

Coordinated Control Of Doubly Fed Induction Generator And Electric Vehicle

Rufina.A¹, Sheeba percis.P², Nalini. ³,Bhuvaneswari. ⁴

Student,Dr.M.G.R Educational and Research Institute

Research scholar,Dr.M.G.R Educational and Research Institute

Research scholar, Dr.M.G.R Educational and Research Institute

Research scholar, Dr.M.G.R Educational and Research Institute

¹rufeeraj@gmail.com

²sheebaedwin@yahoo.co.in

³nalinitosiva@gmail.com

⁴bhuvana_eee@yahoo.co.in

Abstract: At present, the large number of small scale and large scale wind turbines are used to generate electrical energy so as to bridge the gap between demand and supply. This enables the power distribution network to improve power supply and optimize the energy dissipated. Since wind power is varying an energy storage system is needed. In this paper, the coordinated control of doubly fed induction generator and electric vehicle approaches the optimization of wind speed, and to decrease the demand of power supply. Thus the performances are simulated in pscad software and results are achieved between the power generation and demand.

Keywords: DFIG, Electric Vehicle, wind speed, power supply.

I INTRODUCTION

Nowadays, wind energy is one of the penetrated renewable energy increasing rapidly all over the world. Hence the main disadvantage of wind power is its intermittent nature. The power generated by wind farm increases the variations of wind speed. Whenever the wind speed is high, the control is used to limit the power generation in wind farm. If the wind farm is connected to grid, the fluctuations of wind speed cause instability problems in system. To overcome this problem, the energy storage device like electric vehicle are connected to the dc link between the rotor side and grid side inverters of Doubly fed induction generator (DFIG)[2]. Recently more renewable power conversion systems are connected in low voltage ac distribution systems as distributed generators or ac micro grids due to environmental issues caused by conventional fossil fueled power plants. On other hand, more and more dc loads such as light-emitting diode (LED) lights and electric vehicles (EVs) are connected to ac power systems to save energy and reduce CO emission. When power can be fully supplied by local renewable power sources, long distance high voltage transmission is no longer necessary [1]. The advantage of the power structure chosen is not only to operate the machine in a wide range of speed

variation, but also to give to the machine the capacity to operate up to twice its rated power. So the power density is improved[5].

The main characteristics of doubly induction generator scheme are, operation below, above and through synchronous speed with the speed range restricted only by the rotor voltage ratings of the DFIG operation at synchronous speed, with DC currents injected into the rotor with the inverter working in chopping mode low distortion stator, rotor and supply currents independent control of the generator torque and rotor excitation Control of the displacement factor between the voltage and the current in the supply converter, and hence control over the system power factor[6].

II CIRCUIT DIAGRAM

In this fig1 the circuit diagram describes to track the maximum wind power utilization. The power coefficient 'Cp' is a function of wind speed or machine speed changes, the machine speed is changed to operate at maximum Cp.P and Q are controlled irrespective of the machine speed (slip speed). A step change in wind speed would cause the speed controller to react and maximum the tip speed ratio for maximum power. This can be derived from turbine torque equations. The washout filters removes any dc component from the integrated flux without significantly affecting the phase.

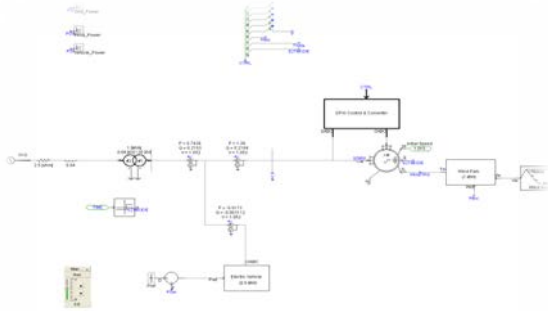


FIG 1

III WIND CIRCUIT

3.1 DOUBLY FED INDUCTION GENERATORS

3.1.1 WORKING PRINCIPLES

An induction generator is composed by a stator and a rotor. In the case of a DFIG, both stator and rotor have three sinusoidally distributed windings, corresponding to three phases, displaced by 120°. The three phases are called a, b and c. The stator has p pairs of poles. The rotor is connected to the grid through converters. A three-winding transformer gives different voltage levels for stator and rotor side. When the machine produces energy, only a small part of the generated power flows from the rotor to the grid. The converters can then be chosen in accordance with this small rotor power. This means smaller converters compared to fully rated converters and this allows to decrease the costs.

