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Management and Optimization of multiple sources to power an autonomous grid

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***Abstract*—Technological change and the lifestyle of the Algerian population took an increasing growth in recent years it was hit by a power demand galloping power. During the summers in southern Algeria and especially for food isolated sites, usually powered by diesel generators: the introduction of a (wind-diesel) hybrid system with battery storage will be a great contribution technical economy in future years. Knowing that the wind speed is unstable, the contribution of the battery storage for a specified period is required. The combination of hybrid energy system (HES)-based renewable energy is a strategy for the use of three sources that are complementary to a reasonable service continuity.**

Our article discusses the optimal management of the production of electro-energy system with adequate adaptation to weather and the power required. This system is managed by an electronic control unit providing switching with a controlled system taking into account the weather and require adaptation of a research strategy of the maximum power point (MPPT maximum point tracking) to transfer permanently the source to the load.

***Keywords*— Autonomous network, Hybrid system, Wind turbine, Diesel generator, Storage system, Energy Modeling, Energy management, MPPT control.**

I. Introduction

Nowadays with technological developments and living comfort air conditioning to various household utensils. Power to increase the demand for especially during the summer of southern production.

The connection of isolated sites southern Algeria is very expensive and difficult to manage, and it is for this reason that the installation of the hybrid system is advantageous. Knowing that the diesel-powered group exists and the addition of wind turbines will be a great contribution to the continuity and preventive and corrective maintenance of HES system. Statistical analysis of the metrological conditions and the load curve (reflecting the highs peak) our storage system can combine different elements of HES and even admitted to the storage system to open the energy needed for optimal management and assurance of adequate stability. In this context, we proposed a site survey of the architectural point of view and the installation of an autonomous power supply consists of a generator, a wind turbine and battery storage. This study focuses on the choice of site, the network architecture and analysis of load curves: one hand and a proposed modélisation.qui will dismiss the achievement HPS system with an economic study.

II. Problem

In most isolated regions in Algeria, the diesel generator is the main source of electrical power Fig.1.

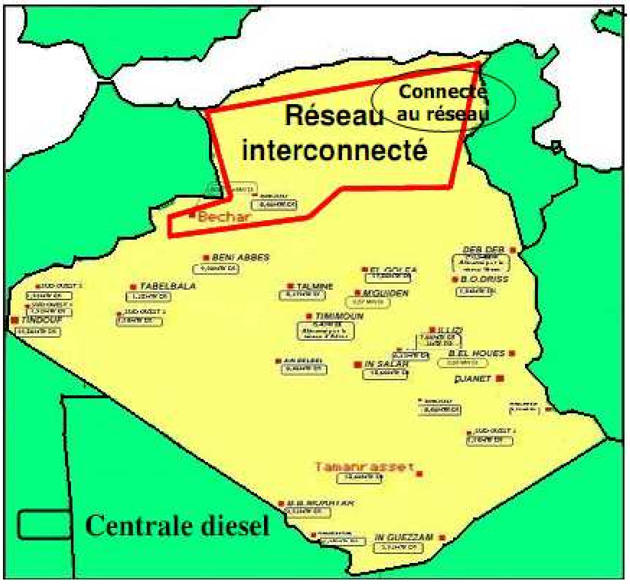

Fig. 1 Distribution of diesel power plants in remote areas in Algeria [1].

For these regions, the fuel is usually more expensive because it must provide additional transport costs to these isolated places, sometimes inaccessible. This is why the use of diesel generators combined with a renewable energy source and a storage system is recommended. It is with this objective that fits my article with the use of multiple sources for energy supply system adopted.

III. Location of Hybrid System

To be good sites for implementing this system in Algeria must choose a place is characterized (wind speed, power requirements) of fig. 2.

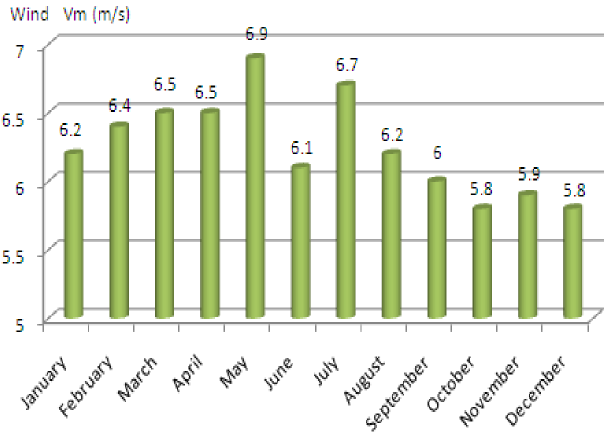

Fig. 2 Monthly averages speed of wind of Adrar.

