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Wind generator principle with double alternator

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ABSTRACT

The authors create a principle new system of wind energy conversion for maximal recovery energy. This will be done by automatics couply and decouply of two statorics to two alternators in series in natural work by the excitement and desxcitement of second rotor reel, on creating one power card of electronics composants speed an powerful, ,before to enter in regularization of frequency and voltage. The objective of this work, on the one hand, is the modeling and the study of synchronous generator to alternator double using in systems of wind energy conversion with the goal of recover all proportional available energy to the maximum speed of wind and, on the other hand, the concept one power card for automatization of copulate and decopulate the coils. The results of various simulations of the conversion chain, carried out under MATLAB/Simulink software, made it possible to evaluate the performances of the proposed system.

KEYWORDS: *Synchronous coil double generator, Automatic copulate and decouplate, maximum recovery, Modeling, MATLAB/Simulink*

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I. INTRODUCTION

Nowadays, the use of renewables electricities such as ecological alternating to fossils and nuclears fuels is seen as attractive solving due that it's inexhaustible, not polluting and well suitable to the decentralized generation [1], [2]. Among the renewable electricities, the wind power occupies the second place back the solar energy. The systems of conversion of wind power use for the most part of synchronous or asynchronous generators [3]. Our work is in line with the study of conversion systems of wind power using the synchronous engines to salient's poles. [4] studied the modeling and the observability of electrics engines on command without mechanics captor. [5] studied excitement double synchronous engine (EDSE), [6] did the study of modeling based on the permeance method networks with a view to the optimization of excitement double and simple synchronous engine. In addition to that, [7] studied influence of the geometry of synchronous engine on their behavior in view of harmonics of current, [8] help us on electronic of regulating and command, [9] on electronic power, and [10] on electronics converters with those we could direct our study on the variable speed generator working of the synchronous engine, mainly at coupling and decoupling level of two statorics coils of two alternators in series. Finally, the alternator double synchronous generator on our work will use in order to recover all proportional available energy to the maximum speed of the turbine.

II. MODELING OF STUDIED WIND GENERATOR

2.1. Bloc diagram of the realization

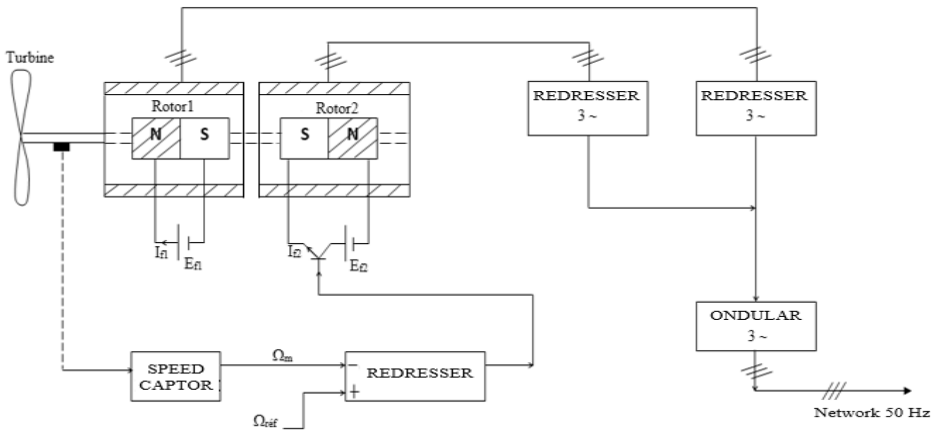

Figure. 1: Installation principle of wind energy conversion based Double Alternator Wind Generator (DAWG)

With E_{f_1,f_2} is Electromotive Force of rotor1 and rotor2 of the Double Alternator Synchronous Engine (DASE), E_{f_1,f_2} is excitation current of rotor1 and rotor2 of the DASE, $\Omega_m$is speed measured on the rotor1 of DASE, $\Omega_{réf}$ is speed reference for the comparator.