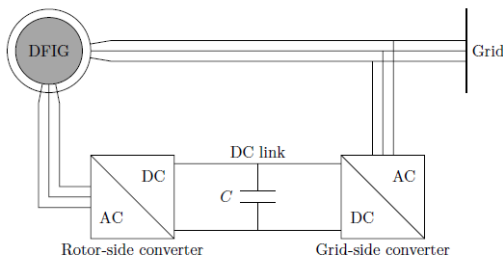


Figure 2.1: DFIG with its converters

FIG 2

The stator windings are connected to the grid which imposes the stator current frequency, f_s . The stator currents create a rotating magnetic field in the air gap. The rotational speed of this field, ω_s , is proportional to f_s :

$$\omega_s = 2\pi f_s$$

If the rotor spins at a speed different from that of the rotational field, it sees a variation of magnetic flux. Therefore, by Faraday’s law of induction, currents are induced in the rotor windings. Let us define ω_m the rotor mechanical speed and ω_r the rotor electrical speed by

$$\omega_r = p\omega_m$$

The flux linked by the rotor windings change with time if $\omega_r \neq \omega_s$. The machine operates usually as a generator if $\omega_r > \omega_s$ and as a motor otherwise. In the case of the DFIG however, it can operate in sub-synchronous mode as a generator. The slip, s, defines the relative speed of the rotor compared with that of the stator:

$$s = \frac{\omega_s - \omega_r}{\omega_s}$$

The slip is usually negative for a generator and positive for a motor. The currents induced in the rotor windings pulse at an angular speed defined by the difference between the synchronous speed and the rotor speed. Indeed, the stator currents at ω_r sees the rotating magnetic field created by the stator pulsating at $\omega_r - \omega_s$. It means the frequency of the rotor currents, f_r is

$$f_r = sf_s$$

If the rotor were to rotate at the synchronous speed, it would not see any change in magnetic fluxes. No currents would then be induced in its windings. Therefore, the machine operates always at speeds different from synchronous speed. The rotor-side inverter controls the rotor currents. It can be noted that controlling the rotor currents controls the slip and so the speed of the machine[7].

3.1.2 PRINCIPLE OF CONTROL

The control strategy involves the control of the rotor currents to control the torque and speed of the induction generator, to achieve output power control. Vector control also enables the decoupled control of stator flux and electromagnetic torque (Darviersiang et al 2006).

Doubly fed control methodologies can generally be broken into two categories: direct torque control and vector control. Direct torque control (DTC) is a non-linear type of control that operates in a hysteresis manner. It identifies the state of certain variables, such as flux and torque, and makes a decision about what rotor voltage to apply to drive the state to a desired value. A description of DTC for a cage induction machine can be found in (Nakra et al 1988). The other form of doubly-fed control is vector control, which is a linear control structure based on simple single input, single output type controllers (Proportional Integration, for example) or more advanced state space theory (Yazhou et al 2006). A rotating reference frame is used to decompose complicated three-phase relationships to orthogonal components. Vector control is used in this research.

IV ELECTRIC VEHICLE

An electric vehicle (EV), also referred to as an electric drive vehicle, which uses one or more electric motors for propulsion. Depending on the type of vehicle, motion may be provided by wheels or propellers driven by rotary motors, or in the case of tracked vehicles, by linear motors.

Electric vehicles are different from fossil fuel-powered vehicles in that they can receive their power from a wide range of sources, including fossil fuels, nuclear power, and renewable sources such as tidal power, solar power, and wind power or any combination of those. However it is generated, this energy is then transmitted to the vehicle through use of overhead lines, wireless energy transfer such as inductive charging, or a direct connection through an electrical cable. The electricity may then be stored onboard the vehicle using a battery, flywheel, supercapacitor, or fuel cell. Vehicles making use of engines working on the principle of combustion can usually only derive their energy from a single or a few sources, usually non-renewable fossil fuels. A key advantage of electric or hybrid electric vehicles is their ability to recover braking energy as electricity to be restored to the on-board battery (regenerative braking) or sent back to the grid (V2G).

