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DFIG Modeling and its Interface to Distributed Wind Farm

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Abstract

With the increase in the demand of power supply, conventional power supply unit may not be able to compensate the demanded power supply. To compensate such a demand an additional power supply is to be incorporated in conventional system. As the resources for power generation is getting constraint the need for incorporation of renewal resources for power generation is in demand. In this regard the power supply based on wind supply is in greater demand. For the optimal generation of power from the wind source a DFIG models are been in use. A mathematical approach to DFIG modeling and its interface to a distributed wind farm is been suggested in this paper.

Keywords: DFIG modeling, Distributed wind farm, power load demand.

Introduction

Use of wind turbines in large power systems is becoming a reality. Modern wind turbines [8 9 10] use complex technologies including power electronic converters and sophisticated control systems. Electromagnetic transients in power systems need to be simulated and analyzed in order to study the impact of these new power generators on the power systems. Methods and tools for simulation either fast or real time of wind turbines in large power systems are therefore needed. Real-time simulation is also required for field and in plant testing in order to evaluate performance of control and protection systems. This paper presents the modeling and real-time simulation of a generic wind-turbine doubly-fed [4] induction generatorin a power system [1, 2, 3]. Matlab/Simulink software is used to develop the WT_DFIG [9] model. The generated code of the Simulink model is linked to the Hypersim digital real-time simulator [4] in order to simulate the power system together with wind turbines. During past recent years the demand of power has increased rapidly. To compensate this demand of power additional resources are used. Wind power energy has contributed a major part towards this fulfillment of power requirement. Currently more than 23, 000MW of wind capacity is operational in various part of globe for this energy compensation. The development in utilization of this wind energy [1] has created new challenge under transmission operators. The growth of generation capacity for wind energy [1] has been majorly effected by extension of power lines and variable wind resources. The output of wind farms [6] depends on the wind resource and cannot be conventionally controlled. This inaccuracy in prediction of energy leads in heavy losses and inefficient operation. These demands in development towards the balancing power for wind farm networks. Basically the power could be controlled by appropriate control strategies for reactive power flow in wind farm networks. This could able to get reactive power optimization and minimization of internal losses. This paper implements suitable reactive power algorithms for optimization of reactive power generation under wind farm network. The algorithm evaluates throughput of multiple wind farms and adjusts the generation of power depending upon the variable speed. The paper works towards minimization of internal losses occurred during power generation. A load flow analysis for a stationary wind farm behavior is assessed.

DFIG Modeling

With a fixed-speed wind turbine system, it may be necessary to use pitch control of the blades to optimize performance, thus introducing additional mechanical control systems, complexities and costs with variable-speed [1 4] generation. It is possible to track the changes in wind speed by adapting shaft speed and thus maintaining optimal energy generation. In above figure the rotor power from the wind turbine is plotted using variable speed operation (VSG) and fixed speed operation (FSG). The fixed speed system is optimized at only a single speed, generally representing maximum energy captures potential for a given site, and power output at near cut-in and maximum power are significantly lower than for the variable speed system. However, the fixed speed system is inherently power limited as increasing wind speeds lower the turbine power coefficient. The variable speed system will attempt to track maximum power at any speed and will eventually exceed the rating of the generator. At that point it becomes necessary to limit the power by abandoning the optimum tip speed-ratio. During variable speed operation wind and rotor speed are related linearly, whereas in the constant power regime, shaft speed drops off sharply and is kept essentially constant thereafter. In case of wind farm operation as each blade passes the supporting tower, the output torque decreases. Thus, the torque produced by a two-blade wind turbine contains a harmonic at twice the rotational speed. Typically, a fixed- speed system is unable to mitigate this effect in order to improve the quality of the output power. In VSG systems, however, appropriate control of the power electronic converter can minimize torque ripple and thus output power pulsations. Some large wind systems are not self-starting or self-stopping. Tower resonances require that the wind turbine be motored up to operating speed. Fixed-speed systems require the starting of a large induction machine with the resulting expense of soft start mechanisms; stopping a fixed-speed system usually requires a large mechanical braking system. In CSCF-systems the electromechanical energy conversion done by means of a synchronous generator, so that variations in wind speed have to be accommodated by pitch control of the winds turbine itself, referring the primary power low control function to the mechanical side of the system. In VSCF systems the wind turbine operates at variable speed, and if this variable speed region is made large enough, it is possible to operate a fixed pitch wind turbine and refer the entire power control function to the electrical side. Only limited variable speed operation is possible with a conventional induction generator, since the efficiency becomes proportional to speed. This has led to the investigation of over synchronous operation of slip ring or doubly fed induction generators with rotor and stator power fed back to supply. In this case, variable speed operation is possible while only controlling the electrical side. For the controlling of wind farm motor cage rotor IM were used. Cage rotor IM systems inherently use large and expensive converters, typically at 125% of machine rating. Wound-rotor induction generators use much smaller and thus cheaper converters to process slip power, but are more prone to failures due to the use of slip rings. In the doubly fed systems shown, the power electronics does not handle all the system power, but only the part that is not directly fed into the supply. Power flow characteristics of the electronic system of rated system in such a way that maximum power operation corresponds to torque at twice synchronous speed; the power electronic subsystem will be rated at 50% of that necessary. The generator system uses a standard cage rotor induction machine (CRIM), of slightly lower cost than the doubly fed cascaded system. While speed range is not limited to over synchronous operation in this case, the power converter have to be rated for the total power flow. The power and control stator windings interact through the rotor, which has a specialized cage structure with a number of identical sections corresponding to the sum of the pole pairs of the stator windings. Stator frequencies and shaft speed are related by;

