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풍력 발전단지의 출력 지령값을 고려한 계통 연계 운영 방안

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A New Control Scheme of Wind Farm Considering P,Q References

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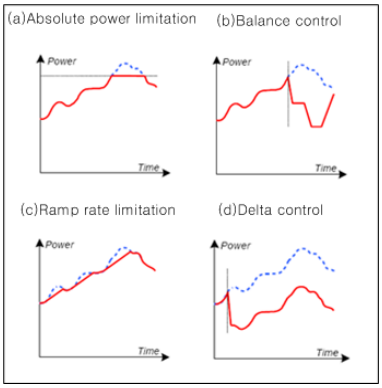
Abstract - At the moment, the control ability of wind farms is a prime research concern for the grid integration of large wind farms, due to their required active role in the power system. As more wind turbines are installed, the power from wind energy will start to replace conventional generation units and its influence on power systems cannot be neglected. Besides, because of the intermittent nature of wind the output power of wind turbines fluctuates according to wind speed variation. Especially an isolated power system with small capacity such like Jeju needs more systematic solutions and regulations(grid code). This paper presents the idea of approach for centralized operating wind farm strategy to regulate the wind farm power production to the reference power ordered by the system operator. The doubly fed induction generator(DFIG) can control active and reactive power in feasible range. So wind farm comprised of DFIG has the possibility of a controllable component in the power system. The presented wind farm control has a hierarchical structure with both a wind farm control level and a wind turbine control level.

1. Introduction

because of the intermittent nature of wind the output power of wind turbines fluctuates according to wind speed variation and As more wind turbines are installed, its influence on power systems cannot be neglected. Especially an isolated power system with small capacity such like Jeju can be seriously influenced by wind power variation. This leads to the situation that sooner or later, the wind farms will have to behave as active controllable components in the power system[1]. The characteristic of DFIG can support reliable operation of power system by controlling in order output of DFIG to the reference power in changing wind speed. This paper presents the idea of centralized operating of wind farm comprised of DFIG to regulate the wind farm power production to the reference power ordered by the system operator .According to this strategy, control of active power output of wind farm comprised of DFIG is simulated in PSCAD/EMTDC.

2. Interconnection of wind farms

For the future it is important to get a view on how systems with larger shares of wind power can be operated and designed in order to get an efficient integration without violating the system security [4]. Therefore, high wind power penetration demands that wind farms be compliant with rules and operation guidelines of international grid codes.At present, many nations in the world have each national grid code [2]. Most of grid codes restrict operation of wind turbines if necessary when it threatens the grid. But, it should be noticed that Jeju is an isolated area with small capacity. Therefore, In order to operate the large wind farms in an isolated area such like Jeju more strict and systematic solutions and regulations will be needed. Furthermore, foreign countries with high wind power penetration have their own operational control strategy. Especially Western Denmark have additional active power control strategies[3]. For example, there are several active power control functions in Denmark (Fig.1). These power controls are all implemented in the Horns Rev wind farm. And in order to operate wind farms reliably, Jeju needs these control functions for active power output limitation and wind farm's operation as a acontrollable component is also important.

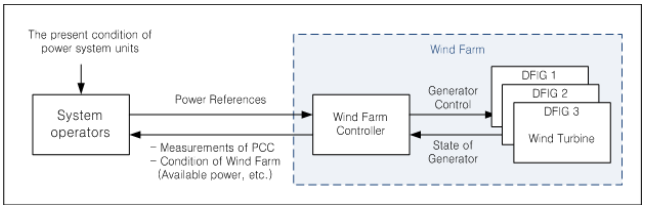


<Fig 1> Power control options in the Horns Rev wind farm

3. Centralized power control

3.1 configuration of wind farm and wind turbines

The wind farm consists of three wind turbines each of variable speed DFIG. and wind farm contoller in order to control sub-wind turbine level. For the reliable .operation of wind farm in the power system, system operator can order power references to the wind farm considering situation of system. First, system operator should gather the information from the wind farm and conventional generator units, and analyze the state system condition. And then, system operator should send proper power reference signals to the both sides. In this paper, DFIG consisting wind farm applied control scheme to regulate total active power output[4].



<Fig 2> organization of wind farm

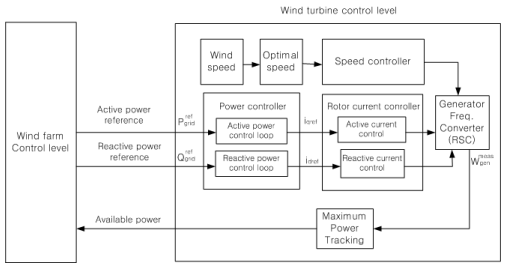
3.2 Control system of a wind farm

The presented wind farm control has a hierarchical structure with both a wind farm control level and a wind turbine control level. The wind farm control level behaves as a single central unit. It controls the power production of the wind farm by sending out active and reactive power references to the wind turbine control level. These power references are prepared in the wind farm control level based on several measurements in the point of common coupling (PCC) and on the available power of each individual wind turbine. The wind turbine control level addresses the local control system of each single wind turbine and ensures that the references sent from the wind farm control level are reached.

