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Comparative Study between Two Types of Wind Chains

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ABSTRACT: We will begin this discussion with a description of a wind conversion chain of average power to make an optimal choice of a system with a reduced cost.
A device MPPT 'Maximum Power Point Tracking' is to be introduced in order to achieve maximum energy efficiency. In order to minimize the cost of the conversion chain and increase efficiency, we will compare the performance of two asynchronous generators for the same input parameters. This will allow us to evaluate the two structures.

KEYWORDS: Performance Electric-Modeling-Simulation-Matlab - Wind Turbine**.**

I. INTRODUCTION

In recent years, wind systems have received increased attention and have been widely used as a suitable power source. Asynchronous generators are increasingly used in wind power generation systems, their advantages are its simple construction (brushless), robustness and low maintenance cost [1].
Wind systems can be used in standalone mode or connected to the network.
Today, we can identify two types of wind turbines connected to electric network: fixed speed wind turbines, it consists of an asynchronous machine with squirrel cage. The second type is a variable speed wind turbine with asynchronous generator dual supply (DFIG) or a synchronous machine with permanent magnet (SMPM). The latter (SMPM or DFIG), which have large adjustment capabilities, are mainly used to increase the power extracted from the wind.
Current wind turbines are very sophisticated machines, taking advantage of the aerodynamic improvements to the structure, materials technology and electrical control, they are able to produce several megawatts of electrical power. We note that with the development of power electronics, asynchronous machines are doubly fed increasingly used for electricity generation high power.

II. DESCRIPTION OF A SYSTEM OF WIND ENERGY CONVERSION.

The chain includes, the wind turbine, speed multiplier, converters and the asynchronous machine whose stator circuit is connected directly, or via a transformer, to the mains. If the asynchronous generator is a (DFIG), a second circuit disposed on the rotor is also connected to the network but by way of power converters.

The Wind chain does not only depend on the asynchronous machine, but also the way in which the two parts of "back-to-back" converter is controlled. The power converter machine side is called "Rotor Side Converter" (RSC) and the network side power converter is called "Grid Side Converter" (GSC). The machine side power converter controls the active power and reactive power produced by the machine. As for the network-side converter, it controls the DC bus voltage and line-side power factor [1],[2].

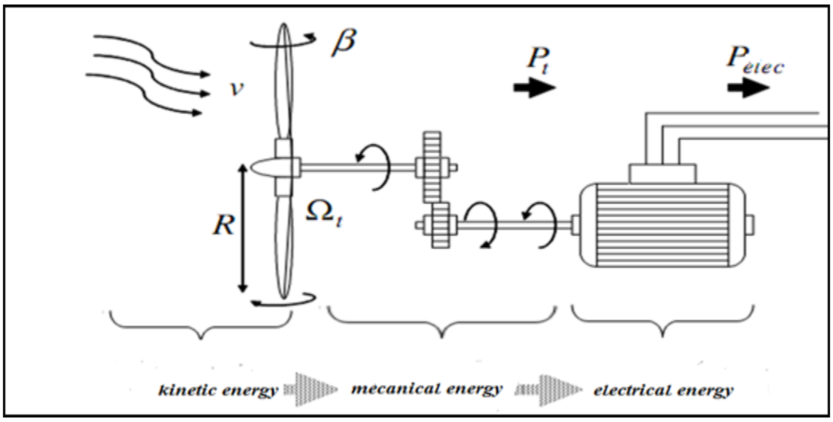

Fig.1.Schematic of a general wind chain

III.MODELLING OF THE ASYNCHRONOUS GENERATOR:

A. The modeling of asynchronous squirrel cage machine:

For the 3-phase stator, this writing is summarized by the following condensed matrix [5], [6], [7], [8]:

$[V_{sabc}] = [R_s] * [i_{sabs}] + \frac{d}{dt}[\emptyset_{sabc}]$ (1)

With$[V_{sabc}]$: three-phase stator voltage of the asynchronous machine.