$$f_c=f_r(P_p + P_c) - f_p$$

P_p and Pc the pole pair number of the stator winding;
f_p is the utility grid frequency (60Hz);
f_r is the shaft speed dictated by the variable speed generator algorithm;
f_c is the required converter out put frequency.

Only a fraction of the generator power is processed electronically, resulting in reduced size and cost as well as improved power quality. For the development of such a DFIG [9] unit operating efficiently the electrical characteristic is needed to be analyzed. The electrical characteristic of such a DFIG[9] unit developed on Matlab is briefed below;

A doubly fed induction machine is basically a standard, wound rotor induction machine with its stator windings directly connected to the grid and its rotor windings connected to the grid and its rotor windings connected to the grid through a converter. The AC/DC/AC Converter is divided to two components: the rotor side converter and the grid side converter. These converters are voltage-sourced converters that use force commutated power electronic devices to synthesize an AC Voltage from a DC source. A capacitor connected on the DC side acts as the DC voltage source. A coupling inductor is used to connect the grid side converter to the grid. The three phase rotor winding is connected to the rotor side converter by slip rings and brushes and the three phase stator windings are directly connected to the grid. The control system generates the pitch angle command and the voltage command signals Vr and Vgc for the rotor and grid side converters respectively in order to control the power of the wind turbine, the DC voltage and the reactive power or the voltage at the grid terminals.

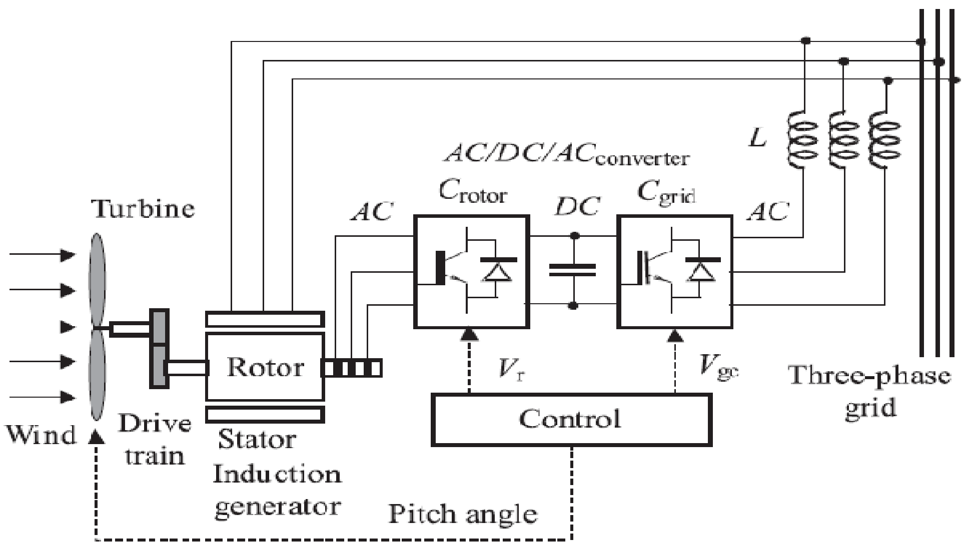

Figure 2: Wind Energy Conversion System.

Figure 3 shows the Power flow in a DFIG [9]. Generally the absolute value of slip is much lower than 1 and consequently the rotor electrical power output Pr is only a fraction of stator real power output Ps. Since the electromagnetic torque Tm is positive for power generation and since Ws is positive and constant for a constant frequency grid voltage, the sign of Pr is a function of the slip sign.

