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A NOVEL STABILITY ENHANCEMENT AND EFFECTIVE REACTIVE POWER CONTROL FOR STATCOM BASED WF AND MCF UNDER VARIOUS FAULT CONDITIONS

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ABSTRACT

Here in this paper presents a control strategy based on a static synchronous compensator (STATCOM) obtain both voltage control and damping enhancement of grid connected integrated 80 MW offshore wind form (OWF) and 40 MW marine current farm (MCF). The demonstration of the investigated Offshore Wind Farm is simulated by an equivalent wind turbine (WT) while an equivalent squirrel cage rotor induction generator (SCIG) driven by an equivalent marine current turbine (MCT) is employed to simulate the characteristics of the MCT. A damping controller of the STATCOM is developed by utilizing modal control theory to contribute effective damping characteristics to the investigated system under different operating conditions. A frequency domain control strategy based on a linearized system structure utilizing eigenvalue techniques and a time domain control scheme based on a nonlinear system model subject to various fluctuations are both employed to simulate the effectiveness of the recommended control approach. It can be finished from the gained responses that the recommended STATCOM combined with the designed with the damping controller is very effective to control the studied system under various voltage inequalities. The voltage changeability like the exterior three phase short circuit faults of the AC bus subject to the active power fluctuations of the studied system can also be effectively maintained by the suggested control strategy.

I. INTRODUCTION

Both wind energy and have been tied together. Water energy may contain energy yield by thermal, energy produced by wave, tidal energy of offshore wind, ocean current energy, etc. Generators driven by marine current turbine (MCT) coupled with offshore generators driven by wind turbine (WT) will become a new control strategy for energy production in the future. Since ocean cover more than 70% surface of the ground, a hybrid power generation system comprising both offshore wind farm (OWF) and marine current form (MCF) can be widely developed at the exact locations of the future. The detailed responses of stability improvement of power system utilizing STATCOMs and the damping controller design of STATCOMs were explained. The construction of generated output feedback linear quadratic controller for a STATCOM and a variable blade pitch of a wind energy conversion system to perform both controlling of voltage and mechanical power under grid connection or islanding conditions were illustrated. System designing and control strategy for fast load voltage regulation and reduction of voltage flicker using a STATCOM were illustrated in this paper. A new D STATCOM control algorithm enabling special control of positive and negative sequence currents was recommended and the algorithm was based on the developed mathematical structure in the coordinates for a D STATCOM operating under unsymmetrical conditions. An in depth examination of the dynamic performance of a STATCOM and a static synchronous series compensator (SSSC) utilizing digital simulation was explained. A STATCOM based on a current source inverter (CSI) was suggested, and the nonlinear structure of the CSI was changed to be a linear model through a new modeling control approach. The interfaced STATCOM Battery Support Storage System was accessible for the betterment of dynamic and transient stability and transmission control capability. The performance of the different FACTS/BESS arrangements was compared and provided experimental verification of the suggested controls on a scaled STATCOM /BESS system. A dynamic voltage control strategy based on a combination of SVC and STATCOM technology on a connected transmission system with IGs in a wind farm was investigated in this paper.

II. EXISTING SYSTEM MODELS OF THE STUDIED INTEGRATED OWF AND MCF

Fig. 1 demonstrates configuration of the studied integrated DFIG based OWF and SCIG based MCF with the recommended Statcom. The 80Mega Watt Off shore Wind Farm is characterized by a big comparable aggregated DFIG driven by an equivalent aggregated different speed WT through an similar aggregated gearbox. The 40-MW MCF is explained by a large equivalent aggregated SCIG driven by an equivalent aggregated variable-speed MCT through an equivalent aggregated gearbox. The Offshore form of wind type, the Tidal power produced the STATCOM and a local load are integrated to an AC bus that is fed to the onshore power grid through an offshore step-up transformer and undersea cables.

