IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676, p-ISSN: 2320-3331, Volume 19, Issue 2 Ser. 2 (Mar. – Apr. 2024), PP 06-09
www.iosrjournals.org

Ensuring Voltage Stability With Control System Of Wind TurbinesConnected To The Grid By Tcsc-Statcom Control

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Abstract:
Enhancing the voltage firmness of wind power grid-connected systems is the main goal of this research. We suggest combining the Static Synchronous Compensator (STATCOM) and Thyristor-Controlled Series Compensator (TCSC) in a control scheme. By carefully adjusting these components, we aim to optimize the system's response to variations in wind power output. Our approach involves in-depth modelling and simulation to check the dynamics of the wind electrical system. The goal is to enhance voltage stability, minimize power fluctuations, and boost overall grid performance during transient conditions and disturbances. We access key indicators like voltage profile, power factor, and system damping to validate the effectiveness of our TCSC-STATCOM control strategy. This research contributes valuable insights to the field, offering a promising solution to the challenges associated with integrating power produced by wind generators into the electrical system. The main of this project is to enhance stability of power grid when it is connected to wind power plant.
Keywords:- *Statcom,Facts Devices, Bus, Tcsc, Compensation*

Date of Submission: 01-04-2024 Date of acceptance: 10-04-2024

I. Introduction

In the integration of renewable energy resources particularly like wind power systems, poses a crucial challenge in maintaining the voltage firmness of electrical grid. The inherent variability and intermittency associated with wind power generation can lead to voltage stability issues, reducing the reliability of the entire power network. Addressing these challenges is imperative for the successful deployment and sustained growth of renewable energy sources. This project is mainly responsible to tackle difficulties which come across in maintaining voltage stability in wind power systems through the application of two advanced control technologies: Thyristor-Controlling Series Compensation (TCSC) and Static Synchronous Compensator (STATCOM) from FACTS devices. By synergizing these control mechanisms, we aim to create a robust and adaptive solution for enhancing overall voltage stability in grid-connected systems reliant on wind power. The integration of TCSC and STATCOM introduces a sophisticated control strategy that seeks to mitigate voltage fluctuations, harmonize power flow, and ensure a stable and secure grid operation.

The research presents detailed simulation results, shedding light on the effectiveness and performance of the proposed TCSC-STATCOM control system. Through this research, we want to make a valuable contribution to the field and provide a better understanding of the complexities that involved in the development of stable voltage in the electrical connection in power lines. The findings presented here not only address the immediate difficulties but also pave the way for advancement of resilient energy infrastructures. Electricity is widely used and produced in electrical generators, which are mainly driven by combustion engines burned by firing or fission but can also be made in various ways such as K.E. the flow of water and air. In wind power systems here, we use the asynchronous generators which are major contributing in reducing stability of the voltage of the system. A feature of electricity that it is not naturally available in the nature so it should be produced. Production is supervised in power stations.

Electricity production involves all advanced techniques that change some amount of energy into useful electricity. Electricity can be a sort of energy that may contain magnetically, radiant and chemical effects. Recently, application of a complicated power electronically interface has maintained a major role in renewable energy systems likewind power plant in the power grid.

II. Basic Principles And Modelling

The basic principles and modelling of the proposed TCSC- STATCOM control strategy for stabilizing voltage in wind power grid-connected systems involves understanding individual components and their mathematical representation.

Thyristor-Controlling Series Compensation (TCSC):

Main principle: TCSC works by placing a controlled vaccine into cells in the delivery line. Thyristor-controlled devices canadjust the switch to quickly control power flow and system stability.

Modeling: The TCSC model includes representations of controllable reactance, thyristor control circuits and interrupt control algorithms. The mathematical equation describes the relationship between the control signal and the resultingchange in reactance.CONTROL EQUATIONS:

After grid failure and power outage, the generator must draw more electricity from the grid to rebuild the generator's internal power during the system voltage recovery process. Therefore, we will decide to add STATCOM device to the system to provide reactive power to the wind turbine, so that there will be no need to restore the amount required to control the wind farm to terminal at the desired price. When the STATCOM device is connected to the system, it can provide the necessary reactive power to the wind power plant and dynamically provides the reactive power used by the non- synchronous generator during transition, increasing the terminal voltage and reducing the fault. - synchronous generator goes offline. Installing TCSC can even change the line reactance, limit the current, make the energy less than the capacity of the wind farm and improve the damping of the system. When STATCOM and TCSC are installed in the power grid at the same time, TCSC can be used to improve the power of the system and increase the power oscillation stability of the system, and STATCOM can be used to pay for reactive power. It meets the demand of the system and thus increases the voltage stability of the system connected to thewind energy grid.

TCSC Control Equation:
Purpose: Adjusts the voltage using a knob.
Explanation: The TCSC knob turns to make the voltagecloser to what we want it to be.

