International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com

Vol.7., Issue.6, 2019
Nov-Dec

RESEARCH ARTICLE

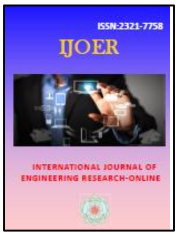
ISSN: 2321-7758

CONTROL-COMMAND OF DUAL POWER ASYNCHRONOUS GENERATOR WITH STORAGE SYSTEM FOR WIND GENERATION IN AL_NAJF GOVERNORATE, IRAQ

ABBAS SAYKHAN ALIJAN

Ministry of Education- Directorate General of Education Al- Rusafa the third/ Al Aqsa evening secondary school for Boys, Iraq

DOI: 10.33329/ijoer.76.10



ABSTRACT

This research paper deals with the study, the modelling and the simulation of a wind energy conversion system, allowing to provide the network with a constant power, based on a unit energy storage and a Dual Power Asynchronous Generator (DPAG). This horizontal axis wind turbine provides the grid with constant active power regardless of the wind conditions. The battery or other storage system on the DC bus can temporarily store power. The modelling of the mechanical part of the wind turbine is particularly detailed, a propeller with variable pitch angle is used to maximize the extracted power. Then modelling, direct control and indirect control of DPAG are present. An independent control of the active powers and the active is used and the dimensioning of the storage unit for this use is particularly detailed. The command of the set with the search for the maximum power point tracking (MPPT) is explained. Simulation results validate the study for two long-term wind profiles. This wind energy conversion system provides system services such as power factor compensation or harmonic current lamination on the network. Thus, the DPAG is used, with an additional command, to reduce the current harmonics of the network. This system facilitates the integration of wind turbines into the distribution network because the network manager can have constant power and useful system services.

Introduction

In recent decades, the ongoing decline of traditional supplies and the increased energy demands due to the increase of the world population have contributed to the search for renewable energy options. [1]. Iraq is an oil country, but this does not prevent the possession of other resources are inexhaustible renewable energies such as solar, hydro and wind power. Throughout Iraq, the increasing reliance on conventional power plants to satisfy the growing demand for electricity has not been recognized as a viable alternative. The move to increase the share of renewable electricity has therefore begun to attract growing interest from scientists and policy makers in the field of energy.[2]. A number of studies have been undertaken internationally to evaluate and examine the ability of wind energy to help find suitable wind sites for wind energy projects. Iraq is one of the areas with significantly long daylight hours in which Iraq receives around 3000 hours of global radiation within a year for one region, namely Al-Najaf (44 °E, 31 °N)[3].

Mechanical design of wind turbines

Vertical axis wind turbine: They are very little implemented today because they are less efficient than those with horizontal axis. They operate on the same principle as the hydraulic wheels with a direction of wind perpendicular to the axis of rotation. The vertical design offers the advantage of putting the multiplier and generator on the ground directly, but this requires that the wind turbine works with the wind near the ground, less strong than height because braked by the relief. By its vertical axis, there is symmetry of revolution and the wind can come from all directions without having to orient the rotor. On the other hand, this type of wind turbine cannot start automatically, it must be launched at the onset of a wind strong enough to allow production. These wind turbines capture the wind up and away from the ground; at this height the wind is much less slowed by the relief. With the same helix size, more power can be generated through this structure than vertical axis wind turbines. Another advantage, and not least, is the footprint which is very low compared to vertical axis wind turbines. Here, only the tower occupies space on the ground and generally contains all the connection systems. Thus it is not necessary to add an electrical room and the footprint is really minimal.

Electrical energy is at the heart of our modern society, which would be in pain if it were to be without it. Its transport facility and especially its transformation into another form of energy make it an essential element. Wind turbines used for the production of electricity must make it possible to maximize power by making best use of the energy available in the wind. For this reason, many control systems of the wind turbine, acting at the level of the mechanical or electrical part, are developed to maximize the energy conversion. This is referred to as maximum power point tracking (MPPT)[4]. These systems use different means to obtain this maximum power point. It is possible to modify the angle of setting of the blades, or the speed of rotation of the hotel or even to play on the command of the host. The search for the maximum is done permanently and therefore it depends on each wind variation to be in a maximum power extraction configuration. Such systems also incorporate safety devices that allow for example to limit the power produced when the wind becomes too large and may damage the wind turbine. It is with this aim in mind that our study, which focuses on one of the renewable energies in development at the moment, is the wind energy. We will be interested in the current state of technological advances that have allowed the construction and operation of these wind turbines, all this while also looking at what hampers their development in order to consider solutions to facilitate the insertion of such a device in electric production. "Most of today's installed wind turbines are equipped with Dual Power Asynchronous Generator (DPAG). This generator allows variable speed electricity generation, which makes it possible to better exploit wind resources for different wind conditions. Wind turbines are also equipped with propellers with adjustable blade angle to adapt to the wind conditions. The entire wind turbine is controlled so as to permanently maximize the power produced by looking for the operating point to maximum power referred to as MPPT.

Thus we are going to develop the modelling of a wind turbine by proposing an electrical energy reduction (GPAG) but also does not allow it to be mechanical in order to determine the energy efficiency and to have a storage unit of energy allowing the whole to maintain constant the power supplied to the network with the aim of storage system for wind generation in Al_Najf governorate, Iraq

Experimental

Compared with the cage asynchronous machine, the DPAG allows a rotation speed range of ± 30% around the speed of synchronism. Moreover, the control of rotational pressures allows us to control the power produced at both the active and the active levels, which is a very interesting point for the management of wind energy and the participation in system services.

International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com
Vol.7., Issue.6, 2019
Nov-Dec

Description of the operation of the DPAG

Structure of the machine

A DPAG has a stator identical to that of a cage asynchronous machine or a synchronous machine. It is the rotor that differs radically because it is not composed of magnets or a squirrel cage but three-phase windings arranged in the same way as the stator windings. It can be seen in figure 1 that the rotor windings are star-connected and the three phases are connected to a system of sliding contacts (slip ring brushes) to access the voltages and currents of the rotor.

Modes of operation of the DPAG

Only the operating mode with the stator directly connected to the network and the rotor powered by an inverter concerns us in this study. Like the conventional asynchronous machine, the DPAG can operate as a motor or generator but the big difference lies in the fact that for the DPAG, it is no longer the speed of rotation that imposes the operating mode engine or generator. Actually, a cage machine must turn below its speed of synchronism to be in motor and above to be in generator. Here, it is the control of the rotor voltages which makes it possible to manage the magnetic field inside the machine, thus offering the possibility of operating in hyper or hypo synchronism as well in motor mode as in generator mode. We will successively present these different modes of operation[5].

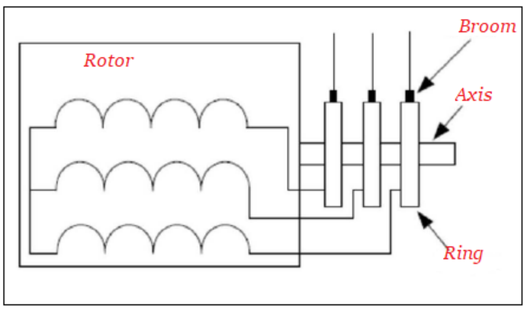


Figure 1: Principle of the wound rotor

Operation in hypo synchronous motor mode

Figure 2 indicates that the energy is supplied to the stator by the network and that the slip power passes through the rotor to be fed back to the network. We've got a motor operation below the speed of synchronization. The traditional asynchronous cage system can operate this way, but the slippery energy is then dissipated into Joule's rotor failure.