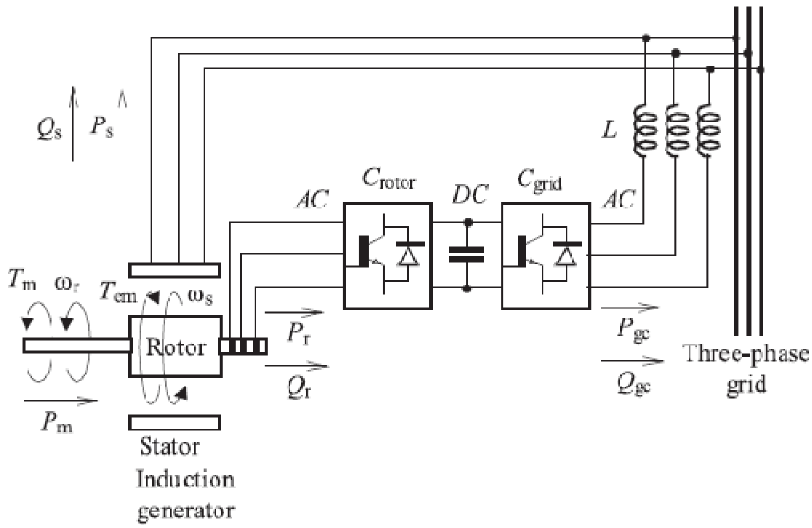

Figure 3: Power flow in a DFIG.

In steady state for a lossless AC/DC/AC converter Pgc is equal to Pr and the speed of the wind turbine is determined by the power Pr absorbed or generated by the rotor side converter. By properly controlling the rotor side converter, the voltage measured at the grid terminals can be controlled by controlling the grid side converter DC bus voltage of the capacitor can be regulated.

Wind Farm Interface

For the interfacing of the designed DFIG[9] unit into a distributed wind farm system a distributed wind farm is considered. Integrating wind power in the European power systems is winning recognition as a valuable option for power generation. With a total of more than 20.000 MW of installed wind power capacity, more than the half of the worldwide energy production from wind power is located in Europe. The huge success of this renewable and environmentally friendly energy source and the respective energy output has to be handled by the Continental European transmission system operators (TSO) in their day-to-day operation of the European Among the RES in the sense of the Directive figures also electricity produced from wind power [2] plants, which has begun to play an important role in the generation mix of several EU member states.

Wind power– overall availability of 20% by nature, wind energy [1] is only available as variable power depending on the weather conditions that may range from calm to stormy conditions. Based on the operational experience gained so far the following can be stated with regard to the power contribution of wind power plants (WPP):

a. An average of 20 per cent of the total wind power installed in a control area was available for electricity generation over the year.

b. For two thirds of the year less than 20 per cent of the installed power was available for electricity generation.
c. For one third of the year, less than 10 per cent of the capacity was available for electricity generation. This was particularly the case in peak consumption periods.

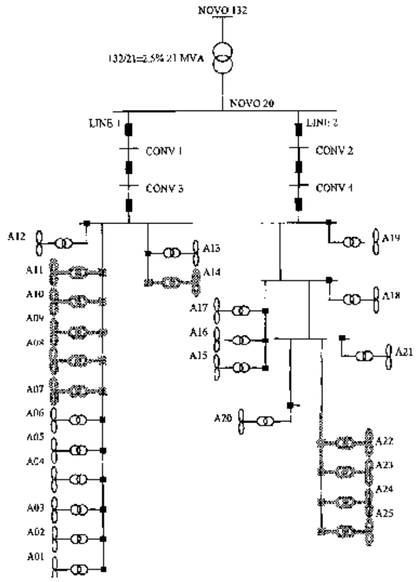

Figure 4: A generic wind farm topology used.

The considered wind farm consists of 25 wind energy [1] converters (WEC) with a nominal capacity of 750 kW each. 15 WEC's are of a conventional design (fixed speed, asynchronous generator directly coupled to the grid). The remaining 10 units are equipped with electronic power converters allowing variable speed operation and perfect control of active and reactive power (see below). This uncommon combination of technologies offers new Opportunities for wind farm operation and control.

The variable speed WEC's show a slightly higher power Output at lower wind speeds. This fact has been taken into account when allocating the particular WECs in the wind farm, i.e. the fixed speed WEC's have been erected at the sites with the best wind conditions. Figure.4 shows the topology of the wind farm and the distribution [3 5] of the two WEC types.

The internal voltage in the wind farm is 20 kV. At the point of common coupling (PCC) the wind farm is connected to a 132 kV line.