2.2. Modeling of wind speed

The wind speed modeled in the form determined by a sum of harmonics several in the form:

$$V_V(t) = A + \sum_{n=1}^{i}(a_n \cdot \sin(b_n \cdot \omega_V \cdot t)) \quad (1)$$

2.3. Modeling of the sails: blade, turbine, engine, and shaft.

A wind sails changes the mass of air of the energy moving and give a power mechanic characterized by the speed of rotation and mechanics couple

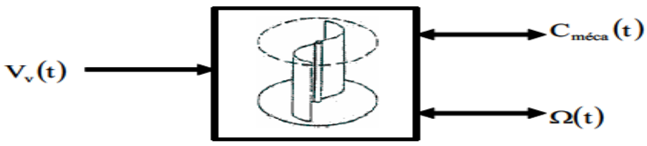

Figure. 2: Input- Output of sails model

With $V_v(t)$ is instant speed of wind, $C_{méca}(t)$ is mechanic couple on shaft, $\Omega(t)$ is angular speed of rotor rotating.

2.4. Study of salient's pole synchronous engine without dampers to polar wheel right

2.4.1. Presentation

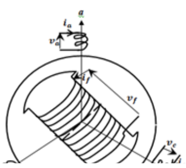

Figure. 3.a: Two polar salient's pole synchronous engine

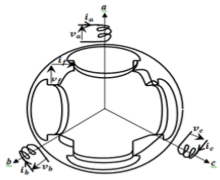

Figure. 3.b: Four polar salient's pole synchronous engine

– A fixed part said Stator, made up of an empilement magnetic sheet metal thin on a length l. It comprises an undershoot which unblock N_z notches uniformly rejoinders. The conductors, which form the statorics coils are housed in these notches. The inputs, such as the Outputs, of the statorics coils are staggered of $\frac{2\pi}{m_s}$ electric between themselves, where m_s is the number of statorics phases. For the particular case three-phased engines, this gap is $\frac{2\pi}{3}$ electric and the Inputs will designated by a, b, c.

– A turning part said Rotor maybe magnetic sheet metal massive or constituted from statorics drops or cut sheet metal destined for that purpose. We do up $2p$ projection constituent inductors poles. Under every pole find a coil which the series with others produce inductor coil f. The space between the rotor and the Stator called entrefer.
Figures 3.a respectively 3.b above mean a pole engine peer respectively two poles peers.

2.4.2. Natural working of an aerogenerator

Wind is the primary source of energy aerogenerator. The kinetics energy of wind, transformed into mechanics energy by the turbine, is converted into electric energy by generator. The variation in wind speed is a natural phenomenon very difficult to handle. This phenomenon leads to a variation of electric energy product by the windmills and the frequency of current provided by the aerogenerator.

2.4.3. Equations of synchronous engine without dampers without consideration of saturation

In a working on permanent regime, a synchronous engine without dampers was in control of by two kinds of equations closely binded.

– Magnetics equations and harmonics of flux

$$[\psi] = [L].[I]$$
(2)

With $[\psi]$ is matrix of natural flux, $[L]$ is matrix of the inductance, $[I]$ is matrix of the current

– Electrics equations and harmonics of voltages

To stator : $$\begin{cases} u_a = R_a i_a + \frac{d\Psi_a}{dt} \\ u_b = R_b i_b + \frac{d\Psi_b}{dt} \\ u_c = R_c i_c + \frac{d\Psi_c}{dt} \end{cases} \quad (3)$$

To rotor : $$\left\{ u_f = R_f i_f + \frac{d\Psi_f}{dt} \right. \quad (4)$$

2.4.4. Effect of the variation in wind speed on the voltage provided by the aerogenerator

– Reminder on the concept of frequency

$$f = \frac{1}{T} = \frac{pn}{60}$$
(5)

Then the variation of n (rotation frequency) will take the variation of f (current frequency) and the angular speed $\omega = 2\pi f$.
With p is the number of even pole.