Operation in hyper synchronous motor mode

Figure 3 indicates that the energy is supplied to the stator by the network and the slip control is also distributed to the rotor by the network. We have a motor operation that is above the speed of synchronism. This task cannot be done by the traditional asynchronous cage system.

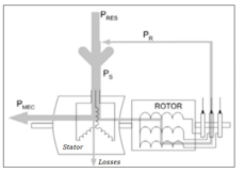


Figure2: Hyposynchronous motor mode operation

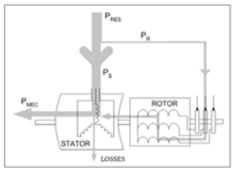


Figure 3: Operation in hyper synchronous motor mode

Operation in hypo synchronous generator mode

Figure 4 indicates that the electricity is supplied to the grid by the stator. The slipping control of the stator is also given. We thus run a generator below the speed of synchronization. The traditional asynchronous cage system cannot have this mode of operation.

Operation in hyper synchronous generator mode

Figure 5 indicates that the energy is then supplied to the network by the stator and the slip power is collected through the rotor to be fed back to the network. So, we have a generator operation above the speed of synchronization. The traditional asynchronous cage system may have this mode of operation, but in this case the slipping energy is dissipated into the Joule loss in the rotor.

It can thus be noted that the DPAG has two main advantages over the conventional cage machine: the production of electric power whatever its speed of rotation (hypo or hyper-synchronism) and the recovery of the sliding power.

International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com
Vol.7., Issue.6, 2019
Nov-Dec

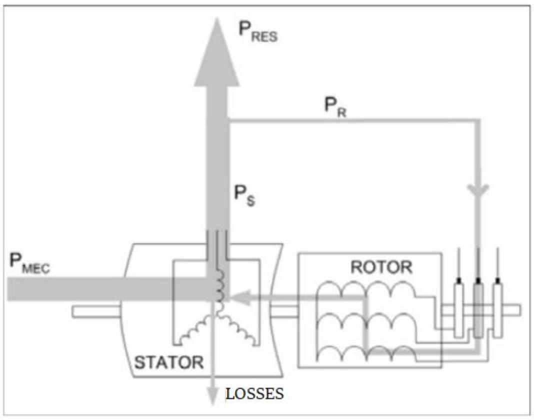


Figure 4: Operation in hypo synchronous generator mode

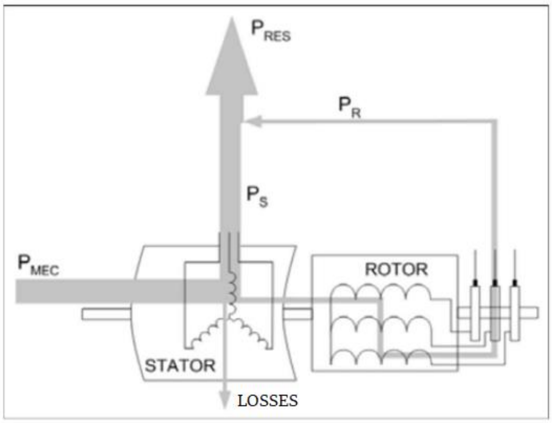


Figure 5: Operation in hyper synchronous generator model

Modelling of DPAG

In order to establish the modelling of the DPAG, it will be determine the model of an asynchronous rotor coil machine. This model will be established in the same way as the model of the cage-type asynchronous machine difference the existence of non-zero rotor voltages[6,7].

We start from the general equations of the asynchronous machine with wound rotor which are written in a traipse reference in the following way[8].

2. General structure of the energy conversion system

We will now be able to assemble the different models previously developed to obtain the energy conversion system presented in Figure 2.1. Our goal is to model and simulate a wind turbine with an asynchronous machine with dual power supply and independent control of the active and reactive powers, with a propeller with control of step and optimal control for a maximum yield of the conversion of the wind into electricity, all associated to a storage unit to help maintain the power produced to the network as consistently as possible and by providing system services to the network manager.

The system to be modelled consists of the mechanical part of the wind turbine, the generator with the inverter connected to the rotor as well as its control described in the previous section, of the rectifier which feeds the DC bus, of the unit of energy storage and the electrical network to which the conversion system is connected. Note that the stator of the generator is directly connected to the network while its rotor is powered by the network via a rectifier and an inverter. Previously, we saw that the power exchanged between the rotor and the inverter corresponds to the slip power, limited to 30% of the rated power of the machine. Thus, the inverter feeding the rotor will be sized for this reduced power. So we have a high power production system with electronics sized for reduced power, which is interesting in terms of cost and reliability.

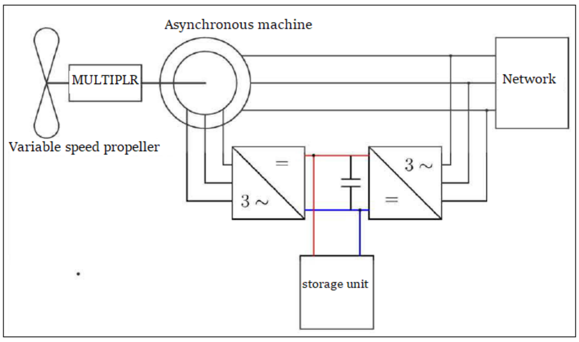


Figure 2.1: Wind generation system with storage.

MLI Rectifier

In order to be able to have a DC voltage to supply the inverter that drives the double-feed asynchronous machine, we chose to use an Impulse Width Modulation rectifier[9] for 2 main reasons:

- use a current-reversible rectifier to allow transfer of the sliding power between the rotor and the network, which allows operation in hyper or hypo synchronism.

International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com
Vol.7., Issue.6, 2019
Nov-Dec

- to implement a rectifier which can be used to generate little or no disturbance on the electrical network by propagation of harmonic currents.

Storage unit

Storage can be carried out in different ways to meet durability and power requirements. It will be possible to have a storage system that can both store a large amount of energy while having a rapid response dynamics in order to smooth any instantaneous variations in power.

Storage connection: First of all, it is necessary to define how and to what level the energy between the storage unit, the network and the host can be discerned. To learn more, let's take a look at the different storage processes and the conversions they perform. We take again here all the possible forms of storage for the wind.

For the short term:

Super capacitor, operating from a DC voltage bus with a chopper and connection with a rectifier / inverter on the network[10].

Flywheel, driven by an asynchronous machine controlled by an electronic variator using a rectifier / inverter[11].

For long-term

Compressed air, operating with a DC motor powered by a DC chopper and a connection to the network with a rectifier/inverter[7].

Modelling of the storage unit

It is therefore appropriate, in the light of these findings, to classify storage devices as DC voltage sources with different capacities, powers and response times, based on their operating principles. Such sources have three essential metrics for their production, which are the quality of fuel and resources that they are able to supply and store, as well as their response times. We can therefore make an accurate modelling of these storage devices as continuous power controlled sources with a measure of power and energy as well as limits on stored energy. The available energy level in this storage unit will be monitored in real time. It will also be necessary to set limits and predict the operating conditions when these limits are reached. We are going to model a hybrid storage system combining a short-term unit with a short response time and a long-term unit with a longer response time, which will be moderated by a single source of voltage. This single voltage source will be voltage controlled so that the load and discharge power can be controlled according to the set point that will be generated by the wind turbine's overall control system. The set thus created makes it possible to combine the advantages of the two solutions: short response time and high storage capacity.