1. Cases without variable speed WEC's: all 25 turbines operating as fixed-speed WEC's.
2. Cases with the variable speed WEC's at different locations in order to evaluate their final locations.

Controlling Operation for Distributed Wind Farm

The constant speed wind farm can stay connected during the voltage dips that have been applied. The high amount of reactive power that is required by this wind farm during voltage disturbances can be problematic. The Cluster Controlled wind farm (CSS-CC) can handle voltage dips if a resistor is placed in parallel to the dc-link capacitor and the surplus of energy during the voltage dip is dissipated.

Wind farms [6] using doubly fed induction machines (VSP-DFIG) are the most problematic concept when voltage dips are considered. A solution is to provide a controlled by-pass for the high currents in the rotor. In the variable speed pitch wind farm with permanent magnet generators (VSP-PM) good voltage dip ride-through is achieved.

The wind farm types use different turbines and different control methods, viz.:

- Constant Speed Stall turbine with directly coupled Induction Generator (CSS-IG, reference case):
- Constant Speed Stall turbine with Cluster Controlled induction generator operating in variable speed mode (CSS-CC);
- Variable Speed Pitch turbine with Doubly Fed Induction Generator (VSP-DFIG);
- Variable Speed Pitch turbine with Permanent Magnet generator and full converter (VSPPM).

The response of a wind farm to a grid frequency dip (5 Hz, 10 sec) strongly depends on the presence of a converter. A full converter, in the case of the CSS-CC and VSP-PM wind farms [6] decouples the turbines from the disturbance. But also the system with a partial converter (VSPDFIG) is hardly affected by the frequency dip due to the effective adjustment of the rotor currents by the rotor converter. The constant speed system on the other hand has serious problems with a frequency dip and the corresponding voltage dip: depending on the depth and the conditions at the start of the dip, current, power and reactive power peaks may exceed rated values and may lead to a wind farm shut down.

The farm with constant speed stall turbines and directly connected induction generators (CSSIG) can stay connected during the voltage dips that have been applied (30%-10 sec, 50%-0.5 sec and 85%-0.2 sec). High currents are flowing during the voltage drop. Due to the high thermal capacity of the induction machine these currents will be no problem. The currents may trigger protective devices in the grid. The high amount of reactive power that is required by the wind farm during voltage disturbances can be more problematic. When the dip lasts too long this may lead to voltage collapse.

The Cluster Controlled wind farm (CSS-CC) can handle voltage dips if a resistor is placed in parallel to the dc-link capacitor and the surplus of energy during the voltage dip is dissipated. A possible solution is to limit the high currents in the rotor by providing a by-pass over a set of resistors connected to the rotor windings.

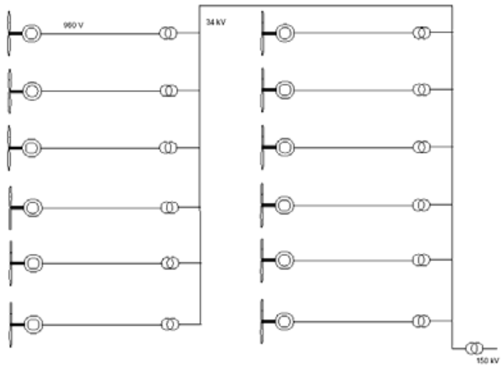

Figure 5: wind farm: electrical layout of a string of 12 CSS turbines.

The reactive power [11] demand of the turbines increases during the gust and is not supplied by capacitors but by the cables connecting the farm to the HV grid.

It can be profitable to absorb (part of) the reactive power production of the cables by the wind farm.

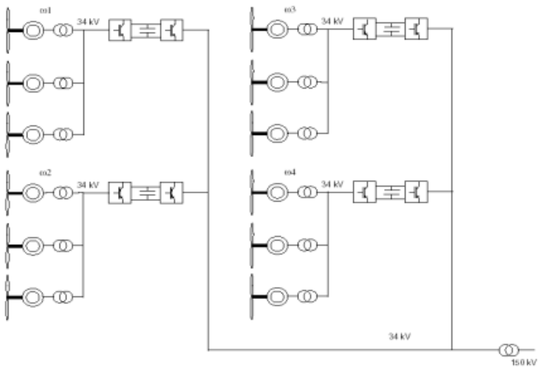

Figure 6: electrical lay out of four strings of 3 cluster-controlled turbines.