$VTCSC=KTCSC\cdot(Vref-Vgrid)$

VTCSC: How much the TCSC changes the voltage.KTCSC: How sensitive the TCSC is.
Vref: The voltage we want. Vgrid: The actual voltage. STATCOM Control Equation:
Purpose: Adjusts the current to control the voltage.

$ISTATCOM=KSTATCOM\cdot(Vref-Vgrid)$

ISTATCOM: How much the STATCOM changes thecurrent.
KSTATCOM: How sensitive the STATCOM is.

III. Result

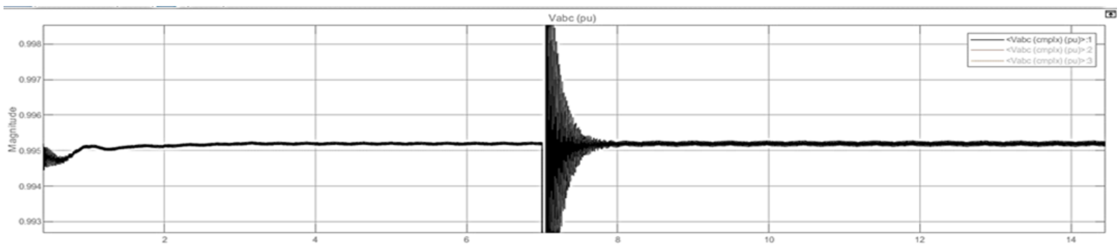

Fig 5.1: Case 1

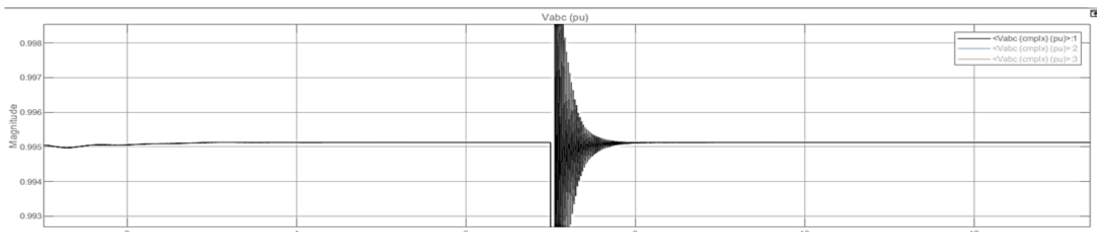

Fig 5.2 : Case 2

DOI: 10.9790/0853-1902020609

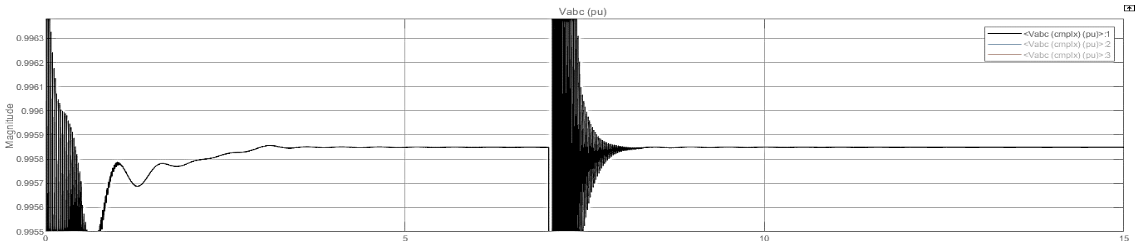

Fig 5.3 Case 3

IV. Analysis Of Output:

be stabilized quickly before operation. 1. Third scene. A Simulated the model, A short circuit from three phases to ground occurs on the 13 kV output line of the system at t = 7 seconds. The fault will be resolved within 50 milliseconds. If Matlab/Simulink is used to create a wind turbine network with simulation models based on asynchronous generator units controlled by TCSC and STATCOM, the wind speed will be controlled at 12 m/s throughout the simulation process. The firing angle of the TCSC will vary depending on the power passing through the line it replaces. These changes will affect the reactance of the TCSC and finally change the total reactance of the line, thus improving the system stability. To maintain system stability, STATCOM balances the reactive power by varying the output voltage. This study simulates four processes when three phase-to-ground short circuit faults occur in the power grid to examine the effect of TCSC- STATCOM control on system voltage stability. In the first case, TCSC and STATCOM are not used for control; in the second case, only TCSC is connected to the system; in the third scenario, the system depends only on STATCOM; In four cases TCSC and STATCOM work. Together to cooperatewhen problems arise.

This research designs a MATLAB/Simulink simulation for TCSC and STATCOM wind power grid integration and control and compares Studies 1 and 2 with Studies 3 and 4.

5.1 to 5.4 show how the simulated waveforms compare. Compare the B2 bus voltage curve of the grid-connected wind farm in the first operation and the second operation. In operation, the busbar voltage amplitude of the grid-connected wind power plant does not have a very stable time and cannot phase-to-phase short circuit fault occurs.