[Rs]: Resistance of stator phase.

$[i_{sabs}]$: Three-phase stator current of the asynchronous machine.

$[\emptyset_{sabc}]$: Feed-phase stator of the synchronous machine.

And $[V_{rabc}] = [R_r] * [i_{rabs}] + \frac{d}{dt}[\emptyset_{rabc}] = 0$ (2)

With$[V_{rabc}]$: three-phase rotor voltage of the asynchronous machine.

$[R_r]$: Resistance of rotor phase.

$[i_{rabs}]$: Three-phase rotor current of the asynchronous machine.

$[\emptyset_{rabc}]$ Feed-phase rotor of the synchronous machine.

B. The doubly fed induction generator (DFIG)

For the 3 phases of stator, we have the same condensed matrix (1):

$$[V_{sabc}] = [R_s] * [i_{sabs}] + \frac{d}{dt}[\emptyset_{sabc}]$$

And For the 3 phases of rotor, we have: $[V_{rabc}] = [R_r] * [i_{rabs}] + \frac{d}{dt}[\emptyset_{rabc}]$ ($\neq 0$) (3)

After the Three phase two-phase transformation (Park), we get the following components along the axis d and q axis, for the stator voltages:

$v_{ds} = R_s i_{ds} + \frac{d}{dt}\emptyset ds - \omega s\, \emptyset qs$ (4)

$v_{qs} = R_s i_{qs} + \frac{d}{dt}\emptyset qs + \omega s\, \emptyset ds$ (5)

And for the rotor voltages:

$v_{dr} = R_r i_{dr} + \frac{d}{dt}\emptyset dr - \omega r\, \emptyset qr$ (6)

$v_{qs} = R_r i_{qr} + \frac{d}{dt}\emptyset qr + \omega r\, \emptyset dr$ (7)

To adequately control the electricity production of the wind, we will achieve independent control of active and reactive powers Ps and Qs stator [2], [3], [4], [5], [6]. The reference (dq) is oriented so that

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$\emptyset ds = \emptyset s$ And$\emptyset qs = 0$(8)
Assuming that the stator flux$\emptyset s$ is constant (constant electric network) and ignoring the stator resistance we obtained for Ps (stator active power), Qs (stator reactive power) and C_{em} (electromagnetic torque):

$Ps = -Vs\frac{M}{Ls}i_{qr}(9)Qs = -Vs\frac{M}{Ls}i_{dr} + \frac{Vs^2}{L_s\omega_s}$(10)

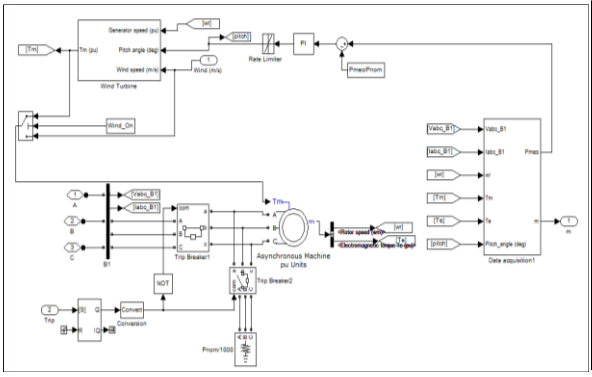
$C_{em} = -p\frac{M}{L_s}\emptyset_{ds}\, i_{qr}$, (p: Number of pairs of poles) (11)

$$\begin{cases} \emptyset_{ds} = L_s i_{ds} + M\, i_{dr} \\ \emptyset_{qs} = L_s i_{qs} + M\, i_{qr} \\ \emptyset_{dr} = L_r i_{dr} + M\, i_{ds} \\ \emptyset_{dr} = L_r i_{qr} + M\, i_{qs} \end{cases} \quad 12), (13), (14), (15)$$

Also: Ls = ls – Ms; Lr = lr + Mr (16)
Ls and Lr are cyclical inductance of a stator phase and rotor phase.