– Variation of the electromotive

$$e_k = -\sum_{\substack{m,h=r \\ 2h+m=r}} \frac{d}{dt}\Psi_k[r], \quad k = a, b, c$$
(6)

h: been the order of harmonics of inductances
m: the current which crosses the reel of every phase

– Expression of the three-phase voltage provided by the aerogenerator to variable frequency

$$\begin{cases} u_{k1} = \left[R_k.\hat{I}_k[r].\cos(r\omega_{init}t + \varphi_k[r]) - r\hat{\Psi}_k[r].\omega.\sin(r\omega_{init}t + \varphi_k[r])\right] \\ u_{k2} = \left[R_k.\hat{I}_k[r].\cos\left(r\omega_{init}t - \frac{2\pi}{3} + \varphi_k[r]\right) - r\hat{\Psi}_k[r].\omega.\sin\left(r\omega_{init}t - \frac{2\pi}{3} + \varphi_k[r]\right)\right] \\ u_{k3} = \left[R_k.\hat{I}_k[r].\cos\left(r\omega_{init}t + \frac{2\pi}{3} + \varphi_k[r]\right) - r\hat{\Psi}_k[r].\omega.\sin\left(r\omega_{init}t + \frac{2\pi}{3} + \varphi_k[r]\right)\right] \end{cases} \quad (7)$$

With u_k is voltage provided by aerogenerator, i_k is statoric current of aerogenerator

2.5. Automatics couply and decouply of two statorics coils of the DASE on natural working

2.5.1. Principle of installation

The global diagram of installation presented following

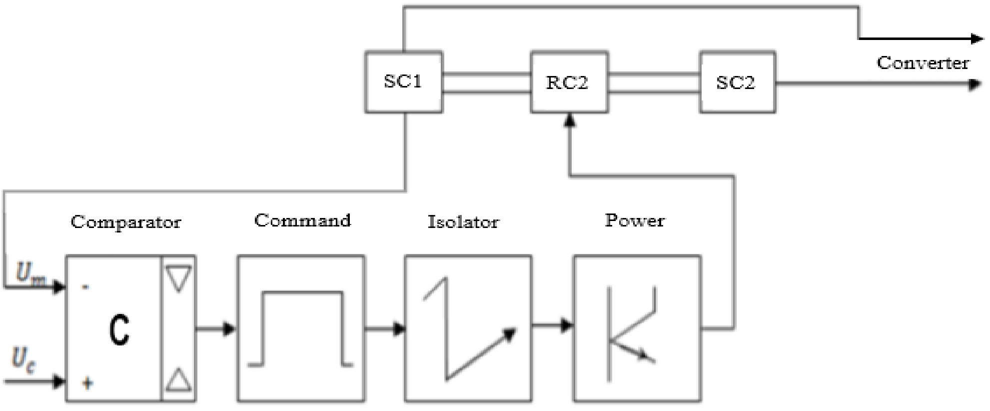

Figure. 4: Installation principle

2.5.2. Description and working of coupling and decoupling of two statorics coils SC1 and SC2 of DASE

In this study, we tackled the couply and decouply of system of two statorics coils of DASE with the aim in view to receive the maximum of necessary energy to the proportional use on the wind speed.

– Initial period

$U_m \leq U_c$: Only SC1 starts

$$U_{use} = U_{SC1} \quad (8)$$

– Coupling period (Acceleration period)

$U_m > U_c$ the coupling of SC1 and SC2 by the excitation of the rotoric coil 2 (RC2)

$$U_{use} = U_{SC1} \parallel U_{SC2} \quad (9)$$

– Decoupling period (Deceleration period)

This is an opposite operation of coupling, it means, the speed of turbine reduces, that is to cause the deceleration of generator. U_m becomes inferior or equal to U_c the decoupling of the SC2 by the desexcitation of RC2, so only Alternator SC1 starts.

$$U'_{use} = U'_{SC1} \quad (10)$$

2.5.3. Equipment of regulating

An equipment of regulating constituted by the organs of input composite to their turn by the organ of instruction and measurement organ; the signals obtained is used for to feed the regulator after the comparison of sizes formed the distance of regulating.

An organ of command which serves to the amplification of signals is necessary before to attack the level of powers which to his turn to feed the system to settle (RC2)

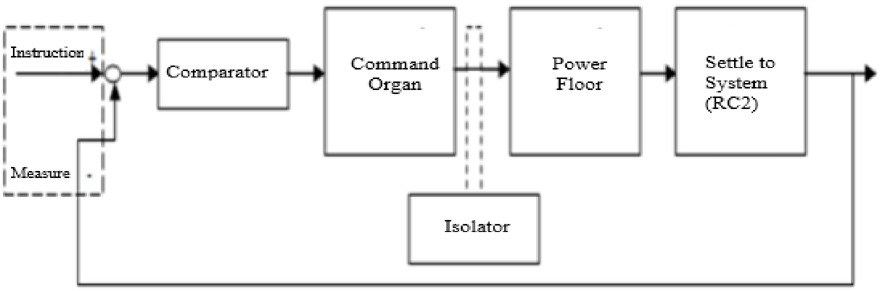

Figure. 5: Regulating equipment

2.6. Modeling of the DASE

Engine modeling is very essential, for the conceptor and the automatician too. It is used generally for system behavior analysis.

