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A Protective Scheme for Wind Power Plant Using Co-ordination of Overcurrent Relay

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Abstract: ***Wind farms are one of the most indispensable types of sustainable energies which are progressively engaged in smart grids with tenacity of electrical power generation predominantly as a distribution generation system. Thus, rigorous protection of wind power plants is an immensely momentous aspect in electrical power protection engineering which must be contemplated thoroughly during designing the wind plants to afford a proper protection for power components in case of fault occurrence. The most commodious and common protection apparatus are overcurrent relays which are responsible for protecting power systems from impending faults. In order to employ a prosperous and proper protection for wind power plants, these relays must be set precisely and well coordinated with each other to clear the faults at the system in the shortest possible time. This paper indicates how the coordination of overcurrent relays can be effectively attained for wind power plants in order to protect the power constituents during fault incidence. Through this research Matlab/Simulink as a powerful simulation software have been applied to model a wind farm and achieve precise setting for coordination of overcurrent relays.***

Keywords: Overcurrent Relay, Coordination of Overcurrent Relay, Wind Power Plant, Power System Protection

1. Introduction

Wind power plants are one of the most crucial types of renewable energies which are increasingly employed in smart grids with purpose of power generation especially as a distribution generation system. Hence, the proper protection of wind plants is an enormously significant aspect which must be taken into consideration when designing the wind plants to not only provide a suitable protection for the power components but also maintain the power generation perpetually in case of fault. The most important and common protection systems are overcurrent relays which can protect the power systems from impending faults. In order to implement a successful and proper protection for wind power plants, these relays must be set accurately and well coordinated with each other to clear the fault at the system in the shortest possible time. This project demonstrates how the coordination of overcurrent relays can be successfully achieved in wind power plants in order to maintain the power generation during fault and protect the power components[2],However an overall protection scheme has yet to come to solve the protection crisis in wind plants. One of the most important studies of power quality and power system protection in wind plants is providing adequate and continual power to the loads, therefore in order to ensure having perpetual power from wind farms, wind plants must feed grids continually. One way of meeting this phenomena is applying a proper protection in the system that in case of fault, only the section of faulty feeder is disconnected from the system and the rest of healthy parts are kept connected to the system. By using overcurrent relays (OCRs) as a protection system and applying an accurate coordination in wind plants, not only in case of fault, the power components are protected from damages from excessive currents but also continual power flow is fed to the grid and superb power quality is provided by wind power plants. This paper demonstrates how OCRs have been successfully used and properly coordinated in a wind power plant. The software which has been used is Matlab/Simulink which is known as one of the best simulation software for electrical engineers and researchers. All of the OCRs have been modelled and designed and the accurate settings have been selected to protect the wind plant.

2. Literature Review

From the rigorous review of related work and published literature, it is observed that In 2015, Yeonho Ok, Jaewon Lee and Jaeho Choi [1], presented *"Coordination of Over Current Relay for Sudden Rise of Input Energy in Renewable Power System".* described There are several new and renewable energy sources including hydro-, solar-, wind-power generation and etc., but the relay coordination is performed regardless of the characteristics of each new and renewable energy source. In this paper, the pickup and instantaneous current and the time delay of the overcurrent relay (OCR) is reviewed firstly, which was already coordinated for the wind power system. And the problem of frequent operation of OCR coordinated equally regardless of the characteristics of the renewable energy source is analyzed and an alternative is proposed.

NimaRezaei and Mohammad Lutfi and Othman [2], presented *"Coordination of Overcurrent Relays Protection Systems for Wind Power Plants".* has described Wind farms are one of the most indispensable types of sustainable energies which are progressively engaged in smart grids with tenacity of electrical power generation predominantly as a distribution generation system. Thus, rigorous protection of wind power plants is an immensely momentous aspect in electrical power protection engineering which must be contemplated thoroughly during designing the wind plants to afford a proper protection for power components in case of fault occurrence. The most commodious and common protection

apparatus are overcurrent relays which are responsible for protecting power systems from impending faults. In order to employ a prosperous and proper protection for wind power plants, these relays must be set precisely and well coordinated with each other to clear the faults at the system in the shortest possible time. This paper indicates how the coordination of overcurrent relays can be effectively attained for wind power plants in order to protect the power constituents during fault incidence. Through this research Matlab/Simulink as a powerful simulation software have been applied to model a wind farm and achieve precise setting for coordination of overcurrent relays

Mohammad KoochakianJazi, and Seyed Masoud Moghaddas Tafreshi [3], presented *"Design of a frequency control system in a microgrid containing HVAC".* has described The advent of smart grids and the growing procedure of controllable loads and tending to the demand response (DR) in small power systems have helped with new ideas, which can be used in the frequency stability of a microgrid. This paper presents a novel model for frequency control of a microgrid containing controllable load and renewable resources. The controllable loads used in this paper are such as heating, ventilation, and air conditioning, which change temperature based on frequency change. The microgrid is hybrid (AC/DC) and able to connect to and energy exchange with the utility grid.