Figure shows the layout of a string of the near shore wind in cluster-controlled mode. The string is divided into four clusters of three wind turbines [8 9 10] each, connected to a single back-to-back [1] converter. The converters are connected through 34 kV submarine cables to the 34/150 kV transformer in the transformer station on shore. For the cluster controlled wind turbine, power limitation by either stall or pitch control can be chosen. In principle, both options are technically feasible. The cluster controlled wind farm in this evaluation will be based on a constant speed stall turbine (CSS-CC). If a variable speed turbine is chosen, a modification of the pitch control is required, especially if an attempt is made to increase efficiency by blade pitching below rated speed wind speed. Speed control of a cluster will be based on measured wind speed.

The turbine speed is dictated by the frequency of the rectifier (turbine side converter). Since these results in a reduced frequency in the stator of the induction machine, the amplitude of the stator voltage is reduced proportionally to this frequency. This is necessary since the stator impedance is proportional to the stator frequency and a decrease in frequency would otherwise lead to high currents and possibly the activation of the thermal protection. A feed forward controller on the turbine side converter, which directly sets the amplitude of the voltage, determines the stator voltage.

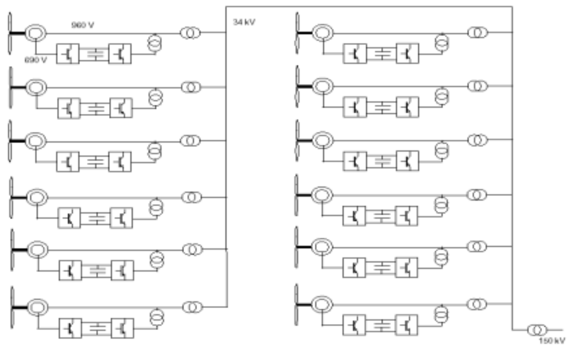

Figure 7: electrical layout of a string 12 DFIG turbines.

Above figure gives the layout of a string of 12 turbines equipped with doubly fed induction generators. Normal operation of this wind farm is demonstrated by the response to a wind gust passing through the farm. The AC-DC converter on the generator rotor controls the generator torque and the reactive power of the stator (reactive power set point zero) by adjusting the d- and q-current in the rotor. The grid side AC-DC converter controls the DC-voltage and the reactive power to the grid (i.e., set point zero, corresponding to a practically zero reactive power) by adjusting the d- and q-current to the grid. The frequency deviations are small, in spite of the relatively small rotating mass in the grid. Consumer load is constant and the synchronous machines adjust the exciter voltage to keep the grid voltage constant.

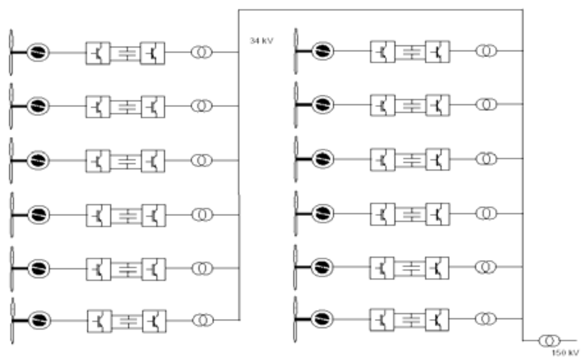

Figure 8: Electrical layout of a string of 12 PM turbines.

Above figure gives the layout of a string of 12 turbines equipped with permanent magnet generators. Normal operation of this wind farm is demonstrated by the response to a wind gust passing through the farm. The AC-DC converter on the generator controls the generator torque and the reactive power of the stator (reactive power set point zero) by adjusting the d- and q-current in the stator.

The grid side AC-DC converter controls the DC-voltage and the reactive power to the grid (reactive power set point zero) by adjusting the d- and q-current to the grid. The synchronous machine adjusts the power to maintain the grid frequency. The frequency deviations are small. Consumer load is constant and the synchronous machine adjusts the exciter voltage to keep the grid voltage constant. The resulting modifications made by the Manufacturers lead to more reliable wind turbine systems and more favorable field deployments.

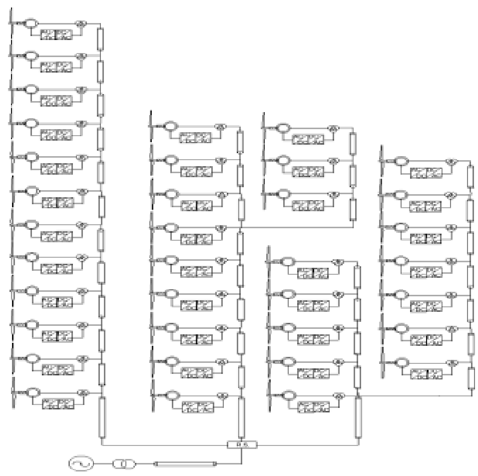

Figure 9: Near Shore Wind Farm layout.