IV. SIMULATION OF A WIND CHAIN DRIVEN BY A SQUIRREL CAGE GENERATOR

A. Block diagram of the simulation



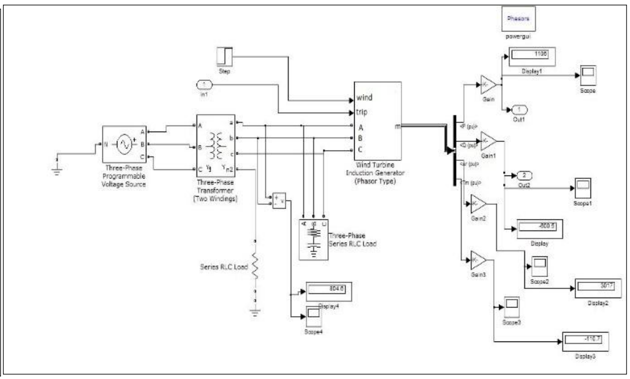


Fig. 2. Block diagram of the wind turbine and Fig. 3. Block diagram of the wind chain
the squirrel cage generatordriven by a squirrel cage generator

B. Simulation parameters

Asynchronous generator	Sn=1,5e4 VA Un=575V f=50hz	Number of pairs of poles	3
Rotor Inductance	0.179 H	Stator Résistance	0.0048 Ω
Rotor Résistance	0.0044Ω	Stator Inductance	0.1248 H
Mutual inductance	6,77 H	Stator Inductance	0.1248 H
Balanced three-phase Load	575V 4kW - 4kVAR	Transformer	[25e3V, 575V]
Wind speed	12m/s		

Table 1. Characteristics of the 1st wind chain.

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C. Results of the simulation