Control of the storage unit

The modelling used is shown in Figure 2.2. It distinguishes the voltage source controlled by the power regulator, the power measurement and the energy calculation. For energy management, we set a maximum threshold that corresponds to the size of the storage unit and a minimum threshold not to exceed to not endornrnager the elements of the unit. In fact, if we use batteries, for example, we must not make deep discharges that lead to damage to the inner plates of cells; on the other hand, in the case of compressed air storage, the tank can be completely emptied without constraint.

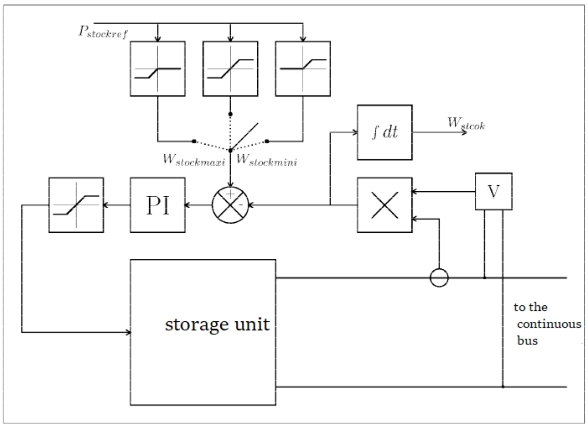


Figure 2.2 Block diagram of the storage unit

Dimensioning of the wind turbine and storage

In order to be able to size the storage unit, it is necessary to have already done a study of the winds on various potential sites of implantation and to choose the one which is the most favorable to the exploitation of the wind potential. In fact, the

Impact Factor 5.8701 (ICI)
International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com
Vol.7., Issue.6, 2019
Nov-Dec

storage unit can only be there to compensate and smooth the fluctuating power of the wind; it is therefore opportune to choose a wind turbine or wind that is very low and high.

Propeller size:

We will first choose the size of the wind turbine based on the production we would like to have. We choose here a low power wind turbine for our study and would like to be able to produce a power of the order of 10 kvV to the network. This power allows us to determine the size of the wind turbine and in particular the diameter of the propeller. n addition, we know that in order to produce a power of 10 kvV to the grid, we will certainly need, in the worst case, to produce up to 20 kW to recharge the storage unit when the wind is strong (10 kW for the network and 10 kW to recharge). So we will need a propeller that is between the size of a wind turbine of 10 kW and a 20 kW, which gives us a diameter between 6 and 7.5 meters[12].

We will now calculate the average power that can be obtained at the chosen site with these wind turbines. we calculate the average to be able to choose the one that comes closest to the 10 kW that we want to produce. Figure 2.3 shows the evolutions of the extractable powers as well as the average power for 4 helix diameters.

$P_{ext} = 0.5\frac{\rho S V_1^3}{2}$ ..Formula 2.1

From the results shown in Figure 2.3 we choose a propeller 6.5 meters in diameter which gives us an average power of 10142 W on the day.

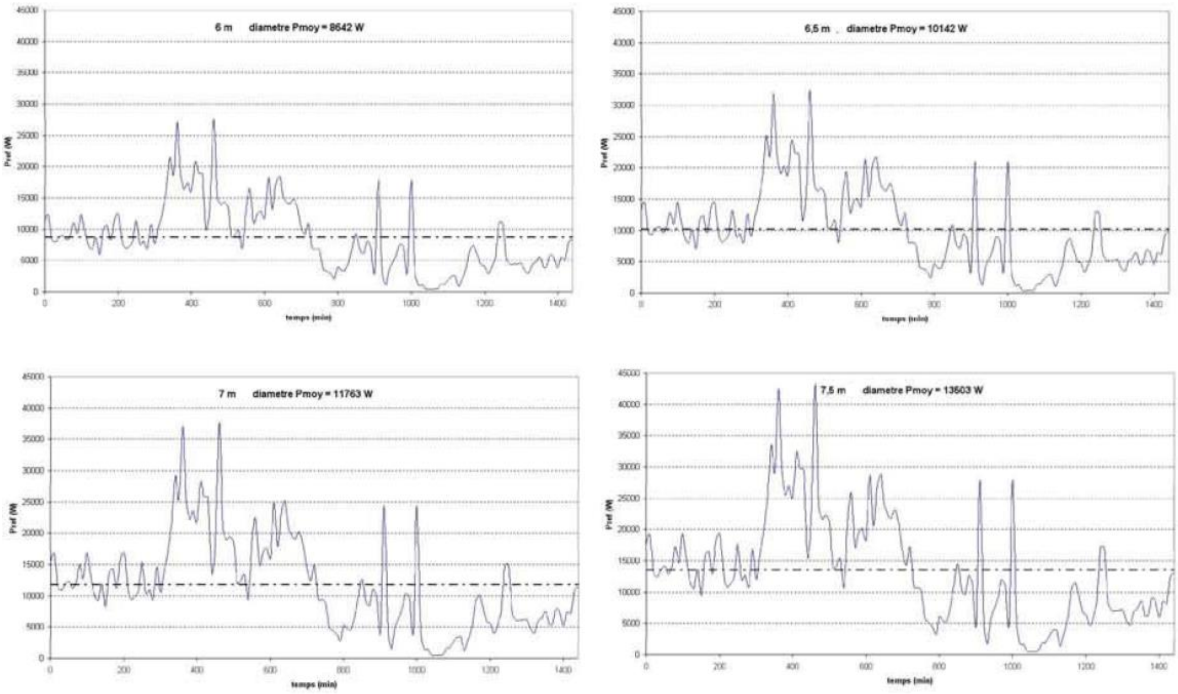


Figure 2.3: Extractable power for different helix diameters (6m, 6.Sm, lm and l.Sm).

Power of the generator and storage

We want to be able to supply the grid with a constant power equal to 10 kW. The generator must be at least dimensioned for this power. However, because of the presence of the storage, which is there to help us maintain the production during the low wind periods, it is necessary to be able to recharge the storage unit.

As a result, during periods of high wind, the generator can supply 10 kW to the grid and refill the storage unit with the surplus of available power. We now need to calculate the maximum power that the generator will have to provide to refill the storage unit.

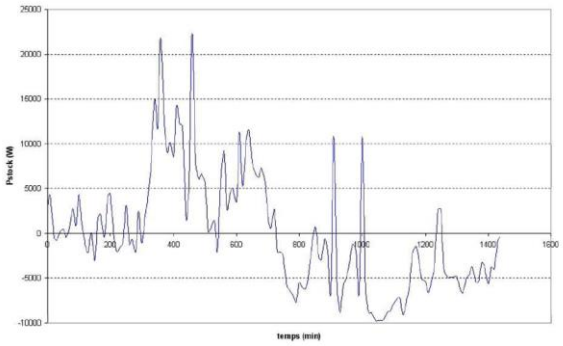


Figure 2.4 - Power to store or compensate by storage.

We will plot the power used to dimension the storage unit by removing 10 kW from the extractable power of the wind. This corresponds to the excess power (P> 0) or deficit (P <0) that should be stored or recovered from the storage unit. The curve is presented in figure 2.4.

$P_{stcok} = P_{ext} - P_{reseau}$

This curve (fig 2.4) will allow us to determine the nominal power of the storage unit. The charge (positive power) and discharge (negative power) phases can be separated. We are interested in the maximum value of the power of the storage unit over periods of time sufficient to have a reasonable value of power.

We can now choose the nominal power of the generator that will be 10 kW (for the network) + 10 kW (to recharge the storage), or 20 kW.