At the beginning of the 21st century, increased concern over the environmental impact of the petroleum-based transportation infrastructure, along with the spectre of peak oil, led to renewed interest in an electric transportation infrastructure. As such, vehicles which can potentially be powered by renewable energy sources, such as hybrid electric vehicles or pure electric vehicles, are becoming more popular and scooters, and electric spacecraft.

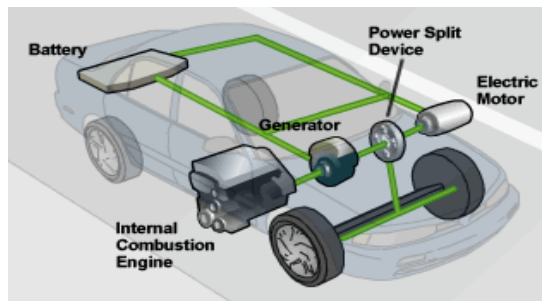


FIG 3

MAIN ELECTRIC VEHICLE PARAMETERS

Symbol	Description	Quantity
m	Overall vehicle mass	1940 kg
x_F	Distance from the center of gravity to the front axle	1 m
x_R	Distance from the center of gravity to the rear axle	1.6 m
$2y_{F/R}$	Front and rear track width	1.625 m
h_{CG}	Height of the vehicle center of mass	0.66 m
-	Tires	235/55 R19
$P_{M,MAX}$	Maximum electric motor power	228 kW
$n_{M,MAX}$	Maximum electric motor speed	14000 RPM
τ_1	First stage transmission gear ratio	3.33
τ_2	Second stage transmission gear ratio	3

Table 1

4.1 Description of Parts and their Functions

Potentiometer. It is circular in shape and it is hooked to the accelerator pedal. The potentiometer, also called the variable resistor, provides the signal that tells the controller how much power is it supposed to deliver.

Batteries. The batteries provide power for the controller. Three types of batteries: lead-acid, lithium ion, and nickel-metal hydride batteries. Batteries range in voltage (power). DC Controller. The controller takes power from the batteries and delivers it to the motor. The controller can deliver zero power (when the car is stopped), full power (when the driver floors the accelerator pedal), or any power level in between. If the battery pack contains twelve 12-volt batteries, wired in series to create 144 volts, the controller takes in 144 volts direct current, and delivers it to the motor in a controlled way [3].

The controller reads the setting of the accelerator pedal from the two potentiometers and regulates the power accordingly. If the accelerator pedal is 25 percent of the way down, the controller pulses the power so it is on 25 percent of the time and off 75 percent of the time. If the signals of both potentiometers are not equal, the controller will not operate [3].

Motor. The motor receives power from the controller and turns a transmission. The transmission then turns the wheels, causing the vehicle to run.

Power Split Device The power-split-device resides between the two motors and together with the two motors creates a type of continuously variable transmission.

Electric Motor. The electric motor on a hybrid car acts as a motor as well as a generator. For example, when needed, it takes energy from the batteries to accelerate the car. But acting as a generator, it slows the car down and returns energy to the batteries.

4.1.2 Theory of Operation for Hybrid

When the driver steps on the pedal the generator converts energy from the engine into electricity and stores it in the battery. The battery then provides power to the electric motor. The internal combustion engine and electric motor work simultaneously and each provide power to the power split device. The power split device combines both powers and uses it to turn the transmission. The transmission then turns the wheels and propels the vehicle.

The energy used when braking is converted into electricity and stored in the battery. When braking, the electric motor is reversed so that, instead of using electricity to turn the wheels, the rotating wheels turn the motor and create electricity. Using energy from the wheels to turn the motor slows the vehicle down. When the vehicle is stopped, the gasoline engine and electric motor shut off automatically so that energy is not wasted in idling. The battery continues to power auxiliary systems, such as the air conditioning and dashboard displays.

