électrique. Ainsi le choix de cette motorisation permet de minimiser le coût et d'augmenter l'autonomie de ce véhicule.

Ainsi dans cette thèse nous avons étudié le choix du moteur électrique associé au convertisseur électronique au vu de leurs performances (coût, poids, vitesse et couple).

Mots clés : véhicule électrique , moteur électrique , convertisseur électronique ,autonomie

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Abstract:

The electric vehicle is a means of transport that has no danger to nature. So replaces the internal combustion engine with an electric motor. So the choice of this engine makes it possible to minimize the cost and increase the autonomy of this vehicle.

So in this thesis we studied the choice of the electric motor associated with the electronic converter in view of their performance (cost, weight, speed and torque).

Keywords: electric vehicle, electric motor, electronic converter, autonomy

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الملخص:

المركبة الكهربائية من وسائل النقل لا تشكل خطراً على الطبيعة. لذلك يستبدل محرك الاحتراق الداخلي بمحرك كهربائي. لذا فإن اختيار هذا المحرك يجعل من الممكن تقليل التكلفة وزيادة استقلالية هذه السيارة.

لذلك قمنا في هذه الأطروحة بدراسة اختيار المحرك الكهربائي المرتبط بالمحول الإلكتروني في ضوء أدائه (التكلفة والوزن والسرعة وعزم الدوران)

الكلمات المفتاحية: السيارة الكهربائية ، المحرك الكهربائي ، المحول الإلكتروني ، الاستقلالية