Above figure gives the Near Shore Wind Farm layout. The farm consists of three sets of twelve 2.75MW turbines connected by three cables to the 150 kV substations. The cables in the farm and to shore are rated at 34 kV. In the farm two types of cables are used, depending on the loading at a given location. For the connection from the wind farm to the transformer in the substation also two types of cables are used, one for the submarine section of the route and a second type for the on-land route. Between the two sections, a relay station is located.

Unit Switching Algorithm for Wind Farm Application

Let D_L = Demanded Load

F_{node}= Fixed node generating units

N = Number of fixed WEC's

n = Number of variable WEC's

E_g= Extra generating capacity

N_g = Maximum fixed WEC's generating capacity
t = Number of nodes switched on
P_R = current generation capacity

Case(i) Full wind
In full wind case, there are two condions
a) D_L<F_{node}generating capacity(t = D_L /N
b) D_L>F_{node}generating capacity(t =N + v)

if D_L<F_{node}generating capacitythen
t = D_L /N
if D_L>F_{node}generating capacity
Fg=D_L-F_{node} generating capacity
In this case have two cases
ifE_g>1/2(maximum generating capacity of each WEC)
then
V=E_g/ n i.e., t=N + E_g/ n
else
E_g< 1/2(maximum generating capacity of each WEC)
then
V=1 i.e., t=N + 1
Only one variable WEC is sufficient.

Case(ii)Variable wind
In variable wind case the current WEC's farm are not able to compensate the demanded load at variable wind speed to over come this limitation in this work the proposed switching scheme able to deliver a constant demanded load under variable wind speed .

Under variable wind speed, two conditions exist,
a) D_L<F_{node}generating capacity
b) D_L>F_{node}generating capacity
If D_L<F_{node}generating capacity
Running generation due to fixed nodes
the current generation capacity(P_R) is proportional to wind speed(W_S)
P_R <F_{node}generating capacity
Then compare with demanded load
If D_L< P_R
Then
t=N
else
D_L > P_R
Fg=D_L-F_{node} generating capacity
In this case have two cases
ifE_g>1/2(maximum generating capacity of each WEC)

then
$V=E_g/n$ i.e., $t=N+E_g/n$
else
$E_g<$ 1/2(maximum generating capacity of each WEC)
then
V=1 i.e., t=N + 1
Only one variable WEC is sufficient.
if $D_L>F_{node}$generating capacity
$D_L > P_R$
$Fg=D_L-F_{node}$ generating capacity
In this case have two cases
if$E_g>$1/2(maximum generating capacity of each WEC)
then
$V=E_g/n$ i.e., $t=N+E_g/n$
else
$E_g<$ 1/2(maximum generating capacity of each WEC)
then
V=1 i.e., t=N + 1
Only one variable WEC is sufficient.

Analysis of Total Power & Losses

A maximum output control of wind power [2] generation system considering loss minimization of machines. The wind turbine has its own optimum rotational speed, which produce the maximum power conversion for give dimension and wind speed. Even at this optimum speed, the generator cannot produce the maximum output power due to the useless machine loss. In general, decreasing the flux level, resulting in the significant reduction [3] of the core loss, can reduce the machine loss. For vector controlled induction machine drives, the d-axis current controls the excitation level and the q axis current controls the generator is controlled according to the variation of the wind speed in order to produce the maximum output power. The generator reference speed is adjusted according to optimum tip-speed ratio. The generated power flows into the utility grid through the back-to-back PWM converter. The grid-side converter controls the dc link voltage and the line-side power factor by the q-axis current control, respectively.

This method is applied to the flux control of the cage-type induction generator for grid connected wind power systems. The generator is operated in indirect vector control mode, where the d axis current controls the flux level and the q-axis current controls the machine speed which is determined so as to capture the maximum energy from the wind. For grid connection, a back-to-back PWM [1] converter is used between the machine terminal and the grid. The grid-side converter is also controlled in d-q vector frame. The q axis current is controlled to keep the dc link voltage constant and d-axis current is controlled to zero for unity power factor.