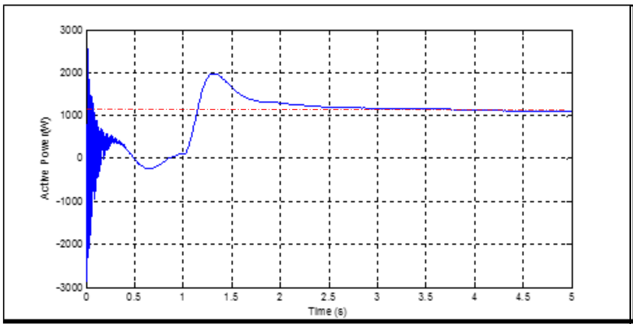

Fig. 4. Active power, final value Pf ≈ 1100W

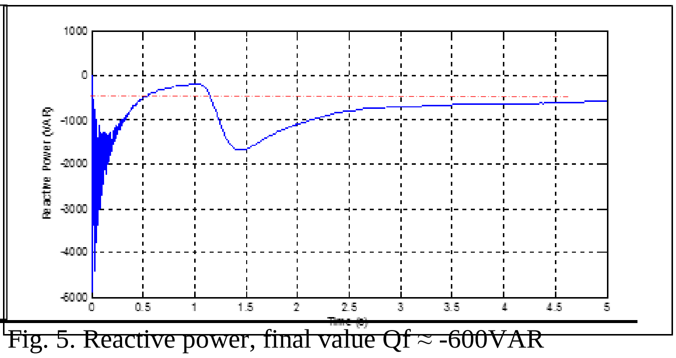

Fig. 5. Reactive power, final value Qf ≈ -600VAR

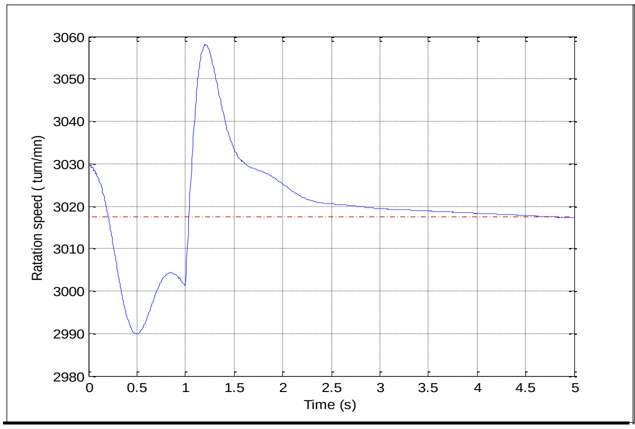

Fig.6. Rotation speed (trum/mn)Nf ≈ 3017trum/mn

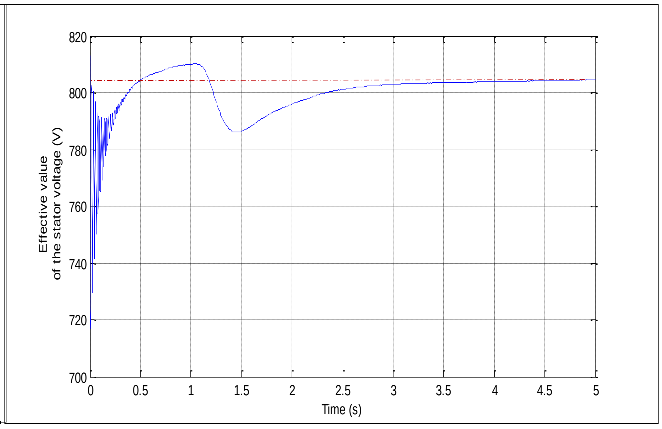

Fig.7. Effective value of the stator voltage (V) Ufs≈804V

V. SIMULATION OF A WIND CHAIN DRIVEN BY A DOUBLY-FED INDUCTION GENERATOR

A. Block diagram of the simulation

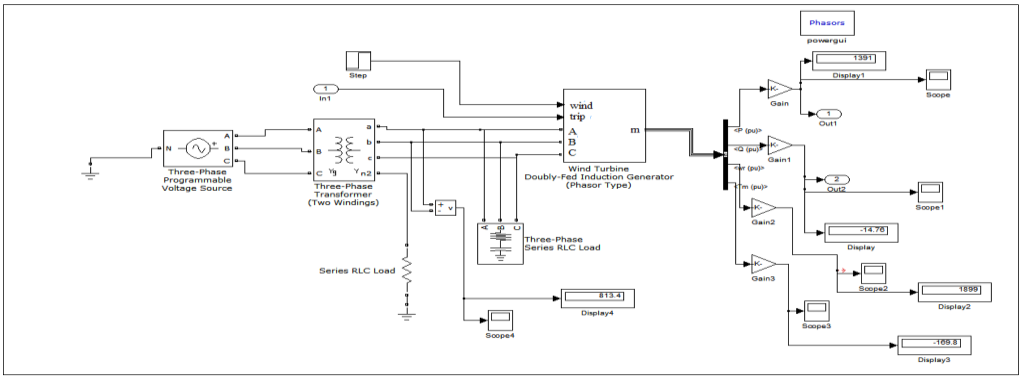

Fig.8. Block diagram of a Wind Turbine driven by a Doubly-Fed Induction Generator

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B. Simulation parameters

Generator Sn(VA), Vn(Vrms), fn(Hz)]	1,5e[4] VA 575 V 50Hz	Wind speed	12m/s
Rotor Résistance	0.0044Ω	Number of pairs of poles	3
Rotor Inductance	0.179 H	Stator Résistance	0.0048 Ω
Mutual inductance	6,77 H	Stator Inductance	0.1248 H
Balanced three-phase Load	575V 4kW -4kVAR	Transformer	[25e3V, 575V]