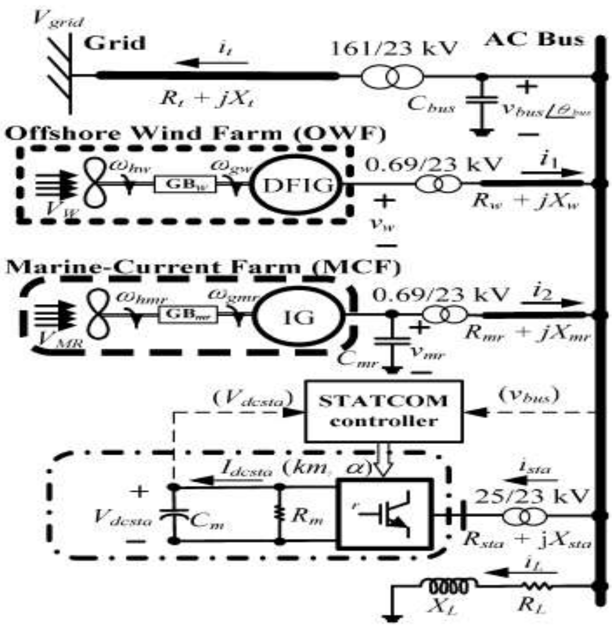

Fig.1 Configuration of the Integrated OWF and MCF with STATCOM

2.1 Wind Turbine

The mathematical power (In W) obtainable by a Wind Turbine can represented by

$$P_{\text{mw}} = \frac{1}{2}\rho_w \cdot A_{\text{rw}} \cdot V_W^3 \cdot C_{\text{pw}}(\lambda_w, \beta_w)$$

Where air density in kg/m^3, A_{rw} is the blade impact area measured in m^2, V_w is the wind speed measured in m/s, and Cpw is the power coefficient of the Turbine which integrated in the wind energy. The wind speed Vw is anticipated as the algebraic sum of a wind speed of base, a wind speed of gust, a wind speed of ramp, and a noise wind speed. The clear equations for these four wind speed components can be referred in this paper. The cut in, rated, and cut-out wind speeds of the examined WT are 4, 15, and 24 m/s, respectively. When Vw is smaller than the rated wind variations of the Turbine. When Vw is greater than Vwrated the pitch angle control system of the wind turbine activates and the pitch angle of the WT improves.

2.2 Mass-spring-Damper System and Induction Generator

The two inertia reduced order equivalent mass spring damper design model of WT integrated to the rotor shaft of the examined wind DFIG. The effect of the similar gearbox between the WT and the DFIG has been included in this control design

2.3 Power Converters of DFIG

The stator winding of the wind DFIG are directly integrated to the low voltage expanse of the 690V/23 kV boost transformer and the other side of the rotor side converter (RSC) integrated to the Doubly Fed Induction Generator 690V side, a DC link a grid side converter (GSC) and also a step up transformer.

For general operation of a wind DFIG in input AC side voltages of the RSC and the GSC can be completely controlled to obtain the goals of simultaneous output active power and reactive power control. Fig.2 demonstrates the control block diagram of the RSC of the examined DFIG.

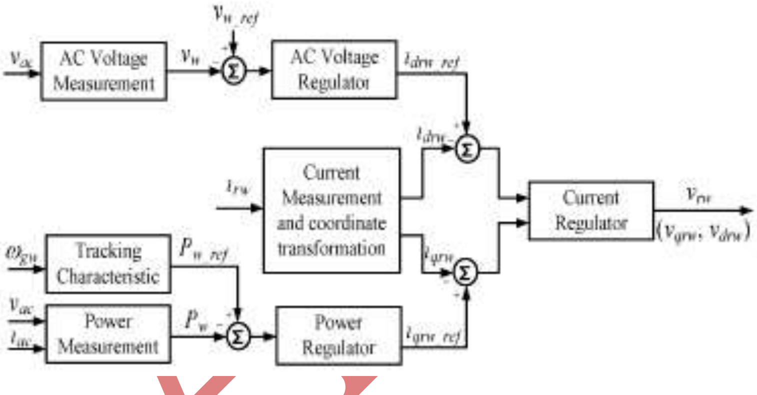

Fig.2 Control Block Diagram for the RSC of the DFIG

The desired voltage for the RSC is derived by maintaining the per unit q and d axis currents of the RSC. The control technique block diagram of the GSC as depicted in Fig. 3 which have to track the reference points that are calculated by controlling the DC link voltage at the setting value and maintaining the output of the GSCat unity power factor.

2.4 Marine-Current Speed and Marine-Current Turbine

The Marine current assumed to be driven by tide velocities, and the current velocity calculated by spring and neap tides. The tidal current speeds are existing at hourly intervals starting at 6h before high waters and ending 6h after. The various operating conditions of the studied MCT are 1, 2.5, and 4 m/s, respectively. When is higher than the esteemed speed, the pitch-angle sustains system of the MCT activates to limit the output power of the MCT at the regarded value. Since the employed turbine structure, pitch-angle control strategy, and mass-spring-damper model of the studied MCF are similar to the ones that are active in the OWF, some mathematical models employed in the OWF can be slightly changed to be used in the MCF except the parameters.