2.6.1. Model of the DASG in the plane

The Double Alternator Synchronous Generator could electrically make by the next picture

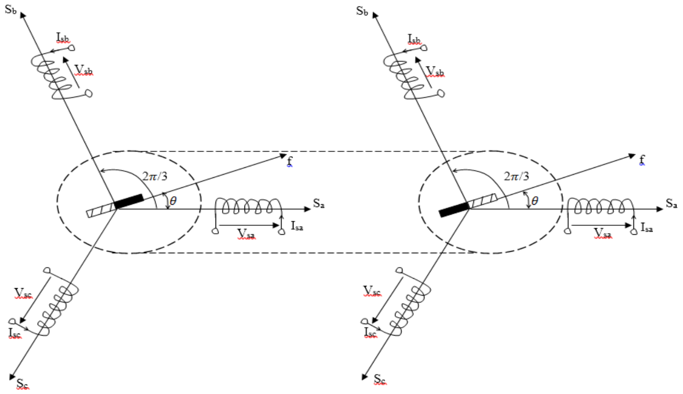

Figure. 6: Representation of DASG in the plane (abc).

– Electrics equations in the plane (abc)

The coils illustrated by the previous picture obey to electrics equations which are written in the form following.

$$\begin{cases} V_{sa} = R_{sa}.I_{sa} + \frac{d\emptyset_{sa}}{dt} \\ V_{sb} = R_{sb}.I_{sb} + \frac{d\emptyset_{sb}}{dt} \\ V_{sc} = R_{sc}.I_{sc} + \frac{d\emptyset_{sc}}{dt} \end{cases} \quad (12)$$

And can to be write in the form following:

$$[V_s] = [R_s].[I_s] + \frac{d[\emptyset_s]}{dt}$$

(13)

With $[V_s]$ is matrix of statorics voltages in the plane (abc), $[R_s]$ is matrix of statorics resistances in the plane (abc), $[I_s]$is matrix of the statorics currents in the plane (abc), $[\emptyset_s]$ is matrix of statorics flux in the plane (abc) in the plane (abc).

– Magnetics equations in the plane (abc)

The magnetic equations are given by the expression in the form matrix following:

$$[\emptyset_s] = [L_s].[I_s] + [M_s].[I_s]$$

(14)

With $[M_s]$ is matrix of statorics mutuals inductances.

– Generator mechanics equations

The movement equation can put in the form:

$$J.\frac{d\Omega}{dt} + K_f.\Omega = C_m - C_{em}$$

(15)

With J is total inertia of the engine.

2.6.2. Model of the DASG in the plane (dq)

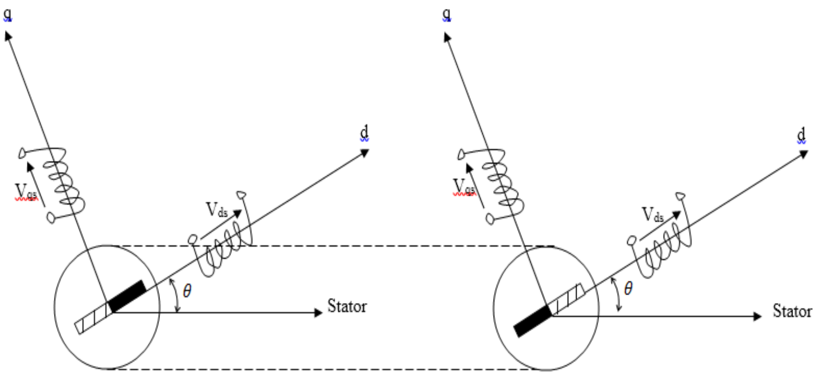

Figure. 7: Representation of the DASG in the plane (dq)