The dimensioning of this generator in kVA, to take into account the reactive power also, will have to be the subject of another study. Indeed, depending on what you want to provide as reactive power to the network the power of the DPAG will be different. We will set the reactive power setpoint to zero in the long-term simulations and thus take a DPAG of 20kVA. In addition, before continuing this study we must review the size of the propeller. Indeed, with a generator of 20 kW of nominal power we will not be able to follow the extractable power on all the day because this sometimes exceeds the 20 kW.

By limiting the maximum power to 20 kW we will not be able to maintain a daily average of 10 kW. We will therefore trace the curve of the extractable wind power for different diameters by limiting the maximum power to 20 kW (Figure 2.5) corresponding to what our generator can actually produce.

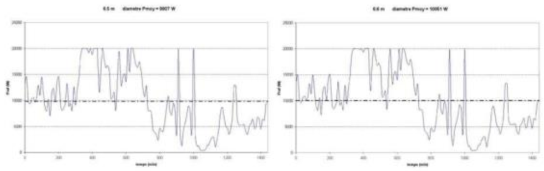


Figure 2.5: Extractable power with saturation at 20 kW.

We look at the value of the average power and we take the propeller diameter allowing an average slightly greater than 10 kW. This gives a diameter of 6.6 m instead of 6.5 m, which gives an average power of 10050 W

Storage capacity: Now that we have defined the generator and storage ratings, we need to determine the energy capacity of the storage unit. To do this, we allonstrate the Wstock energy that must be stored or destocked by integrating the power that corresponds to the storage with respect to the time.

$$W_{stock} = \int P_{stock}dt$$

With

$$Pstock = Pext - 10kW$$

The representative curve of the evolution of energy W during the day is presented in Figure 2.6. Note that the curve ends at the same value it started, it is reproducible over several days without lack of energy, because we chose the power according to the wind profile. It allows to supply to the grid a power of 10kW constant with a profile of wind which gives us daily an average power of 10,05 kW. These are the 50W for 24 hours which causes the small theoretical excess of energy at the end of the day, observed on figure 2.6.

International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com
Vol.7., Issue.6, 2019
Nov-Dec

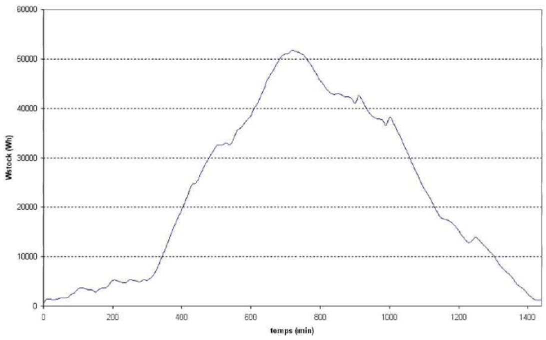


Figure 2.6: Energy storage system

Storage represents only 21.5% of the energy produced per day. Convert this energy into equivalent battery capacity to get an idea of the size of such a storage, with a bus voltage of 800V, we get:

$$capacity\ in\ Ah = \frac{Wh\ capacity}{V_{dc}} = 65Ah$$

This capacitance value represents quite standard batteries and does not occupy an unrealistic volume. This corresponds to 67 diesel car batteries (12V 65 Ah) which occupy a volume of about 1 m^3.

Power of static converters

The sizing of the generator and converters may seem important compared to the power supplied to the network. However, it must be kept in mind that our storage system allows a constant power of 10 kW supplied to the grid. Storage makes it possible to smooth the power supplied to the network and cannot under any circumstances increase the power extracted from the wind.

On the other hand, in comparison with a conventional wind turbine, without storage unit, the power produced would have been very fluctuating. This will not be easy to manage by the network manager. Take the case where a wind turbine of 20 kW without storage unit has been installed. The power produced would have varied between 0 and 20 kW as can be seen in Figure 2.7. The average daily power would have been 10 kW as with our conversion system. This is normal because we use for our conversion system the same wind turbines and the same generator with the same control of maximization of the extracted wind power (MPPT). In terms of sizing the converters, the standard 20 kW wind turbine requires a 6 kW rectifier and a rotor inverter of 6 kW (30% of the nominal power of the generator).

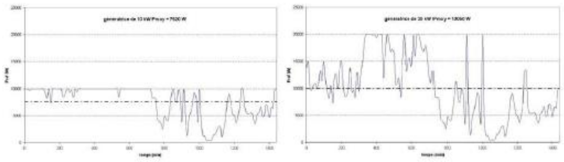


Figure 2.7 : Power produced by a 6.6 m conventional wind turbine with a generator of 10 kW and 20 kW.

Control of the active and reactive powers of the generator

The primary purpose of a wind energy system is to produce electrical energy to supply it to the grid as consistently as possible. To do this, we will use storage to buffer between periods of high and low winds. It is for these reasons that our wind turbine must capture at best the power available in the wind to supply it to the grid and store any surplus. We obtained a control system that maximizes the power produced, a system commonly called MPPT[13], but with high wind limitation. Such a system searches for the optimum operating point of the wind turbine (here by acting on the wedge angle (3) in the operating wind range and then limits the power produced for strong winds to ensure safe operation of the wind turbine. the whole wind turbine.

Figure 2.8 describes the characteristic curve of a control called MPPT, presenting the power produced by the generator (in bold) of our wind turbine according to the speed of the wind, the (fine) curves correspond to the power produced for different angles of wedging of the blades. Note that the MPPT command orients the blades, depending on the wind speed, to maximize the power produced.

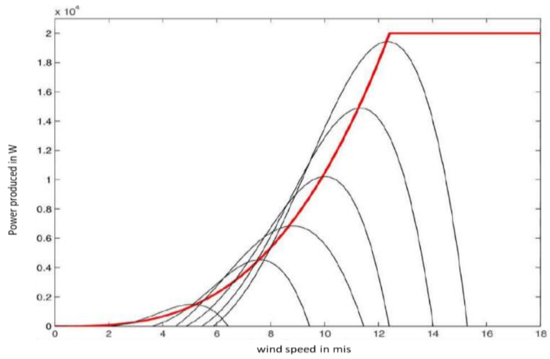


Figure 2.8 - Power generated by the generator as a function of wind speed

Stored power control: The instantaneous power of the storage unit depends on the power produced by the generator and the power supplied to the network. The storage must be controlled in order to keep the power produced in the network constant.

Control of the tension: For an electrical distribution or transport network, the presence of inductive loads imposes in the lines a power factor lower than 1. This results in an increase in the rms value of the currents for the same active power carrier.

Action on the reactive power: It is important to be able to correct the power factor by offsetting the energy consumed by a part of the receivers. As wind turbines are most often connected to distribution and non-transmission networks, they are most likely to be receivers that consume reactive energy. It is a system service much appreciated by the network manager.

Action on active power: The active power in the network will have a direct infiuence on the frequency. In fact, if the power consumed by the charges is lower than the power produced, there will be an increase in the frequency. So when the frequency at the connection point varies out of its tolerated limits, this means that there is no longer any balance between the power produced and the consorned power. It is therefore important to maintain this balance of powers in the network. It is also an important system service that the wind turbine can offer

SIMULATION RESULTS

The results presented here have no obtained from a modelling carried out using the MATLAB software and the associated tools SIMPOWER SYSTEM. These simulations require a lot of material resources because of the complexity and the large number of modelled elements. We perform simulations over short but long enough times to obtain the permanent regimes of all the panies of the energy conversion system. If our system is able to respond appropriately with slow times, it will do so for much longer.