Table 2 Characteristics of the wind chain

C. Results of the simulation

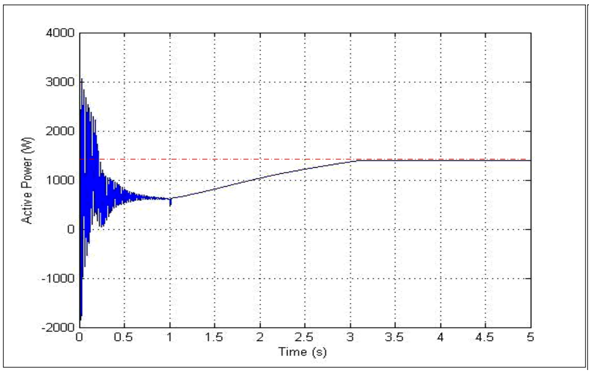


Fig. 9. Active power (W),Pf ≈ 1400W

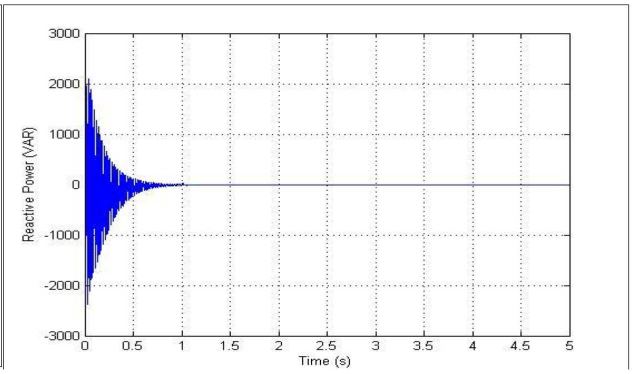
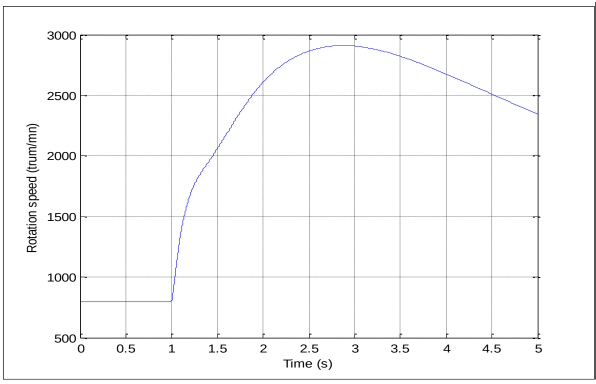


Fig. 10. Reactive power (VAR), Qf ≈ 0 VAR



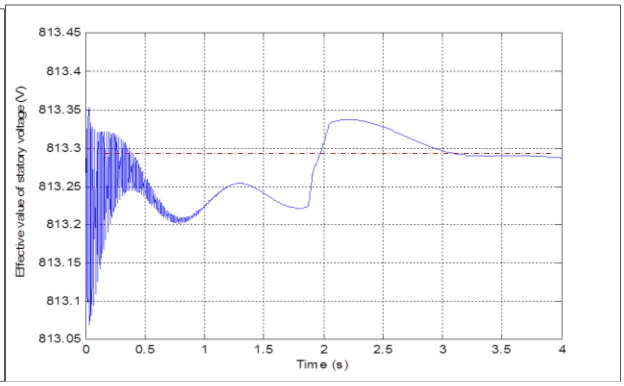


Fig.11.Rotation speed, Nf ≈ 2800 trum/mn Fig. 12. Effective value of the stator voltage, Ufs≈813V

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VI. COMMENTS AND DISCUSSIONS

In this paragraph, we will try to compare simulation results of two conversion channels wind power driven by a synchronous generator whose components are identical (see Table 1 and Table 2), but the generators drive them are different, the former is a squirrel cage generator and the second is an asynchronous generator with dual power.
These two electric generators practically have the same parameters: same power, same rated voltage and the same frequency and almost identical internal parameters. All this in order to make a good comparison of the performance of each wind turbine chain.
We see all sides that the two channels are working properly: they provide both to the load (here a load R-C), a relatively large electric power. We note that the two chains pass through a transitional period lasting almost 3 seconds (150 times the signal period).
The steady has allowed us to make a good comparison of two wind turbines channels, for this, we grouped in Table 3, the measured values steady following main variables: P (active power), Q (reactive power), N: rotational speed and Us (the effective value of the stator voltage).