For this study, a geographical localization is considered with the wilaya of Adrar fig.3, located at the Algerian western south with co-ordinates following: Longitude 0.28;Latitude 27.82 and covering a total surface of 427.968 Km².

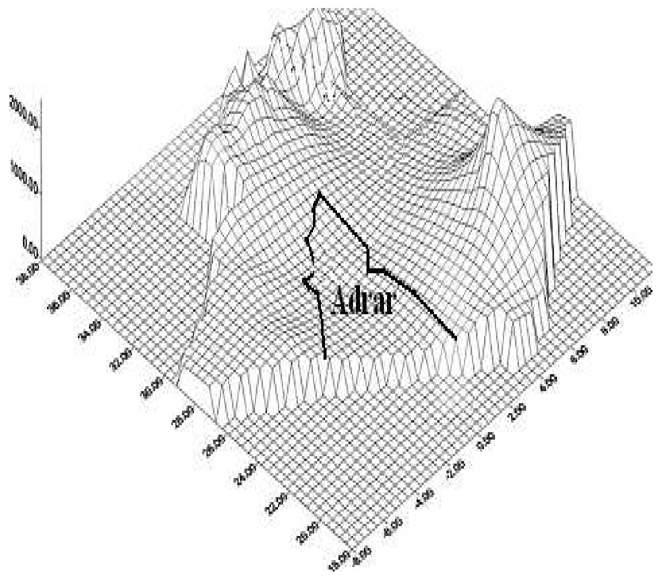

Fig. 3 Map geography of wilaya Adrar.

The majority of sites in the wilaya of Adrar could be considered as isolated sites to the vast size and distance from the city and each other. Climatic conditions are extremely difficult to consider another parameter. All this leads us to think of hybrid systems for powering an area in this region [8].

IV. Operating Strategy

This system consists of a wind turbine with machine double-fed asynchronous (DFIG), the generator diesel (GD) and a battery. Depending on the strength of the wind, 3 operating modes can be distinguished for systems with high penetration Fig. 4.

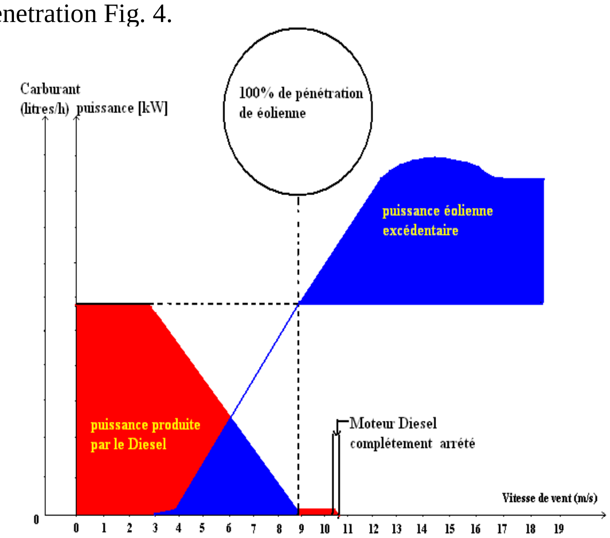

Fig. 4 Variation of energy covered by a system Wind -Diesel and diesel consumption as a function of wind speed [2].

The terms of the commissioning of different sources are presented in the following chart:

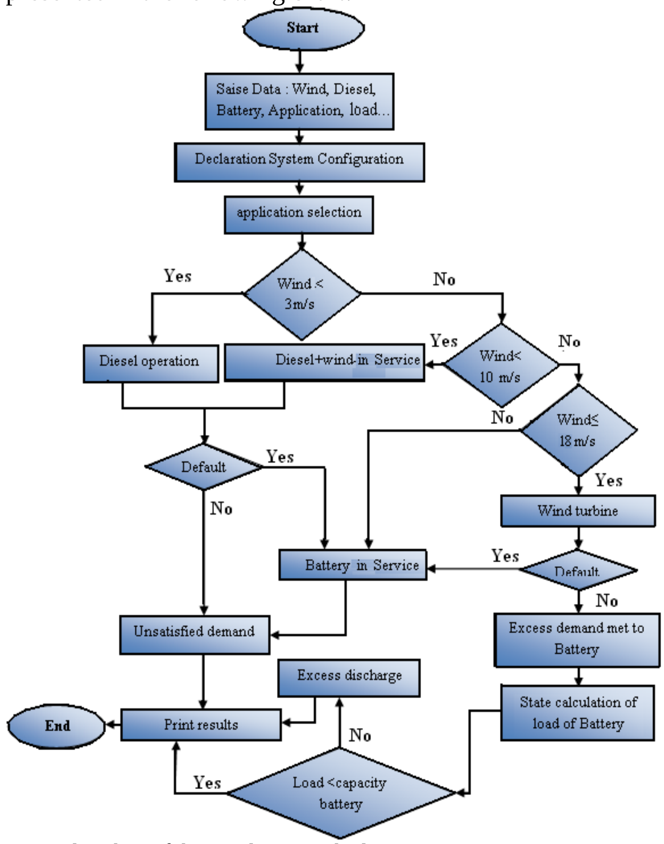

Fig.5 Flowchart of the simulation method.

Figure 6 shows a diagram of the overall hybrid system supplying an electrical charge. The connection of these elements is performed at a DC voltage bus. This bus has the advantage of more easily interconnect the different components of the hybrid system.

From the DC bus, the network connection is achieved thanks to a DC power / AC, which then adjusts the voltage and frequency of the front into AC power fed into the grid.

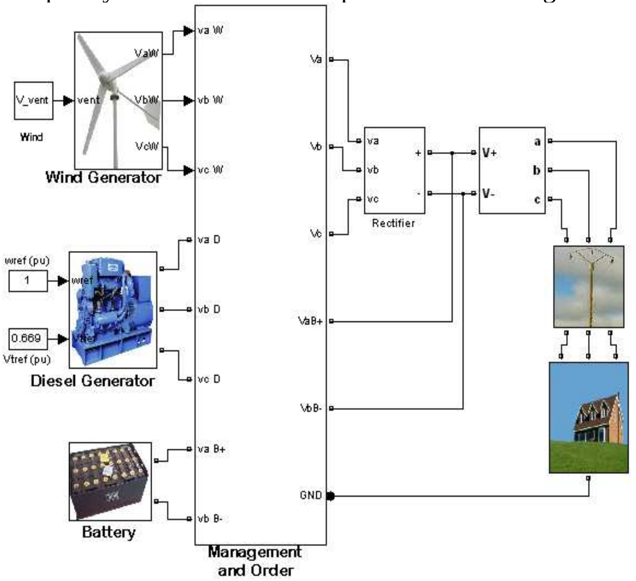

Fig.6 Overall system diagram.

IV. Modeling of Sources

A. Wind generator

In our paper we consider a three-bladed wind turbine associated with a turbine driving an asynchronous generator dual power through a shaft and a speed multiplier Fig.7.

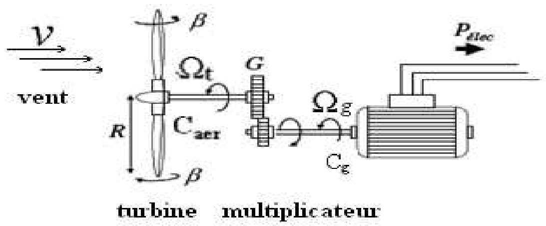

Fig.7 Components this wind.

1) *Model Wind:* The wind speed is usually represented by a scalar function that evolves over time.

$$V_v = f(t) \tag{1}$$

The wind speed will be modeled in this part, as deterministic as a sum of several harmonics [9]:

$$V_v = A + \sum_{n=1}^{i} a_n.\sin(b_n.W_v.t) \tag{2}$$

Fig.8 shows the speed of a simulated (2) random wind.

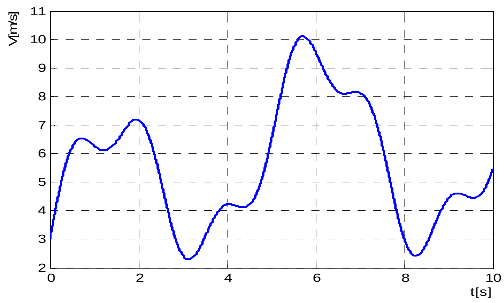

Fig.8 Speed versus time.

2) *Model of the turbine*

Applying the theory of momentum and Bernoulli, we can determine the incident power (theoretical) due to wind [3], [4]:

$$P_{incidente} = \frac{1}{2}.\rho.S.V^3 \tag{3}$$

S : The area swept by the blades of the turbine surface[m²].
ρ : the density of the air (ρ =1.225 (m ^{3}/ kg) at atmospheric pressure).
V: Wind speed [m / s].