Here, we present in figure 2.9 a simulation of maintaining the voltage below the maximum tolerance of 235V by first acting on the reactive power of the wind then decreasing the active power injected when the roaming power regulation is no longer sufficient. Figure 2.9 shows, respectively from top to bottom, the wind speed, the single voltage at the connection point, the active power correction, the active power of the wind turbine, the reactive power. It can be seen that when the voltage is lower than the 235 V limit, the reactive power is set at -0 kVAR and the active power follows the wind revolution thanks to the MPPT control of the wind turbine which maximizes production at all times.

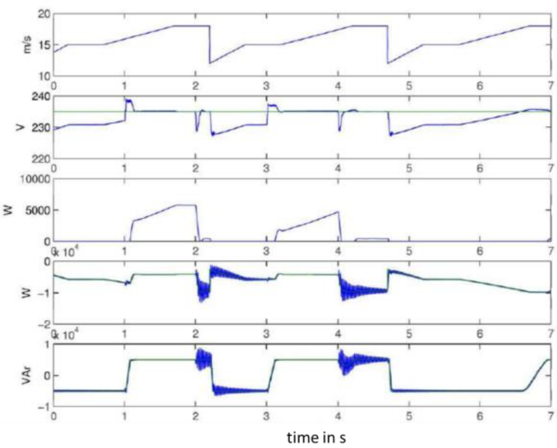


Figure 2.9 - Regulation of the voltage

In this simulation, a resistive and inductive load is alternately connected and disconnected in order to vary the operating conditions of the assembly. It is these connections and disconnections that cause the sudden changes in tension that we observe in transitory regimes.

Long-term simulations of the set

The modelling of the entire energy conversion system was initially developed under MATLAB and

International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com
Vol.7., Issue.6, 2019
Nov-Dec

then expanded to SABER in order to be able to perform simulations over larger periods while remaining within reasonable computing times. Indeed, with MATLAB it is necessary to count 24h of calculation for 2.5 seconds of simulation, whereas with the same system on SABER. It is possible to simulate 1000s in 24h of calculation. The simulations proposed in this section have therefore been carried out with the SABER software and present two cases of operation highlighting the interest but also the limits of the storage system associated with the wind turbine.

Time scale reduction: We can afford this downscaling because if the system reacts correctly to wind changes brought back to 15 min it will work equally well on the same wind profile over the next 24 hours. Indeed the dynamics will be slower on the 24 hours than on the 15 mm.

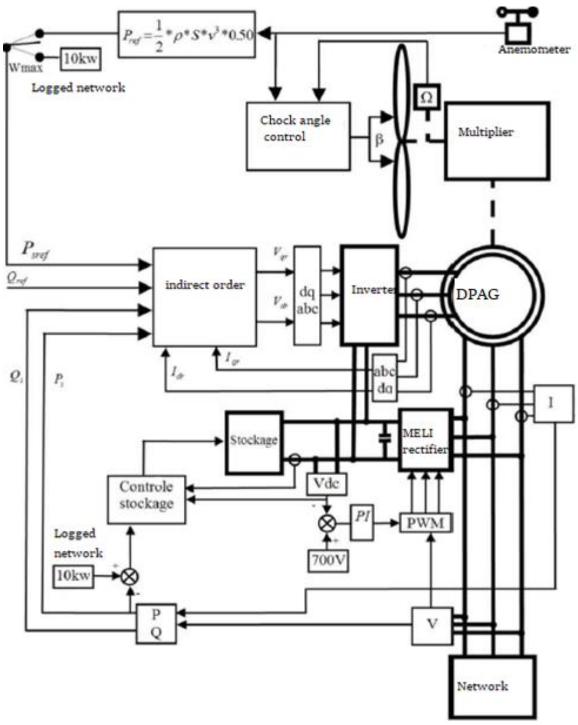


Figure 2.10 Regulation of the energy conversion system

The choice of this power was made for the future realization of a test bench in the laboratory. Modulation is quite transferable to higher powers.

Simulation with storage: This first simulation is made with a wind profile that allows to provide the network with the storage unit. The curves shown in the following figures show the evolution of the operation of the wind turbine.

- Figure 2.11a shows the change in the number of vehicles in m / s where it is in the United States, and this recovery at 900 seconds corresponds to the initial 24-hour registration for a suitable site. at the installation of oleoliennes.

- Figure 2.11b illustrates the active power produced by the asynchronous dual-power generator. With our convention, this power is negative because the power is transmitted to the network. It is limited to 20k \ V, the nominal power of the generator.

- Figure 2.11c corresponds to the power of the storage unit. This power can be positive or negative depending on the wind conditions that allow the load or discharge. The power is limited to 10kV.

-Figure 2.11d shows the evolution of energy in the storage unit; it increases when the wind is strong and decreases during low wind periods.

-Figure 2.11e shows the active power supplied to the grid by the entire wind generator (wind turbine storage). It is maintained at 10 kW.

-Figure 2.11f shows the reactive power injected into the network by the assembly. Here we set ourselves a zero instruction.

Note that the power supplied to the network is maintained equal to 10 kV, thanks to the storage unit. Indeed, if we look at the times when the wind is weak, we realize that the power produced by the generator is less than 10 kW. It is therefore the storage unit that compensates for this lack of power.

Impact Factor 5.8701 (ICI)
International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com
Vol.7., Issue.6, 2019
Nov-Dec

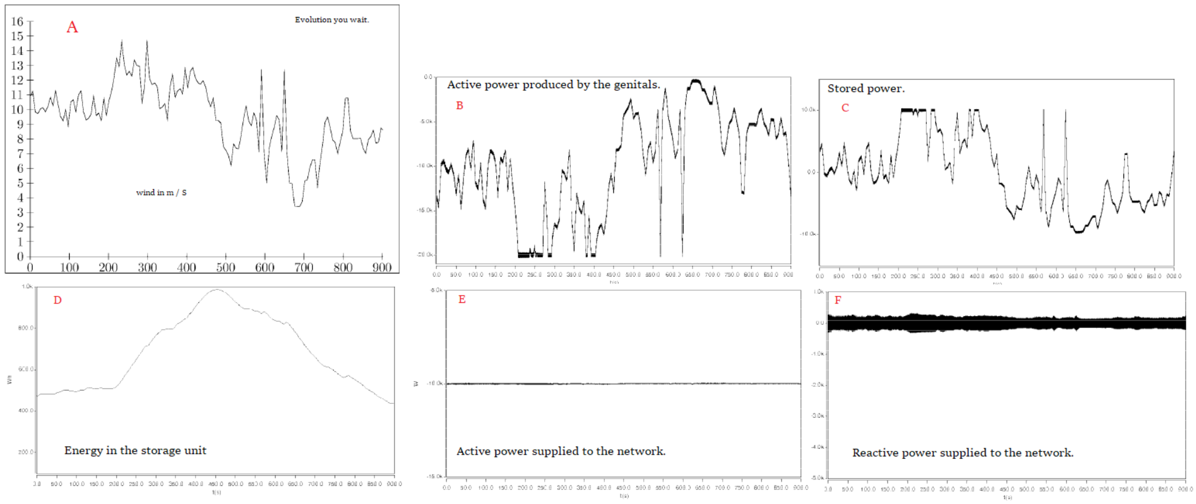


Figure 2.11 (a-f)

Compensation of harmonics by parallel active filter

We seek here to reduce the harmonic pollution present on a network so that it spreads as little as possible in it so as not to disturb the users of this network. In order to limit this harmonic pollution we have four solutions[14]:

- The first is to reduce the short-circuit impedance because it appears that the overall harmonic disturbance increases as the short-circuit power decreases. However, it is not always possible to increase the short-circuit power for economic considerations. Therefore, this solution is not always possible.
- The second concerns the modification of the polluting converter either by changing its structure and / or its control, in order to directly intervene at the source of the harmonic disturbances. This solution is not possible in our case because we do not control the loads connected to the network.