– Application of the transformation of Park

The matrix of Park is given by:

$$[P_3(\theta)] = \sqrt{\frac{2}{3}}.\begin{bmatrix} 1/\sqrt{2} & cos\theta & -sin\theta \\ 1/\sqrt{2} & cos\left(\theta - \frac{2\pi}{3}\right) & -sin\left(\theta - \frac{2\pi}{3}\right) \\ 1/\sqrt{2} & cos\left(\theta + \frac{4\pi}{3}\right) & -sin\left(\theta - \frac{4\pi}{3}\right) \end{bmatrix} \quad (16)$$

– Electrics equations in the plane (dq)

In applying the transformation of Park for the system of electrics equations of stator, we will have:

$$[V_{dq}] = [P_3(\theta)].[V_s]$$

(17)

$$[I_{dq}] = [P_3(\theta)]^{-1}.[I_s]$$

(18)

With:

$$[V_{dq}] = \begin{bmatrix} V_d \\ V_q \end{bmatrix};\ [I_{dq}] = \begin{bmatrix} I_d \\ I_q \end{bmatrix}$$

(19)

With $[V_{dq}]$ is matrix of the voltages in the plane (dq), $[I_{dq}]$ is matrix of the currents in the plane (dq).

– Equation of electromagnetic couple in the plane (dq)

$$C_{em} = p.\left((L_d - L_q)I_d + \phi_f\right).I_q \quad (20)$$

With C_{em} is electromagnetic couple, $[L_{dq}]$is matrix of the inductances in the plane (dq).

III. RESULTS AND DISCUSSIONS

3.1. On natural working to aerogenerator studied

In adopting the simplify hypothesis following: $\begin{cases} .\ \varphi_k[r] \approx 0 \\ .\ \psi_k[r] \approx L_k i_k[r] \end{cases}$, we obtain voltage's aspect by programming MATLAB above:

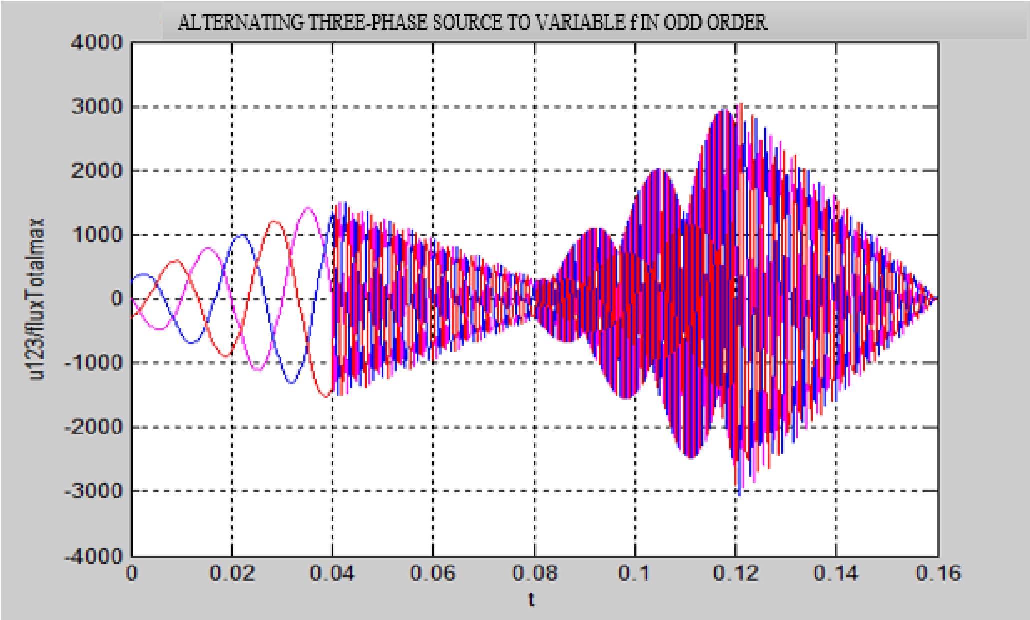

Figure. 9: Voltage's aspect alternating three-phase to variable frequency in odd order