V GENERATION OF ELECTRICITY

Electric cars usually also show significantly reduced greenhouse gas emissions, depending on the method used for electricity generation to charge the batteries. Even when the power is generated using fossil fuels, electric vehicles usually, compared to gasoline vehicles, show significant reductions in overall well-wheel global carbon emissions due to the highly

carbon intensive production in mining, pumping, refining, transportation and the efficiencies obtained with gasoline. Researchers in Germany have claimed that while there is some technical superiority of electric propulsion compared with conventional technology that in many countries the effect of electrification of vehicles' fleet emissions will predominantly be due to regulation rather than technology. Indeed electricity production is submitted to emission quotas, while vehicles' fuel propulsion is not, thus electrification shifts demand from a non-capped sector to a capped sector.

Many countries are introducing CO₂ average emissions targets across all cars sold by a manufacturer, with financial penalties on manufacturers that fail to meet these targets. This has created an incentive for manufacturers, especially those selling many heavy or high-performance cars, to introduce electric cars as a means of reducing average fleet CO₂ emissions.

5.1 ENERGY EFFICIENCY

Internal combustion engines are relatively inefficient at converting on-board fuel energy to propulsion as most of the energy is wasted as heat. On the other hand, electric motors are more efficient in converting stored energy into driving a vehicle, and electric drive vehicles do not consume energy while at rest or coasting, and some of the energy lost when braking is captured and reused through regenerative braking, which captures as much as one fifth of the energy normally lost during braking. Typically, conventional gasoline engines effectively use only 15% of the fuel energy content to move the vehicle or to power accessories, and diesel engines can reach on-board efficiencies of 20%, while electric drive vehicles have on-board efficiency of around 80%. Production and conversion electric cars typically use 10 to 23 kWh/100 km, (0.17 to 0.37 kWh/mi). Approximately 20% of this power consumption is due to inefficiencies in charging the batteries. Tesla Motors indicates that the vehicle efficiency (including charging inefficiencies) of their lithium-ion battery powered vehicle is 12.7 kWh/100 km (0.21 kWh/mi) and the well-to-wheels efficiency (assuming the electricity is generated from natural gas) is 24.4 kWh/100 km (0.39 kWh/mi).

5.2 SAFETY

The safety issues of BEVs are largely dealt with by the international standard ISO 6469. This document is divided in three parts dealing with specific issues:

On-board electrical energy storage, i.e. the battery Functional safety means and protection against failures Protection of persons against electrical hazards.

5.3 BATTERIES

While most current highway-speed electric vehicle designs focus on lithium-ion and other lithium-based variants a variety of alternative batteries can also be used. Lithium-based batteries are often chosen for their high power and energy density but have a limited shelf life and cycle lifetime which can significantly increase the running costs of the vehicle. Variants such as Lithium iron phosphate and Lithium-titanate attempt to solve the durability issues with traditional lithium-ion batteries.

Other battery types include lead acid batteries which are still the most used form of power for most of the electric vehicles used

today. The initial construction costs are significantly lower than for other battery types, but the power to weight ratio is poorer than other designs, Nickel metal hydride (NiMH) which are somewhat heavier and less efficient than lithium ion, but also cheaper. Several other battery chemistries are in development such as zinc-air battery which could be much lighter, and liquid batteries that might be rapidly refilled, rather than recharged, are also under development.

5.4 RANGE

The range of an electric car depends on the number and type of batteries used. The weight and type of vehicle, and the performance demands of the driver, also have an impact just as they do on the range of traditional vehicles. Range may also significantly be reduced in cold weather.