The third solution uses passive filters. This solution, which is the oldest and most widespread, prevents the harmonic currents produced by a non-linear load from spreading over the rest of the network by trapping them in a circuit of passive elements (LC) connected in parallel with the However, the passive filter depends mainly on the characteristics of the network to which it is connected. These must be known in detail when installing the filter, to avoid any risk of resonance. This technique also requires knowing the rank of the harmonic present and asks to perform an accord filter for each harmonic that we want to eliminate. The filters thus borne are not adaptive and if the harmonic pollution is variable, the filters will be ineffective. In addition, these filters may cause aging problems of the filter components that cause shifting of the tuning frequency reducing their efficiency.

For our purpose, we will be interested in the compensation of current harmonics generated by a rectifier bridge supplying an inductive load. We will be inspired by the structure of a parallel active filter. This will serve as a basis for comparing the results.

The filter is an inverter controlled so as to absorb harmonic currents dictated by the control circuit which determines them according to what is measured as harmonic present side of the polluting load. Thus the active filter produces the harmonics that the load absorbs, thus avoiding their propagation through the network.

Figure 2.12 shows the structure of a parallel active filter connected to the network. The filter is located close to the pollutant load and is connected in parallel to provide the harmonic currents generated by the load (here a diode bridge). The currents absorbed by the load are measured to determine the control of the six switches.

International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com
Vol.7., Issue.6, 2019
Nov-Dec

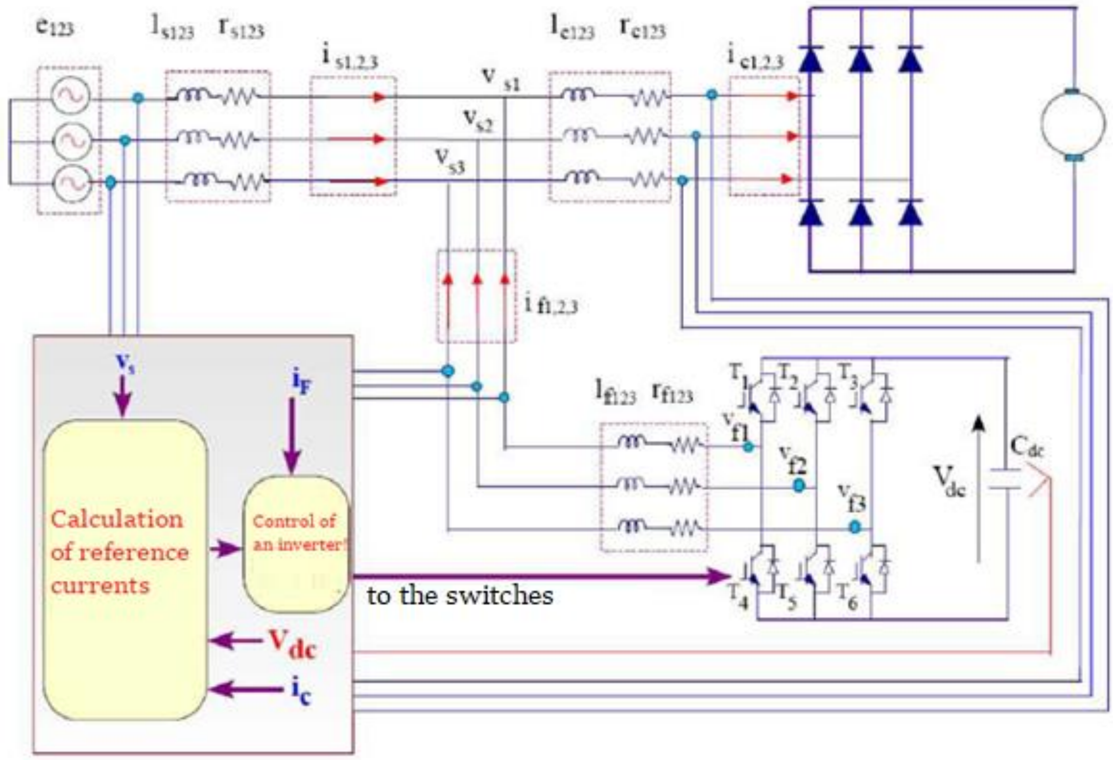


Figure 2.12: Active filtering of current harmonics using a parallel filter

The harmonic currents circulating in the electrical network generate disturbances and energy losses on all the portions of the circuit they pass through. It is therefore appropriate to be able to eliminate these polluting currents closer to their sources.

Asynchronous machine used as active filter

It is realized that the voltage inverter used for the active filtering is of the same structure as the inverters available to perform the control of the asynchronous dual feed machine. In addition, the machine has power amplification between the rotor and the stator. It is this amplification that we want to use to set up active filtering from the rotor of the asynchronous machine[15]. Figure 2.13 shows the structure for filtering the harmonics of currents generated by pollutant loads connected to the network. It remains to develop the command for active filtering and superimpose it to the power control of the DPAG.

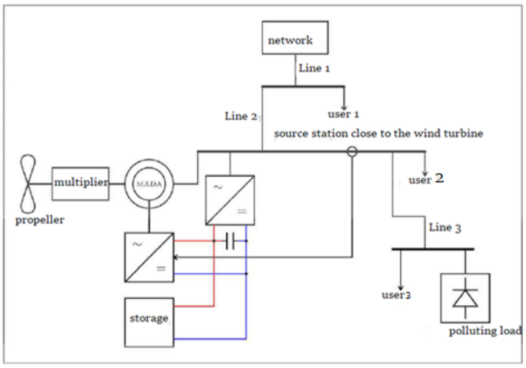


Figure 2.13: Diagram of the wind system with DPAG filtering

Complement on the DPAG model: We will establish the equations linking the rotor harmonic currents and the stator harmonic currents of the machine.

$$\begin{cases} I_{ds} = -\frac{M}{L_s} I_{dr} + \frac{\varphi_s}{L_s} \\ I_{qs} = -\frac{M}{L_s} I_{qr} \end{cases} \quad ...2.3$$

$$\begin{cases} P = -Vs\frac{M}{L_s} I_{qr} \\ Q = -V_s\frac{M}{L_s} I_{dr} + \frac{V_s^2}{L_s\omega_s} \end{cases} \quad ...2.4$$

International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com
Vol.7., Issue.6, 2019
Nov-Dec

$$\begin{cases} V_{dr} = R_r I_{dr} + (L_r - \frac{M^2}{L_s})\frac{dI_{dr}}{dt} - g\omega_s(L_r - \frac{M^2}{L_s})I_{qr} \\ V_{qr} = R_r I_{qr} + (L_r - \frac{M^2}{L_s})\frac{dI_{qr}}{dt} + g\omega_s(L_r - \frac{M^2}{L_s})I_{dqr} + g\frac{MV_s}{L_s} \end{cases}$$
...2.5

If we replace now in equation 2.3 the stator flux $\varphi_s = \frac{V_s}{\omega_s}$ the following expression is obtained for the currents:

$$\begin{cases} I_{dr} = -\frac{L_s}{M} I_{ds} \\ I_{qr} = -\frac{L_s}{M} I_{qs} \end{cases}$$
...2.6