Rehana Perveen, Soumya R Mohanty, NandKishor[4], presented "Optimal Coordination of Overcurrent Relay for Offshore Wind Farm Integrated to Onshore Grid with VSC-HVDC" has described Overcurrent(OC) relay is one of the most commonly used protective relays in the power system.

Coordination of overcurrent relays is a challenging task in the field of offshore wind farm (OWF). A reliable protection system is needed for transmitting large amountof power over long distances. An optimal relay coordination using overcurrent relay is used at four different points in the OWF. The optimal coordination of OC relay is carried out by the exploration of different meta heuristic algorithm such as Genetic algorithm (GA), Particle swarm optimization (PSO) and Gravitational search algorithm (GSA) algorithm. The formulation of objective function is accomplished by two variables such as time multiplier setting (TMS) and plug setting multiplier (PSM).Thus this multi-objective optimization is explored to minimize the operating time of the associated relay that exists in the ac side of OWF.

3. Analysis of Problem

The impressive growth in the utilization of wind energy has consequently spawned active research activities in a wide variety of technical fields. Moreover, the increasingly penetration of wind energy into conventional power systems highlights several important issues such as reliability, security, stability, power quality, etc. Among these issues, providing wind farms with the proper protection is quite essential. The essential benefits from the dedicated protection functions are to avoid the possible local damage resulting from incident faults and minimize the impact of these abnormal conditions on other sound parts of the network. This consequently enhances the reliability and dependability of the overall grid performance. These terms such as continuity, reliability etc. have recently received much attention due to the new de-regulation policies and marketing liberalization. On the other hand, wind farms are characterized with some unique features during their normal and faulty operating conditions. Different factors participate usually into these conditions such as the distributed generation concept, the own behavior of the induction generator, varying wind speed, etc. Moreover, the economic perspective plays a major role as well. This consequently highlights different challenges regarding the behavior of their protection and control schemes.

4. Objectives

1) To Model Overcurrent Relay For Wind Power Plant Protection.
2) To Design Wind Power Plant & Power System By using over Current Relays Protective Scheme.
3) To Simulate over Current Relays Protective Scheme & Analyse Results.

5. Overcurrent Relay Model For Wind Power Plant Protection

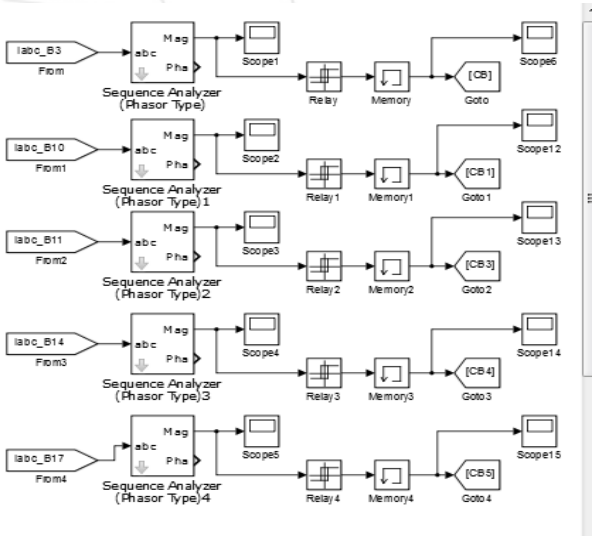

Figure 1: Overcurrent Relay Model

6. Design Simulink Model for Wind Power Plant

Matlab/Simulink as a powerful software has been used to model the wind plant, relays, set the relay settings and coordinate them well with each other. A typical wind power plant has been modelled in this paper and based on the load flow, OCRs using IEC standard has been designed, set and coordinated. The wind power plant modelled in this paper, consists of 5 wind turbines that each of them produce 2 MW. Their voltage and frequency are 575V and 60 Hz respectively. Transformers corresponding to each wind turbine has voltage ratio of 575V/25KV in star delta configuration where the star side is earthed. The last

Transformer corresponding to the grid has the voltage ratio of 25KV/110KV and delta star configuration where star is earthed. The transmission lines have 10 Km length each. The wind power plant model is illustrated in Fig 2. In this figure, since the protection area is the main scope of this paper, the breaker named by CB1, CB2… CB12 and the corresponding relays to each breakers, are shown by R1, R2 … R12.In order to set the relays and properly coordinate them, the exact value of current and short circuit current flowing through each CB should be derived. Fig 3. To Fig 7. Depicts the characteristic of current in Amper unit at each CB before, during and after fault. In this simulation, the total simulation time is 50s. A three phase fault has been imposed to each breaker at time 25 lasting for 5s.