In wind energy system due to various losses, provided on the power extracted from the turbine rotor is less than the forward power. The power extracted is expressed by equation (4) [10].

$$P_{extraite} = \frac{1}{2}.\rho.S.Cp(\lambda,\beta).V^3 \tag{4}$$

Cp (λ/β): power coefficient, which expresses the aerodynamic efficiency of the turbine. It depends on the ratio λ, which represents the ratio between the speed at the tips of the blades and the wind speed, and the angle of orientation of the blades β.

The ratio λ expressed by (5) [11]:

$$\lambda = \frac{\Omega_t.R}{v} \tag{5}$$

The maximum power coefficient Cp was determined by Albert Betz as follows [5]:

$$Cp^{max}(\lambda,\beta) = \frac{16}{27} \approx 0.593 \tag{6}$$

The power factor is the aerodynamic efficiency of the wind turbine. It depends on the shape of the turbine rotor and the angle of orientation of the blades *β* and the ratio of the speed λ. This coefficient can be written as follows:

$$Cp(\lambda,\beta) = 0.5176\left(\frac{116}{\lambda i} - 0.4\beta - 5\right)\ell^{\frac{21}{\lambda.i}} + 0.0068\ \lambda i \tag{7}$$

With:

$$\frac{1}{\lambda i} = \frac{1}{\lambda + 0.08\beta} - \frac{0.035}{\beta^3 + 1} \tag{8}$$

Figure 9 shows the curves of the power coefficient as a function of λ for different values of *β*.

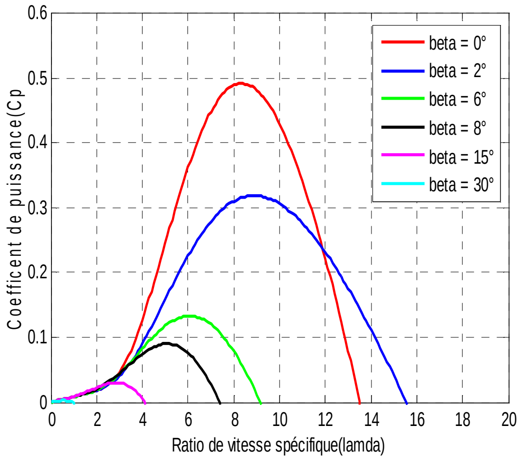

Fig.9 Power coefficient according to λ and β.

The aerodynamic torque on the output shaft can be expressed by (9):

$$C_{al} = \frac{P_{eol}}{\Omega_t} = \frac{1}{2}.\rho .S .Cp \ (\lambda , \beta).V^{3}.\frac{1}{\Omega_t} \qquad (9)$$

Ωt : Rotational speed of the turbine.
C_{al}: Torque on the slow axis (turbine side).

Mechanical speed is related to the rotational speed of the turbine by the coefficient of the multiplier. The torque on the slow axis is connected to the torque on the fast axis (generator side) by the coefficient of the multiplier.

3) *Model multiplier*

The multiplier is characterized by its gain G. He adjusts the speed of rotation of the turbine Ω_t the speed of the generator Ω_g:

$$\Omega_g = G * \Omega_t \qquad (10)$$

4) *Tree model:*

The basic equation of dynamics applied to the shaft of the generator determines the evolution of the mechanical speed Ωm from the total mechanical torque Cm:

$$C_m = J\frac{d\Omega_m}{dt}$$

(11)

J : total inertia that appears on the rotor of the generator:

$$J = \left(\frac{J_t}{G^2}\right) + J_g \qquad (12)$$

With:
J_g : the inertia of the generator.
J_t : the inertia of the turbine.

The above equations are used to establish the servo block diagram of the turbine speed Fig.10.

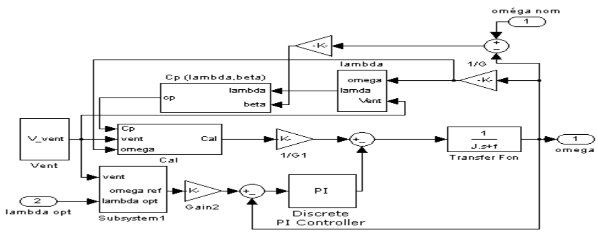

Fig.10 Diagram of control of the speed of the turbine unit.