VI VEHICLE TO GRID : UPLOADING AND GRID BUFFERING

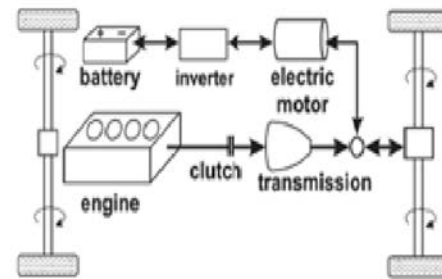


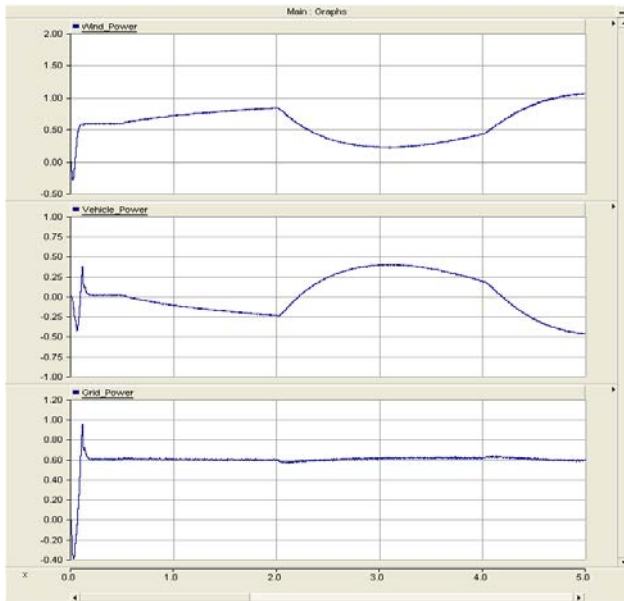
FIG 5

During peak load periods, when the cost of electricity can be very high. These vehicles can then be recharged during off-peak hours at cheaper rates while helping to absorb excess night time generation. Here the batteries in the vehicles serve as a distributed storage system to buffer power. During blackouts, as an emergency backup supply.

The main advantage of electric drive vehicles do not consume energy while at rest or coasting, and modern plug-in cars can capture and reuse as much as one fifth of the energy normally lost during braking through regenerative braking[5]. All-electric and plug-in hybrid vehicles also have lower maintenance costs as compared to internal combustion vehicles, since electronic systems break down much less often than the mechanical systems in conventional vehicles, and the fewer mechanical systems on board last longer due to the better use of the electric engine. PEVs do not require oil changes and other routine maintenance checks. The potential overload of the electrical grid the existing electrical grid, and local transformers in particular, may not have enough capacity to handle the additional power load that might be required in certain areas with high plug-in electric car concentrations.

As recharging a single electric drive car could consume three times as much electricity as typical home overloading problems may arise when severe vehicles in the same time, or during the normal summer peak loads. To avoid such problems, utility executives recommend owners to charge their vehicles overnight when the grid load is lower or to use smarter electric meters that help control demand.

VII RESULT



VII CONCLUSION

As of today, each vehicle has its own characteristics that makes it better than other only time and technological improvements will tell which vehicle will excel in the future. Thus the uninterruptible power supply improves and energy dissipation is optimized. Hence the wind power is stored and controlled by a storage system of electric vehicle to decrease the demand in PSCAD software and results are observed.

REFERENCES

- [1] R. H. Lasseter, "MicroGrids," in *Proc. IEEE Power Eng. Soc. Winter Meet.*, Jan. 2002, vol. 1, pp. 305–308.
- [2] Pinaki Mitra, Ganesh K. Venayamoorthy. "Intelligent Coordinated Control of a Wind Farm and Distributed SmartParks", Rolla, Missouri, USA, IEEE 2010.
- [3] A Hybrid AC/DC Microgrid and Its Coordination Control Xiong Liu, Student Member, IEEE, Peng Wang, Member, IEEE, and Poh Chiang Loh, Member, IEEE
- [4] "Electric vehicle as a reactive power compensator and oscillation damper in a DFIG based wind farm", Blessy Mathew, Jancy Varghese, *International Journal of Advanced Information Science and Technology (IJAIST)*
- [5] "Introduction of Doubly Fed Induction Machine in an Electric", Vehicle R.Babouria, D.Aouzellagb, K.Ghedamsia,b, *International conference August 2014.*
- [6] "Doubly fed induction generator using back to back PWM converters and its application to variable speed wind energy generation", R.pena,J.C.Clare,G.M.Asheriss
- [7] "Doubly-fed Induction Generator Modeling and Control in DigSilent Power Factory" CAMILLE HAMON.
- [8] "Overvoltages due to synchronous tripping of plug-in electric vehicle chargers flowing voltage dips" Soumya Kundu, Member, IEEE, and Ian A. Hiskens, Fellow, IEEE June 2014.
- [9] "An Event-Based Simulation Framework to Examine the Response of Power Grid to the Charging Demand of Plug-In Hybrid Electric Vehicles", *IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS*, vol,10,No.1,February 2014.
- [10] "A technical research report of electric vehicle ",Rony-Argueta, March", 2010.