The current references are then equal to the sum of the currents necessary for the regulation of the powers and the generation of the harmonic currents:

$$\begin{cases} I_{drtotal} = I_{dr} + I_{drharmonique} \\ I_{qrtotal} = I_{qr} + I_{qrharmonique} \end{cases}$$
...2.7

We thus have the relation which makes it possible to make the link between the harmonic currents and the control of the inverter feeding the rotor:

$$\begin{cases} I_{drharmonique} = -\frac{L_s}{M} I_{dsharmonique} \\ I_{qrharmonique} = -\frac{L_s}{M} I_{dsharmonique} \end{cases}$$
...2.8

In Equation 2.8, $I_{dsharmonic}$ and $I_{qsharmonic}$ correspond to two-phase harmonic currents absorbed by the nonlinear load. We obtain the regulation scheme presented in figure 2.14, tt includes the summators for harmonic current references

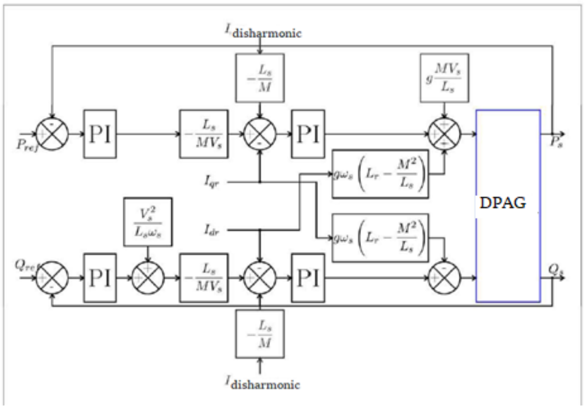


Figure 2.14: Block diagram of the regulation integrating active filtering.

Determination of roasts

The harmonic current identification system is the same as that of a conventional parallel active filter. It determines the two-phase values of the harmonic currents present on the part of the network where currents are measured. We use here an identification method developed in our laboratory[16] and presented in Figure 2.15.

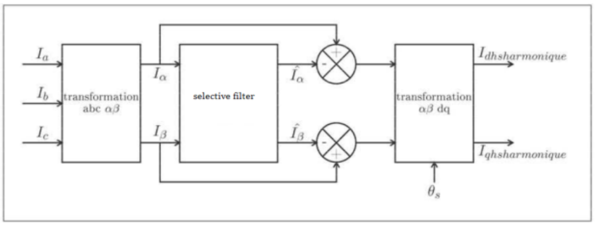


Figure 2.15 : Elaboration of harmonic reference currents of the filter

This method of determining the harmonic references makes it possible to take into account all the harmonics present in the currents of the polluting load. It is not enough to mitigate some particular harmonics but we want to compensate all the harmonics through the asynchronous machine. In addition, this filter is adaptive; the calculation of the references would be done in real time. The currents of the polluting load can thus evolve, the generator will compensate them in real time.

Overall operation of the entire wind system with conventional active filter

Here we associate the connection point of the wind turbine with a parallel active filter. This configuration is illustrated in Figure 2.16. The parallel active filter will filter the harmonics produced by the loads supplied by the network, from this source station. In our case, we have placed a diode rectifier bridge as a pollutant load but any other polluting load can be considered, or combination of loads, because we have an active filter that adapts in real time to harmonic currents present on the network. The filter will compensate the harmonic currents generated by users 2 and 3.

The simulation results presented in Figure 2.17 show the temporal evolution of the line current of the network (phase 1), the current absorbed by the rectifier bridge and the current supplied by the wind turbine.

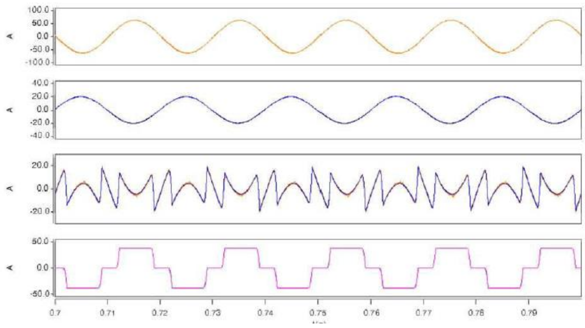


Figure 2.17 - Classic active filtering (from top to bottom: Network, I_{DPAG}, $I_{reference\ Harmonic}$, $I_{redressor}$).

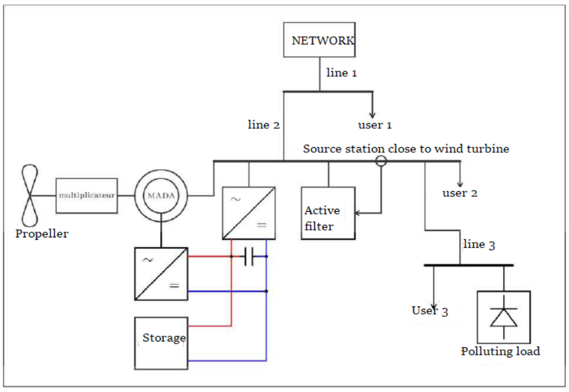


Figure 2.16 :System diagram with classic active filter.

It can be observed that the correction of the harmonics is effective because the current becomes almost sinusoidal after the operation of the filter while it had an extremely rich harmonic form before. In this configuration, the user 3 does not see any change because it is right next to the polluting load. On the other hand users 1 and 2 will have their voltages decontaminated thanks to the action of the active filter.

Overall operation of the entire wind turbine system with active filtering by the DPAG.

Here the wind turbine is controlled to compensate for harmonic currents. We have the same pollutant load and the same operation of the wind turbine in terms of power output and wind conditions. Therefore, the parallel active filter was removed and the appropriate harmonic current references were fed to the DPAG control, as shown in Figure 2.18.

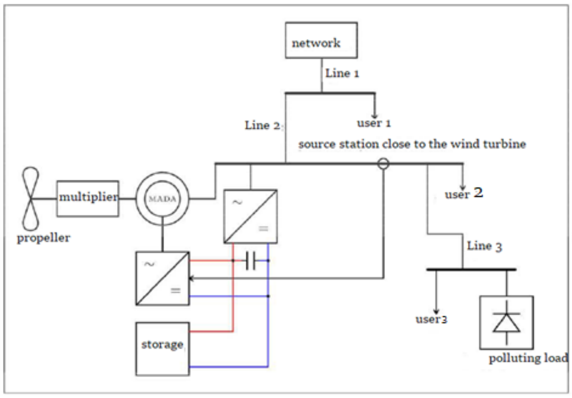


Figure 2.18: Diagram of the wind system with filtering by the DPAG

The simulation results are shown in Figure 2.19 , which shows the current supplied to the grid (in line 2), the current absorbed by the polluting load (measured at the source substation) and the current produced by the generator. Here, as before, we ran the system with and without the filter control. The THD in current thus passes from 27% to 3.6%, always with the same parameters for the wind turbine.

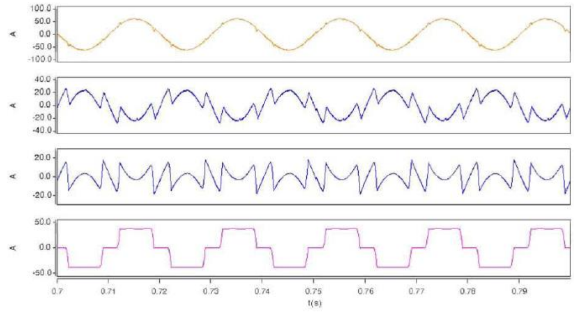


Figure 2.9: Classic active filtering (from top to bottom: I_{rseau}, I_{DPAG}, $I_{referenceharmonic}$, $I_{redresseur}$)

The use of the DPAG as active filter is an interesting option for the network manager since its implementation is inexpensive because it only requires the installation of two or three current sensors at the source station.