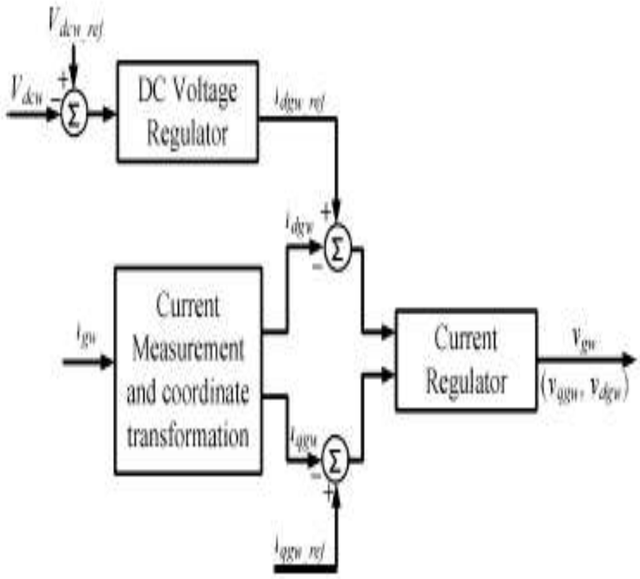

Fig.4 Control Block Diagram for the GSC of the DFIG

III. PROPOSED SYSTEM

3.1 Steady-State Analysis under Various Operating Conditions

The study state operating condition results of the examined system when Vw is improved from 4 to 24 m/s while V_{MR} is improved from 1 to 4 m/s.

3.2 Non Linear Model Simulations

Here in this segment utilizes the nonlinear system model developed to compare the damping characteristics committed by the recommended STATCOM joined with the designed PID damping controller on dynamic stability betterment of the examined system under a noise speed fluctuations, a marine current speed fluctuations, and a three external phase short circuit fault at the grid.

3.3 Noise Wind-Speed Disturbance

Here the examined system with and without the recommended STATCOM and the developed PID damping controller under the noise wind speed fluctuations. The simulation order is validated. 1) In the bandwidth, the OWF operates under base marine speed of the current.

1) When0.5s<t<30s, the wind noise speed depicted in above a Fig, is additional to the system but the seafaring speed is still kept at V_{MR} = 2.5 meters/sec.

2) It can be observed from the dynamic response of Vbus shown in Fig 5(g) that recommended STATCOM with the designed PID damping controller can completely control the AC bus voltage at approximately 1.0 pu by orderly adjusting α to tune the quantity of the reactive power of STATCOM supplied to the DC bus.

3) The magnitudes of the active power supplied to the power grid (Pgrid) and the active power produced by the SCIG of the MCF can be slightly reduced and the absorbed reactive power from the power grid (Qgrid) as illustrated in above fig, can be reduced when the STATCOM integrated with PID controller is included in the examined system.

4) The produced active power of the DFIG Pw is not effected by the addition of the STATCOM with the controller of PID.

3.4 Marine-Current Speed Disturbance

The investigated system with and without the recommended STATCOM and the developed PID damping controller under the marine current speed fluctuations as illustrated in Fig.6, when t < 0s, the OWF works under a base wind speed of Vw =12 m/s and the MCF works under a base marine current speed of Vmr =25 m/s. It is observed from the dynamic simulation responses that all quantities are slightly deviated from the steady state working points at t = 0s due to the small fluctuations on marine current rapidity. Meanwhile marine current speed is approximately associated to the output active power of the Marine CurrentTurbine; it is detected that the dynamic reply of Pmr as depicted, is alike to the one of Vmr and the factor of high frequency consisting in Vmr.

3.5 Three-Phase Short-Circuit Fault at Power Grid

The transient response of the examined system with and without the suggested STATCOM integrated with the developed design PID damping controller under a three phase short circuit fault at the grid side. The OWF works under a base wind speed of 12 m/s and at the same time the MCF works under a base marine current speed of 2.5vmeter/sec. A three phase short circuit fault is unexpectedly integrated to the grid at t =1s is eradicated at certain time. It is detected from the transient simulation results. The most quantities abruptly drop to smaller values when the fault happens. When the fault is recompensed, all responses become unchanging and homecoming the original steady state operating condition within 4s. The mentioned STATCOM with the established PID damping controller can offer better damping characteristics to the examined system under the severe three phase short circuit fault than without the controller of PID.

IV. CONCLUSION

Here in this paper has presented the dynamic stability t of an improvement of a combined OWF and MCF utilizing a STACOM. A PID damping controller has been developed for the STATCOM by utilizing a unified control strategy based on pole consignment. Eigenvalue intentions and time territory simulations of the examined system subject to a noise wind speed fluctuations, a marine current speed fluctuations, and a external three phase short circuit fault at the grid have been orderly operated to explain the effectiveness of the suggested STATCOM integrated voltage disturbances the developed PID damping controller on eliminating voltage disturbances of investigated system and improving system dynamic stability under various different operating conditions. It can be concluded from the simulations response that the recommended STATCOM integrated with the developed PID damping controller is capable of improving the performance of the investigated OWF and MCF under different kind of fault conditions.

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