According to the aero dynamic characteristics of wind turbine blade, there is an optimum rotating speed to give maximum wind energy capture. The theoretical power obtainable from the wind passing through a circular area is

$$P_{air} = 0.5\rho A v^3$$

The power conversion coefficient of the rotor is defined as the ratio between the mechanical power available at the turbine shaft and the power available in the wind. Neglecting the friction losses, the mechanical power available to be converted by generator is given by

$$P_m = 0.5\rho C_p v^3$$

The power conversion coefficient is a function of the tip speed ratioλ, which is defined as

$$\lambda = \frac{\omega_m}{v} R$$

Torque of wind turbine (T_{wt}) = (0.5)*(ρ)*(π)*(R_{wt})*(R_{wt})*$(V)^3$*(C_p)/ (ω)

When a synchronous machine is operated as a generator, a prime mover is required to drive the generator. In steady state, the mechanical torque of the prime mover should balance with the electromagnetic torque produced by the generator and the mechanical loss torque due to friction and wind age.

$$T_{pm}=T_{em}+T_{loss}$$

Multiplying the synchronous speed to both sides of the torque equation, we have the power balance equation as

$P_{pm}=P_{em}+P_{loss}$

$P_{pm}=T_{pm}\,(t)_{syn}$ is the mechanical power supplied by the prime mover

$P_{em}=Tw_{syn}$ is the electromagnetic power of the generator

$P_{loss}=T_{loss}(t)_{syn}$ is the mechanical power losses of the system.

The electromagnetic power is the power being converted into the electrical power in the three phase stator windings.

$$P_{em} = T\omega_{syn} = 3E_a I_a \cos\varphi_{E_a I_a}$$

Where ø is the angle between phasors$E_a$and I_a.

For larger synchronous generators, the winding resistance is generally much smaller than the synchronous reactance and thus the per phase circuit equation can be approximately written as

$$V_a=E_a-jX_sI_a$$

Active Power (P) = (V_r)*(V_r)*(cos (φ)) / (Z_r)

Reactive Power (Q) = (V_r)*(V_r)*(sin (φ)) / (Z_r)

Stator cupper losses: $i_{ds}^2R_s + i_{qs}^2R_s$

Rotor cupper losses: $i_{dr}^2R_s + i_{qr}^2R_r$

Stator iron losses: $K_h w_e i_s^2 + K_e w_e i_s^2$

Rotor cupper losses: $K_h w_{sl} i_r^2 + K_e w_{sl} i_r^2$

Simulation Results

For the evaluation of the developed approach the designed system is tested under variable wind speed condition, the obtained case study is as outlined below,
At load = 300MW.

S.no	Wind speed(km/hr)	Power Generation(MW)
1	4	19.395
2	5	21.802
3	6	30.654
4	7	33.558
5	8	36.98
6	9	44.967
7	10	51.761
8	11	55.718
9	12	62.996
10	13	67.731
11	14	66.412
12	15	73.522
13	16	79.84
14	17	82.832
15	18	90.181
16	19	91.345
17	20	99.997
18	21	100
19	22	100
20	23	100
21	24	100
22	25	100
23	26	100

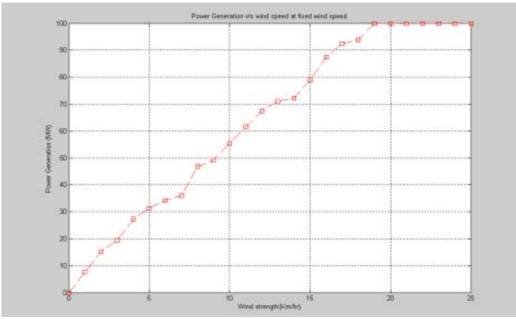

Figure 10: Generation / Wind speed at fixed wind speed.

The simulation of developed WEC's shows the generation of power at maximum wind speed due to fixed and variable units for a load of 300MW.It can be observed that the power generation due to maximum wind strenght generates the rated power linearly and maintain uniform generation once the units are reached for rated power generation, as shown in figure 10.

S.no	Wind speed(km/hr)	Power Generation(MW)
1	4	41.716
2	5	42.42
3	6	46.263
4	7	36.696
5	8	49.682
6	9	53.624
7	10	44.846
8	11	46.832
9	12	58.94
10	13	60.827
11	14	62.275
12	15	66.31
13	16	67.447
14	17	73.252
15	18	66.582
16	19	71.291
17	20	70.695
18	21	70.534
19	22	73.717
20	23	87.759
21	24	82.603
22	25	86.992
23	26	96.206

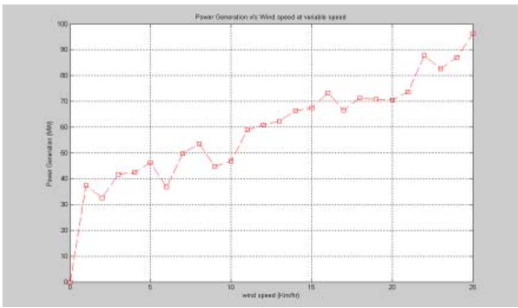

Figure 11: Power Generation / Wind speed at variable wind speed.