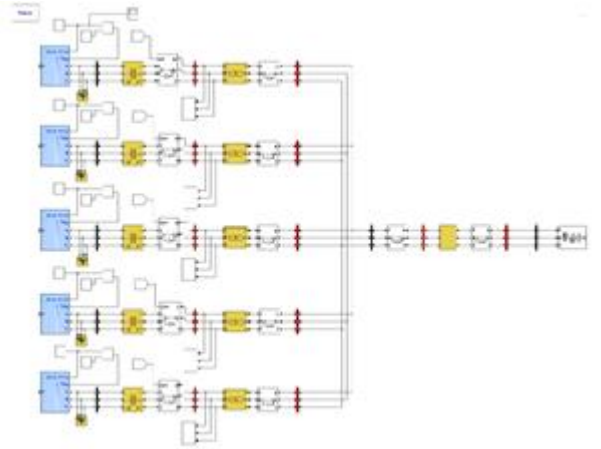

Figure 2: Simulink Model for Wind Power Plant

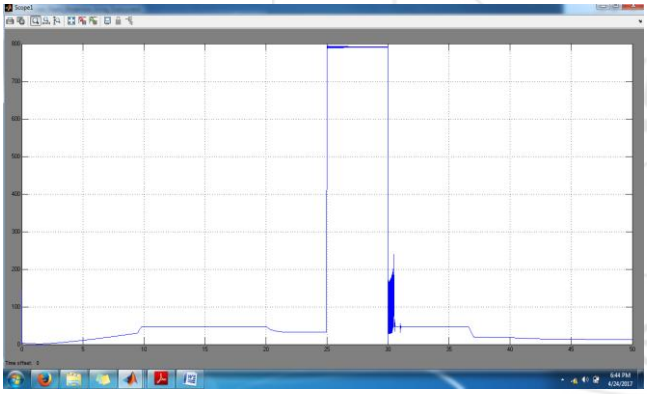

Figure 3: Load Flow through CB3 during Fault

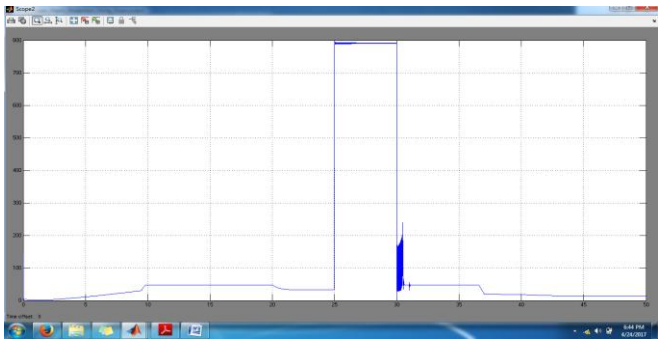

Figure 4: Load Flow through CB10 during Fault

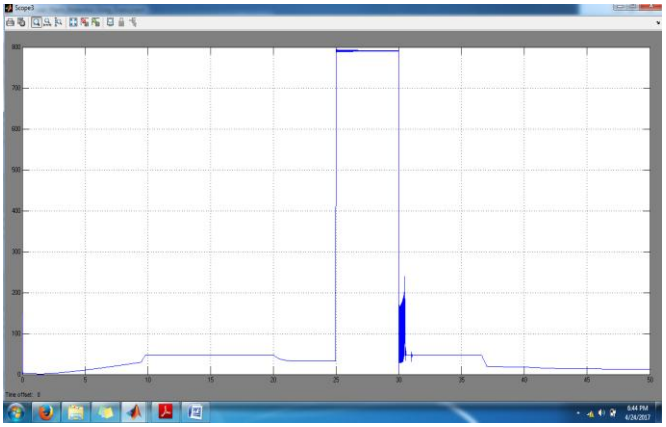

Figure 5: Load Flow through CB11 during Fault

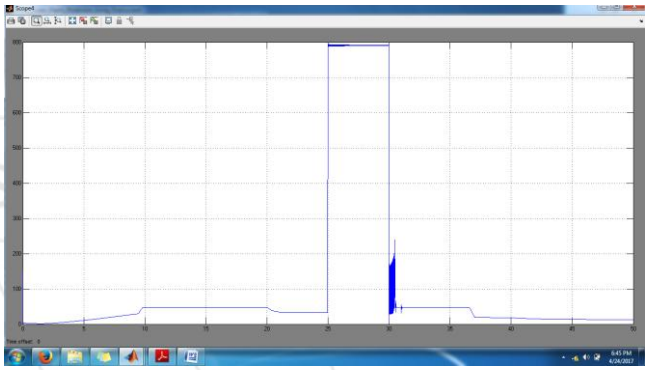

Figure 6: Load Flow through CB14 during Fault

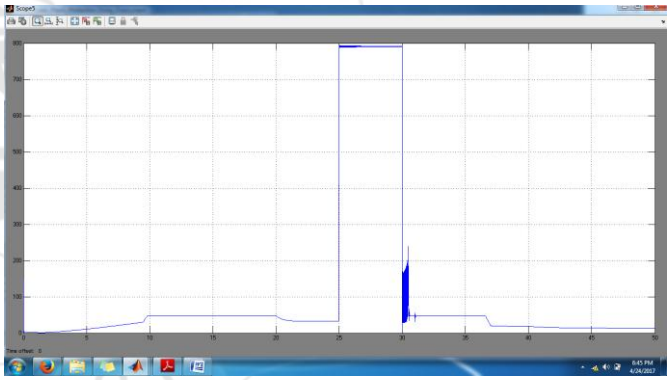

Figure 7: Load Flow through CB17 during Fault

7. Results & Discussion

After getting the required data for setting the relays, including exact value of load current and short circuit current at each CB, OCRs can then be modelled, set and coordinated. In order to get the best results with purpose of relays coordination, the exact value of short circuit current located near each CB should be extracted and based on the maximum load current, relays can be set. Fig 8. Illustrates the relays behaviour at each fault occurred from time 25 to 30 also Depicts theCBs operation corresponding the each relays.

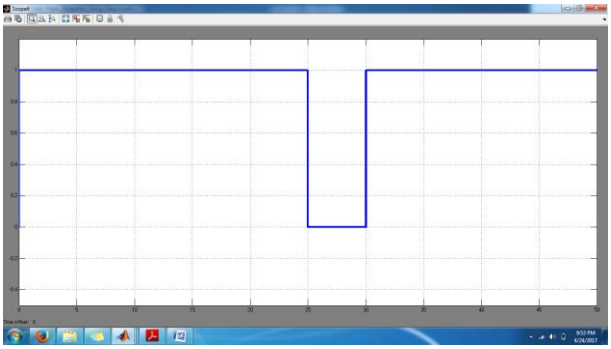