	P: Active power	Q: Reactive power	N: Rotation speed	Us: Effective value of stator voltage
1st Chain (With ansquirrel cage machine)	Pf = 1100 W	Qf = - 600 VAR	Nf = 3017 trum/mn	Usf=804V
2nd Chain (With a doubly-fed asynchronous generator)	Pf = 1400 W	Qf = 0 VAR	Nf = 2800 trum/mn	Usf = 813V

Table 3. Final values of the variables measured for both wind chains

We can say that for
- Active power: The active power supplied to the load (R-C) is more important for the second chain.
- Reactive power: The Difference between two of the output chain is obvious. The 2nd Chain with a doubly-fed asynchronous generator have a reactive power at the output which is almost zero.
- Rotational speed: this variable Is Almost Identical, but we note that in the 2nd chain it is not very stable.
- The stator voltage: Same It is Almost a footnote what is more Slightly High for the second chain.

VII. CONCLUSION

We can conclude from this study, that for both chains all variables are stable during continuous operation, which shows that the system works properly.
We note, for this power range, that the second channel works best, in fact, the active power delivered to the load is more important, that because the rotor to bi-fuel machines restores active power load: Pr (power supplied by the rotor) = g * Ps(Ps active power in the stator, g is the slip).
Regarding reactive power which is zero for the second string, we can say that the load capacitors offset the reactive energy involved in the wind power system something that does not happen with the first string. We can conclude from this study, that for both chains, all variables are stable during continuous operation, which shows that the system works properly.
We note, for this power range, that the second chain works best, in fact, the active power delivered to the load is more important, that because the rotor of doubly-fed asynchronous generator restores active power load: Pr (power supplied by the rotor) = g * Ps(Ps active power in the stator, g is the slip).
Regarding reactive power which is zero for the second string, we can say that the capacitors of load offset the reactive energy involved in the wind system, this does not happen with the chain driven by a squirrel cage machine

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REFERENCES

[1] A.Wahabi, A.El Moudden, A.Sandali, F.E. Bounifli."Improved performance of a Wind Energy Conversion Chain Driven by an Asynchronous Generator Doubly-Fed and using a « R-L » Filter". April 2015 *International journal of Electronics Communications and computer Engineeing. (IJECCE).*

[2] A.El Moudden, A.Wahabi, A.Sandali, F.E. Bounifli."Control and Optimization of the Energy Produced by a Chain of Wind Energy Conversion Controlled by a Double-fed Asynchronous Generator". June-July 2014 *Current Trends in Technology and Sciences (CTTS).*

[3] A. El Moudden, A. Aarib, A. Wahabi, F. E. Bounifli."Command of the active and reactive stator powers of the doubly-fed induction generator used in wind energy". *International Journal of Emerging Technology and Advanced Engineering (IJETAE)*,Website: www.ijetae.com(ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 10, October 2014).

[4] A. El Moudden, A. Wahabi, A. Sandali, F. E. Bounifli, "Modelling and simulation of a double-fed asynchronous generator for control of wind energy", *International Congress of Thermal, Agadir*, Maroc, April 2014.

[5] A. Boyette controlling a doubly-fed asynchronous generator with the storage system. *PhD University Poincaré, Nancy, 2006*.

[6] K. Belmokhtar, ML Doumbia, K. Agbossou, modelling and control of a wind energy system based asynchronous machine dual power to supply power to the electricity grid, *Journal of Scientific Research vol. 2 (2010)*.

[7] F. Kendouli, K. Nabti, K. Abed et H. Benalla, Modelling and simulation of a double-fed asynchronous,*review of renewable energy volume 14 March 2011*.

[8] S. Khojet El Khil, Vector control of a doubly fed induction machine (DFIG) / Optimization losses in the converters, 2006.

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