The power generation due to fixed and variable WEC's at randomly varying wind strength. The figure11 shows that to random increment and fall in wind speed results in non-linear generation of power resulting in less dependent or static power generation for load delivery. It is observed that when the wind is at higher speed th power generation should high to rated generation and fall down once wind speed reduces. This variation in power generation gives the limitation in linear load compensation due wind energy.

S.no	Wind speed(km/hr)	Power Generation(MW)
1	4	41.716
2	5	42.42
3	6	46.263
4	7	36.696
5	8	49.682
6	9	53.624
7	10	44.846
8	11	46.832
9	12	58.94
10	13	60.827
11	14	62.275
12	15	66.31
13	16	67.447
14	17	73.252
15	18	66.582
16	19	71.291
17	20	70.695
18	21	70.534
19	22	73.717
20	23	87.759
21	24	82.603
22	25	86.992
23	26	96.206

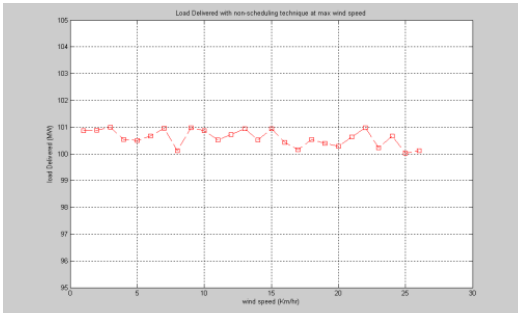

Figure 12: Load Delivered with non-scheduling technique at max wind speed.

The power delivered due to maximum wind speed under non scheduling of desingnd WEC's it is observed that load delivered due to maximum wind speed remain almost linear to rated power generation resulting in constant delivery of power with out any external scheduling of these WEC's as shown in figure12.

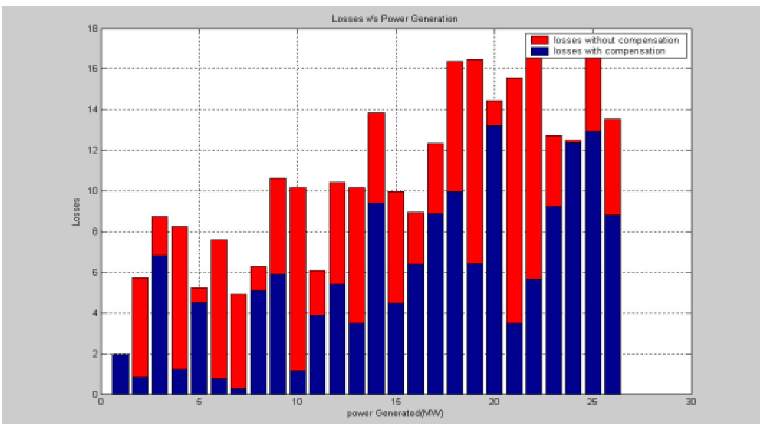

Figure 13: Losses(with& with out rotor and grid control) / Power Generation.

The losses generated due to the variation in switching the power generated unit compensating the demanded load under variable wind condition. The figure5.6 shows the compensation of losses due to power generation with the loss compensation technique and the reductionin amount of loss due to the rotor/grid control mechanicsum. It can be observed from the above figure that losses due to increase in generated power could be mminimised to 30-70% by applying the proposed control strategy.

Conclusion

An efficient scheduling scheme for WEC's is proposed with loss compensation technique for fixed and variable wind conditions have been studied. Also, the proposed schemes are appiled for a10 nodes WEC's with 5 fixed and 5 variable nodes for constant load delivery. From the above work, the following implementation and conclusions are made:

1. The wind farm consists in wind energy converters (WEC) with a nominal capacity of 100MWeach.
2. 5WEC's are of a conventional design fixed speed, asynchronous generator directly coupled to the grid. The remaining 5units are equipped with electronic power switching allowing variable speed WEC's to incorporate with fixed wind WEC's terminals for variable wind load compensation.
3. The proposed switching logic for fixed / variable WEC is developed to compensate demanded load under variable wind condition. The active and reactive power generations are governed for meeting the demanded load based on dynamic scheduling of fixed wind WEC with variable wind WEC.

From all the above observation it is concluded that under variable wind speed the demanded load can be compensated by incorporating dynamic switching with rotor / grid control logic for fixed / variable wind WEC's

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