Figure 8: Relay Tripping during Fault

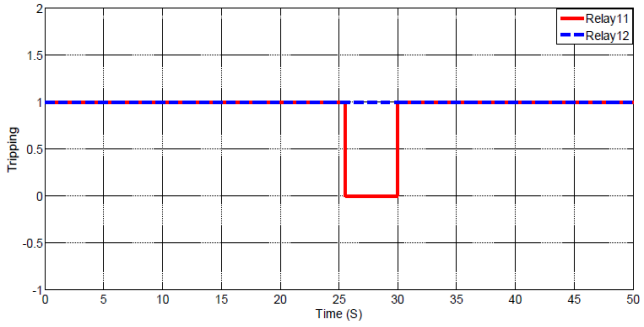

Figure 8: Relay11 Trips while Relay12 is Malfunctioning

Through the simulation results it is resulted that relays have been set accurately and are well coordinated with each other in order to protect the wind power plant. Thus OCRs can be considered as one of the best and most successful technique of protection for wind farms.

8. Conclusions

In this paper, a comprehensive protection for wind power plants has been successfully implemented by using OCRs. Three phase fault has been imposed at each CB and the settings for each relay have been conducted. Moreover all of the relays have been modelled based on IEC standards in order to provide proper protection to the system, prevent the damage from fault current to the power components, provide perpetual power to the grid and contribute to superb power quality. The results have shown that OCRs can be successfully employed for wind power plants and has proved to be effective, accurate, and be considered as the best method for protection.

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