Mechanical power that appears on the shaft of the generator (*Pm*) is expressed as the product of the mechanical torque (*Cm*) and the mechanical speed:

$$P_m = C_m * \Omega_m \qquad (13)$$

B. Diesel

The generator consists of a diesel engine and a synchronous machine Fig.11. The diesel engine produces mechanical energy by combustion of fuel. Synchronous generator converts mechanical energy into electrical energy. The frequency is regulated through regulation of the speed of the diesel engine. As the amplitude is controlled via the excitation of the synchronous machine. [6]

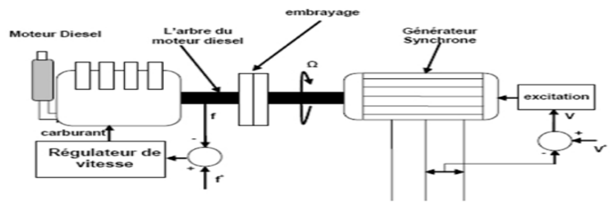

Fig.11 Configuring the diesel generator.

C. The Battery

The battery model is based on the observation of the physical-chemical phenomenon of the charge and discharge of the storage system [7].
You can use the following equivalent circuit:

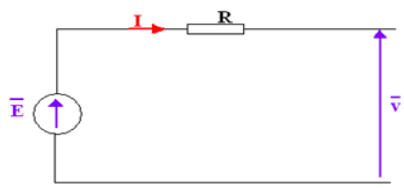

Fig.12 Simplified electrical diagram of a battery.

So the mathematical model is:

$$V = E - \left(R * \bar{I}\right) \qquad (14)$$

Where $\bar{I}$ is the algebraic value of the current (in case of positive and negative load for discharge).

IV. SIMULATION RESULTS

To simulate the hybrid system (wind / diesel unit), we made the simulation scheme of Figure 6 in the Matlab-Simulink 7.8 software.
At t = 1.2s time coupling between two sources.

A. Wind turbine (DFIG)

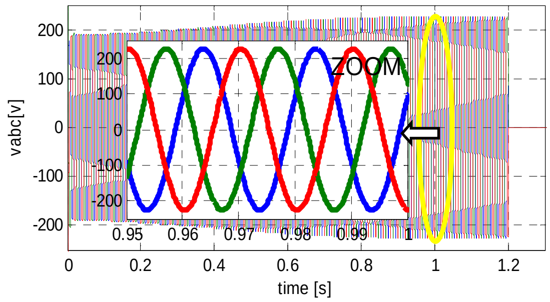

Fig.13 The evolution of the stator voltages.

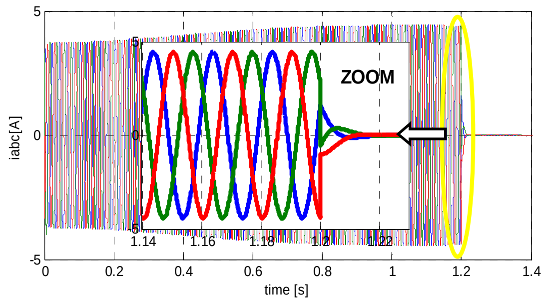

Fig.14 The evolution of the stator currents.

B. Diesel group

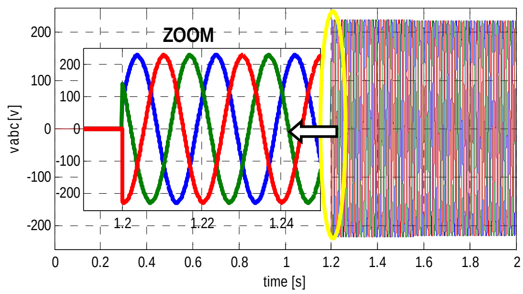

Fig.15 Voltages produced by the Diesel Group.

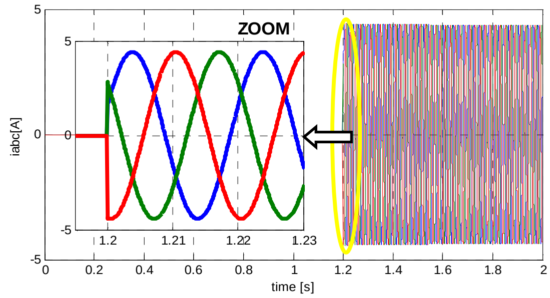

Fig.16 Currents produced by Diesel Group.