We have studied the quality aspect of energy by looking at the nonlinear charges that hindered harmonic currents propagating through the electrical network. The minimization solutions of these harmonics exist and work properly, which we have proposed here is not an alternative to conventional filtering but rather a plus brought by the wind energy conversion system. The simulation results showed that the active filtering operation of the DPAG was a possible and interesting option, both in terms of service quality and installation cost. In addition, the active filter operation does not lead to degradation of the power operation of the system which can always ensure a constant power to the electrical network.

Conclusion

Our study allowed us to realize a complete and global modelling of a system of hydroelectricity generation from wind energy. This modelling is mainly due to the different approach that has been taken from the mechanical part that uses aerodynamic calculations to determine the relationships between the wind speed, the torque and the speed of the propeller, but also study of the whole with the association of the storage unit allowing the supply of a constant power to the network and system services such as the power of the active or the option of active filtering of the harmonics with the DPAG. All this has been designed around a DPAG and a MPPT control of the wind turbine to maximize the power produced at any time. The independent control of the active and reactive powers has been studied and two commands, direct and indirect, have been exposed, the indirect control having been retained for its control of the rotor currents and its good robustness due to the two current and power control loops. . In addition, the indirect control makes it possible to simply add the active filtering control by simply adding the reference currents, which does not make possible the direct control. The goal is to facilitate the insertion of wind turbines into the power grids in order to increase the share of renewable energy production in the future electricity grid. The implementation of the storage unit and its simulation showed us that it was wise to use this solution in order to obtain a more practical production system for the network manager; it can now rely on constant power as shown by the simulation over a long period. The DPAG produces, thanks to the MPPT command, the maximum of the power which is available in the wind and the storage unit manages its power and its energy to maintain constant the power supplied to the network by unloading and recharging at the sandstone of the wind.

However, the second simulation showed the limits of such a system and especially highlighted that if the wind turbine and the storage unit were not well adapted to the wind profile of the implantation site, the operation does not It may not be possible to keep the power constantly constant, thus causing moments when the power supplied to the network is inferior to the fixed set point. It therefore appears that the sizing of the storage unit requires an appropriate study of the wind conditions of the site on which the wind turbine is to be installed. This type of system is not added to a conventional wind turbine but must be thoroughly studied on each site where we plan to exploit wind energy. In comparison with a non-storage wind turbine, our main conversion system is mainly used to obtain constant power supplied to the network. So this aspect is interesting because for a wind turbine without storage, we cannot rely on a power throughout the period envisaged, 24h in our case, and the fluctuations of the power supplied to the network are difficult to manage and cause disruption to users. In addition, for a real case, the period will have to be wider in order to take into account the wind effects over the entire army. With regard to current harmonic filtering, with the dual-power asynchronous machine operating both as a 50 Hz electrical power generator and as an active filter, we have demonstrated its ability to act as a parallel active filter with very high efficiency good results. The implementation of this additional command to correct the current harmonics has been possible because it was available, on the control of the DPAG, regulation of the rotor currents through indirect control.

This active filtering someone is interesting because, in addition to presenting good results, its implementation requires only two to three current sensors and a little control electronics for a reasonable cost. It would now be good to focus on the design and study of the impact of harmonics on the DPAG and also to study machine structures to minimize high frequency losses. This will have to be done in order to optimize its construction so that it revolves the best possible harmonic currents without changing its operation at 50 Hz.

We have therefore touched on a subject which is in full development, the DPAG control for wind generation is topical and already used in large commercialized wind turbines.

REFERENCES

1 Ali M. Rasham, Assessment of Annual Wind Energy Potential at Three Sites in Iraq for Wind Energy Applications,International Journal of Computer Applications, Volume 168 – No.5, June 2017

2 A.M. Rasham and J.M. Mahdi, Performance of Wind Turbines at Three Sites in Iraq, International Journal Of Renewable Energy Research,Vol.8, No.3, September, 2018, 1327-1398

3 Dhafer Manea Hachim, Assaad Alsahlani, Adel A. Eidan., Measurements of Wind and Solar Energies in Najaf, Iraq. Advances in Natural and Applied Sciences. 11(9); Pages: 110-116

4 P.E. Vidal, Etude Commande Non-linéaire d'une Machine Asynchrone à Double Alimentation, Thèse de Doctorat, INP Toulouse 2004

5 A. Peña, S.E. Gryning, J. Mann, C.B. Hasager, J. Appl. Meteor. Climatol. 49 (2010) 792–806

6 Bakar A. A., Utomo W. M., Taufik T., Aizam S., Jumadril, ARPN J. Eng. Appl. Sci. 10 (2015) 9078-9082

7 M. Lellis Thivagar, Abdulsattar Abdullah Hamad, Topological geometry analysis for complex dynamic systems based on adaptive control method, Vol. 7, No. 3, September 2019, pp.1345-1353.

8 K Marouani, K Nounou, Mohamed Benbouzid, B Tabbache, H Alloui. Control of a Power Generation System Based on a Dual Star Induction Generator. 2015 ICREPQ, Mar 2015, La Coruna, Spain. pp.1-5. ffhal-01154254f

9 A. Nesba, ‘‘Caractérisation du phénomène de la saturation magnétique de la machine asynchrone,” Phd. thesis (in french), Ecole Nationale Polytechnique, Algiers, Algeria, Jan. 2007

10 J. B. Patton and D. Curtice, “Analysis of utility protection problems associated with small wind turbine interconnections,” IEEE Trans. Power Apparatus and Systems, vol. 101, no. 10, pp. 3957-3966,1982

11 L. Harnefors, S. Saarakkala, and M. Hinkkanen, “Speed control of electricaldrives using classical control methods,” IEEE Trans. Ind. Appl., vol. 49, no. 2, pp. 889–898, Mar. 2013.

12 Bouzid, Allal; Sicard, Pierre; Guerrero, Josep M.; Chereti, Ahmet; Bouhamida, Mohamed; Golsorkhi, Mohammad, Voltage and frequency control of wind-powered islanded microgrids based on induction generator and STATCOM, Proceedings of the 2015 3rd International Conference on Control, Engineering & Information Technology (CEIT) 10.1109/CEIT.2015.7232986

13 D. Chermiti, N. abid, and A. Khedher, “Voltage regulation approach to a self-excited induction generator: Theoretical study and experimental validation,” International Transactions on Electrical Energy Systems, vol. 27, no. 5, 2017.

14 A. Edpuganti and A. K. Rathore, “Optimal pulsewidth modulation for common-mode voltage elimination scheme of medium-voltage modular multilevel converter-fed open-end stator winding induction motor drives,” IEEE Transactions on Industrial Electronics, vol. 64, no. 1, pp. 848–856, 2017.

15 Y. Zhou, P. Bauer, J. Ferreira, and J. Pierik, “Operation of grid-connected DFIG under unbalanced grid voltage condition,” IEEE Trans. Energy Convers., vol. 24, no. 1, pp. 240-246, Mar. 2009.

16 Mohamed Arbi Khlifi, “Behavior of a Dual Stator Induction Machine Fed by Neutral Point Clamped Multilevel Inverter,” Journal of Energy, vol. 2018, Article ID 6968023, 10 pages, 2018. https:// doi.org/ 10.1155/ 2018/ 6968023.