3.2.1 Wind turbine control level

Fig 3 shows the controllers of each wind turbine control level in more details. Power controller receives power reference from wind farm control level. And then, it makes rotor current signal and sent it to the rotor current controller. Then, Rotor current controller controls active and reactive power using received rotor current signal. Speed controller assures the generator speed operation by acting on the pitch angle. And Wind turbine control level also makes the available power signal and send it to the wind farm control level.

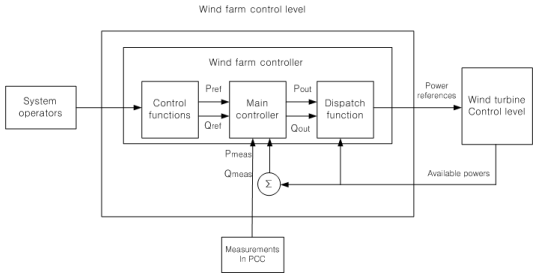
Wind turbine level has two operation modes. One is independent operation mode and the other is reference following mode. When the wind farm operate in independent mode, power output of wind farm fluctuate with wind speed but loss of energy will reduce while reference following mode will help reliable operation of wind farm. System operator can order each operation mode by considering system facilities condition and wind farm operation condition.



<Fig 3> Wind turbine control level

3.2.2 Wind farm control level

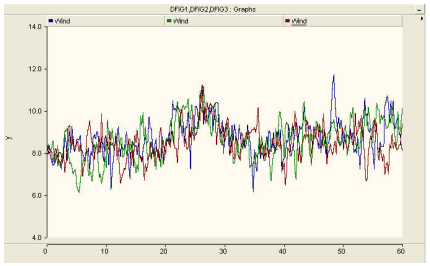
The goal of the wind farm controller is to control centrally the active and reactive power injected by the whole wind farm into the grid. Based on received demand from system operator, wind farm control level applying control functions. And send the output signal to the main controller. And then, main controller makes demand signal for whole wind farm based on several measurements in the point of common coupling (PCC) and on the available power of each individual wind turbine. Dispatch function makes reference signal for each wind turbine. There are different ways to design the dispatch function but the one presented in this paper simply distributes the power references to the wind turbines $P_{ref}^{WTi}, Q_{ref}^{Wi}(i=1:n)$ based on a proportional distribution of the available active and reactive power.



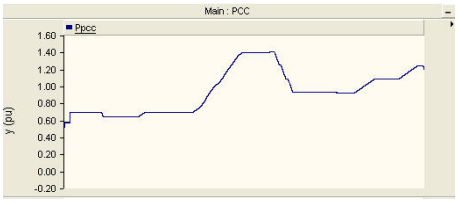
<Fig 4> Wind farm control level

4. Simulation

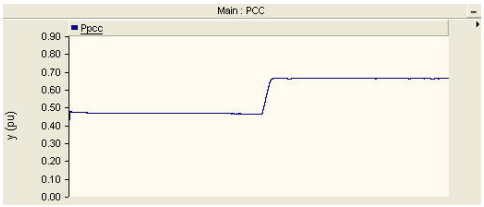
Control ability of active power output of wind farm comprised of three DFIG wind generators is simulated in PSCAD/EMTDC. Each generator has different wind speed which is on an average of 8m/s. Fig 5 shows wind speed condition. based on this wind speed condition, independent operation mode and reference following mode are simulated. First when the wind farm operate in independent mode, wind generator follows available power. But unlike variation of wind speed(fig 5) Fig 6 shows active power output of each generator because DFIG directly controls its output power. In case of reference following mode, wind turbine control level limits power output to reference signal from wind farm control level. To simulate this capability, active power reference for the whole wind farm is set to 0.5 p.u. the first 30s and 0.7 p.u. between 30 and 60 s considering available power. Fig 7 shows the active power output of PCC. Notice that the output power is controlled according to reference signal from system operator and it means that wind farm can behave as a controllable component in the power system.



<Fig 5> Wind speed condition



<Fig 6> Active power ouput of PCC - independent operation mode



<Fig 7> Active power ouput of PCC- reference following mode

5. Conclusion

This paper presents the idea of approach for centralized operating wind farm strategy to regulate the wind farm power production to the reference power ordered by the system operator and control of active power output of wind farm comprised of DFIG is simulated in PSCAD/EMTDC. For the reliable .operation of wind farm in the power system, system operator can order power references to the wind farm considering situation of system. Based on these references, wind farm controls whole power output. The presented wind farm control has a hierarchical structure with both a wind farm control level and a wind turbine control level. With presented scheme, wind farm can behave as a controllable component in the power system.

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