C. Diesel Group /Wind turbine

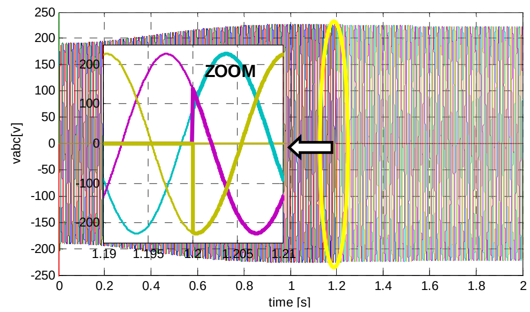

Fig.17 The evolution of the stator voltages.

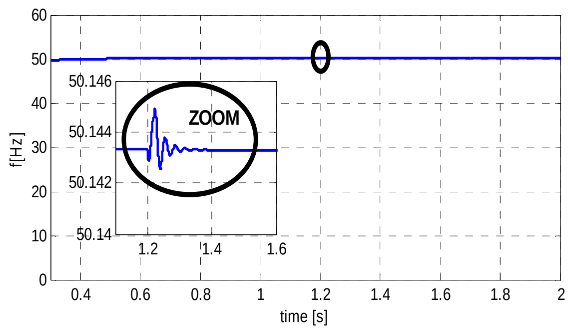

Fig.18 Overview of frequency.

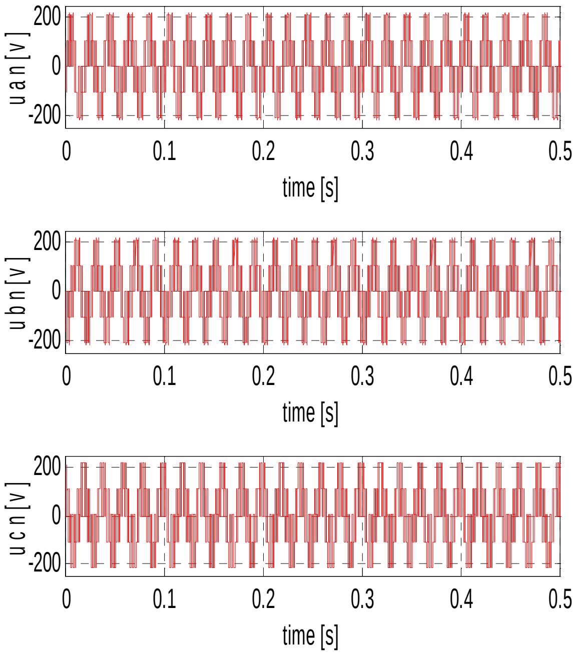

Fig.19 The phase voltages generated by the PWM inverter.

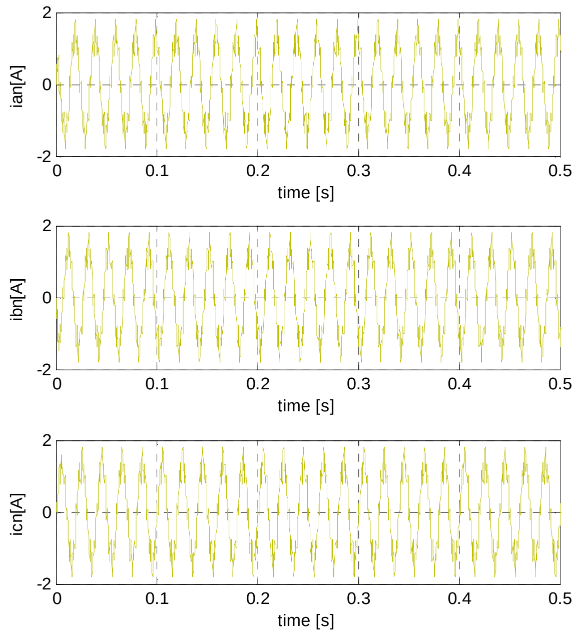

Fig.20 Simple currents generated by the inverter PWM.

VII. CONCLUSIONS

In this article we modelled and simulated a hybrid system of management for an isolated site containing a wind mill at variable speed ordered by order **MPPT** (**Maximum Power Point Tracking**), a diesel power generating unit and a battery electrochemical like system of storage or the system of storage of energy is a factor predetermining in a system of hybrid energy in isolated site, in the majority of the cases the batteries still represent the most profitable technology.

The example of simulation was applied to the site of Adrar where the weather data (speed of the wind, temperature, relief) are available.

The analysis of the results of this article allowed us to obtain a technical-economic profit into containing hydrocarbon and a longevity of the power generating unit, without forgetting the insurance of a continuity of service and the elimination of part of gases by effect of greenhouse during operation into wind.

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