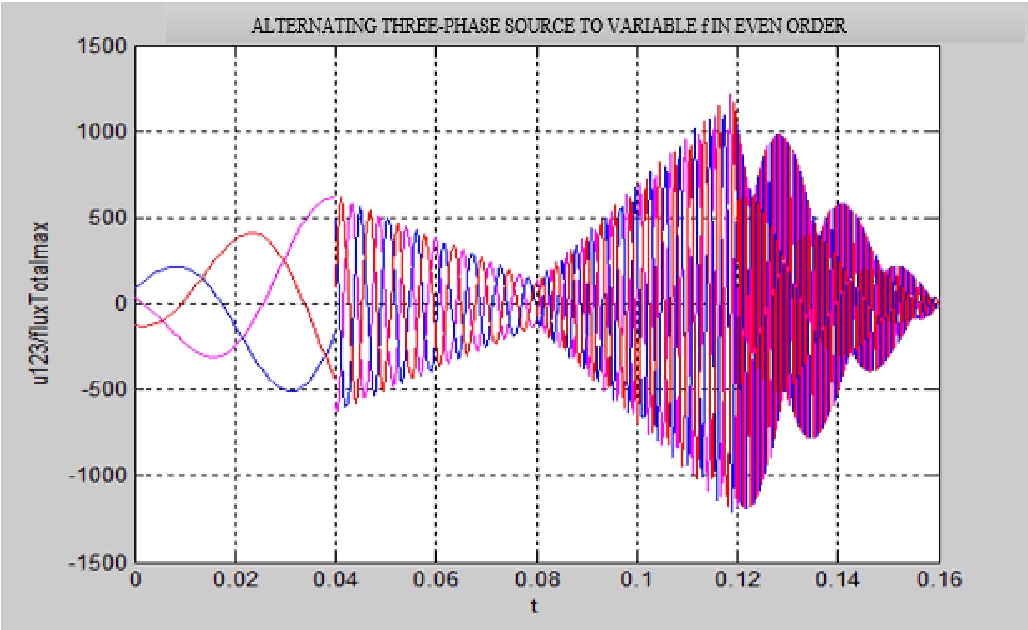

Figure. 10: Voltage's aspect alternating three-phase to variable frequency in even order

Thus, we notice that the voltage in odd order is more fluctuated compared with to the one in even order

3.2. On couply and decouply of SC1 and SC2 to the DASE in natural working

The diagram of achievement automatic coupling and decoupling is following:

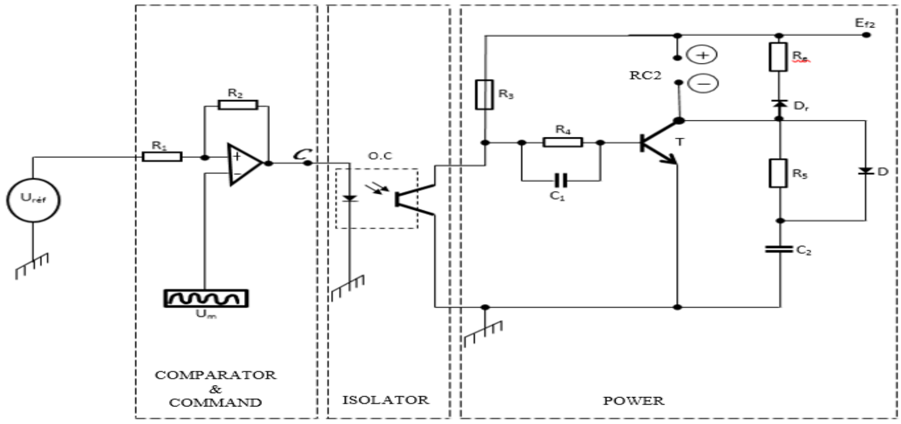

Figure. 12: Diagram of achievement coupling and decoupling

The speed to statorics voltages are presented with supposition of command C-0101:

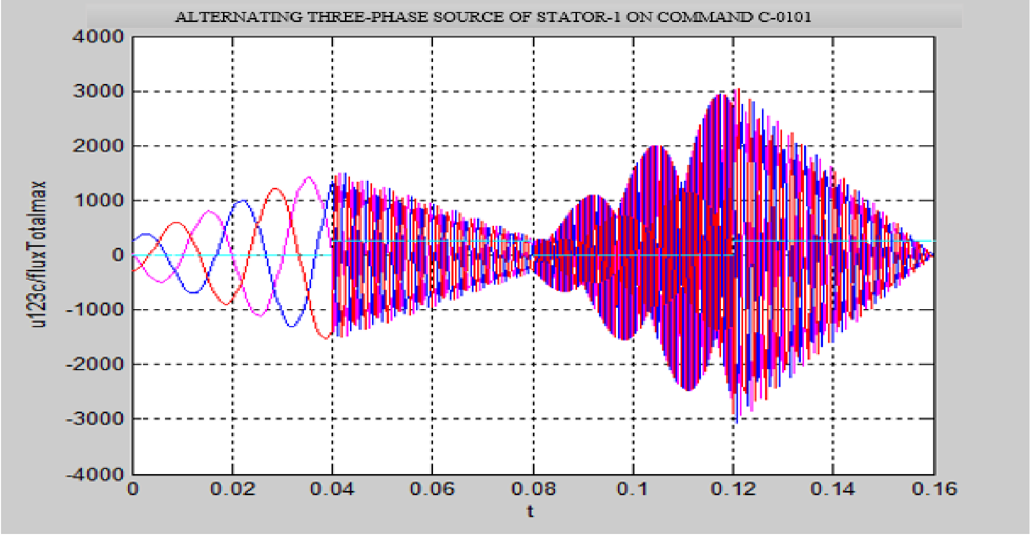

Figure. 13: Voltage's aspect alternating three-phase of stator-1 on command C-0101

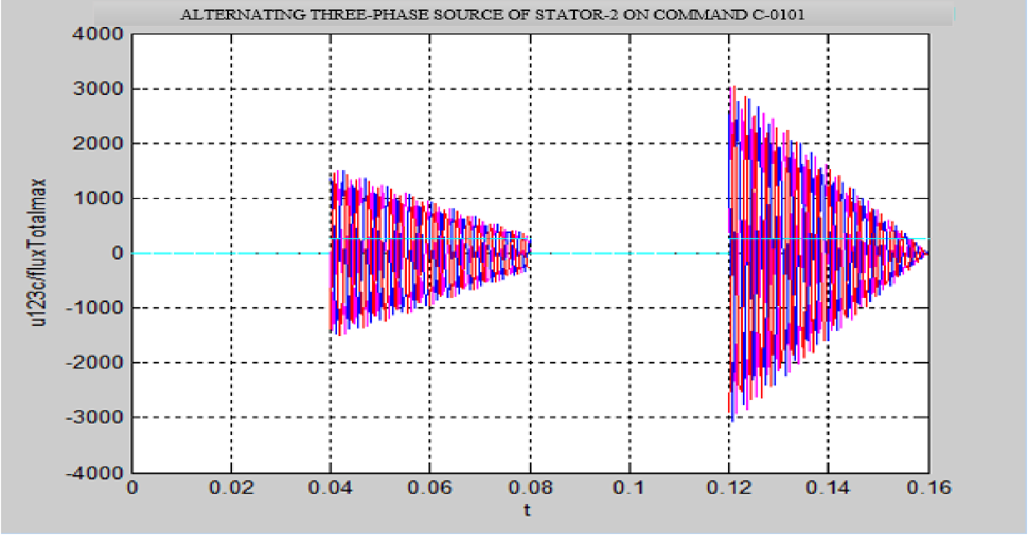

Figure. 14: Voltage's aspect alternating three-phase of stator-2 on command C-0101

Therefore, at the time of the acceleration to the turbine, maximal recovery does at level of SC2 to the DASE by the reel excitation of rotor 2 (RC2).

IV. CONCLUSION

In the aim of this work, we are studied the natural working of aerogenerator and we designed an electronic circuit which allows to couple and to decouple the two statorics coils of the double alternator synchronous generator. Then we have modeled the DASG and we have chosen the model of Park expressed in a referential binded to statoric flux.

For continue this work, this referential choice has allowed to implement one vectorial command leading to express the statorics active and reactive powers.

Finally, the simulations results have been brought to the speeds on natural working of the aerogenerator and on the couply and decouply of statorics coils.

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