Operating condition 1 causes a three-phase short circuit fault in the system for up to 7.05 s. At this time, the voltage ofthe grid-connected wind farm suddenly dropped to about 0.05

p.u. The busbar voltage value of the wind farm starts. Change around 0.96 p.u. Here. 7.05 seconds after the problem was resolved, the bus voltage is still unstable and constantly changing, but it is also slightly higher than before and not stable. According to Case 2, in the system using only TCSC compensation, the busbar voltage amplitude of the grid- connected wind farm continues, but the busbar voltage cost of the grid-connected wind farms began to stabilize around 0.97 p.u. Approximately 1 second before a three-phase short circuit fault occurs. And when the fault is cleared, the busbar voltage can be quickly stabilized, reducing the frequency and amplitude of voltage oscillation. By comparing these two cases, we can clearly see that TCSC can reduce the oscillationamplitude, reduce the oscillation time when the system is affected, and improve the voltage stability.

TCSC wind farm cannot increase the bus voltage; is still 1.0 p.u lower than the bus nominal voltage. However, TCSC can reduce the oscillation decay time and oscillation amplitude, allowing the bus voltage to return to a constant value of 0.936. p. You do it once the fault is resolved. For grid- connected wind farms using STATCOM compensation, before a three-phase short circuit fault occurs, the bus voltage amplitude at operating condition 3 is significantly higher than the bus voltage amplitude at operating Study 1. The busbar voltage value of the wind power plant connected to the grid starts to change from 1.0 p.u. In job 3, about 1 second, about 0.05 p.u. higher than work 1.At 7-8 seconds, the voltage amplitude changes of state 3 is smaller than that of state 1. In the grid-connected wind power plant operating in Operation 1, the busbar voltage amplitude changes greatly during the return to its stable value. 0.965 p.u. and the busbar voltage cannot be controlled close to the nominal voltage.

The system only has TCSC correction as shown in figure 5.2; This correction is more effective in improving busbar stability rather than increasing the amplitude of busbar voltage on the connection line with wind farms. Although the system can increase the bus voltage amplitude of the grid-connected wind farm when STATCOM compensation is calculated alone, it cannot improve the voltage oscillation amplitude. A comparison of the B2 bus voltage curve in the 1st and 4th operation of the grid-connected wind farm is shown in Figure

10. TCSC-STATCOM controls the bus voltage amplitude to increase the speed of 4. operation of the grid connection point. and the bus voltage oscillation amplitude operating is less than 3.

Operating condition 4: After the busbar voltage value of the grid connection point starts to reach 0.988 p.u., the voltage amplitude stabilises at 1 s. When a three-phase short circuit fault occurs in the system, the voltage amplitude quickly returns to the measured value and after 7.8 seconds, the voltage fluctuation becomes very small. The frequency of rapid changes in the electrical power line is shown in figures 1 and 2. 5.1-5.2 Cases 1-4 can be associated with the normal operation of electrical appliances and electrical equipment (such as computers) in the system. even if they are within the limits of electrical power. This problem can be solved perfectly with the joint control solution between TCSC and STATCOM, which is the subject of this article. With TCSC- STATCOM control, as shown in figure 5.4, the voltage will quickly reach the measured value according to state 4, even before or after the problem. Graph based comparison 5.4 and Fig. Figures 5.1-5.3 show that the control system coordinated by TCSC and STATCOM has better results than the system alone in increasing the busbar voltage of the grid-connected wind farm.

V. Conclusion

In conclusion, a viable and practical method for improving voltage firmness in wind power grid-connected systems is the merging of Static Synchronous Compensator (STATCOM) and Thyristor-Controlled Series Compensation (TCSC). The study discussed in this paper emphasizes how crucial it is to solve voltage stability issues brought on by wind powergeneration's intermittent nature.

Through theoretical exploration and simulation results, we have demonstrated the ability of the TCSC-STATCOM control system to effectively mitigate voltage fluctuations, harmonize power flow, and ensure the overall stability of the grid. The synergy between TCSC and STATCOM offers a dynamic and adaptive approach, capable of responding to the variability inherent in wind power generation. The specifications of this research contribute not only to the theoretical understanding of advanced control strategies but also provide practical insights for the deployment of robust solutions in real-world grid scenarios. As we strive towards a sustainable energy future, the integration of renewable sources like wind power becomes increasingly pivotal, and mitigating voltage stability issues is crucial for their successful incorporation into existing power systems. In essence, this study opens avenues for further research and development, encouraging the exploration of innovative control mechanisms and their application in addressing the evolving challenges of renewable energy integration. By fostering a deeper understanding of TCSC- STATCOM control, we hope to contribute towards the creation of resilient and efficient power grids that can seamlessly accommodate the growing share of reproducable energy sources.

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