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OBJECTIVE

To acquire strong technical skills and experience in the organization and pursue a challenging career in a system that encourages continuous learning and creativity in the field of teaching, research and development.

EDUCATION

Ph.D. (Electrical Engg) (2015-2020)

(Ph. D. Awarded on 28 Dec 2020)

MNNIT Allahabad, India [8.25/10]

Study on some aspects of Stability and protection scheme of grid interactive Offshore Wind and Marine Current Farm



M.Tech (Power System)2013-2015

Delhi Technological University [8.05/10]

New Delhi, India

Challenges In The Grid

Connection Of Marine Current Power



B.Tech (2008-2012)

Electrical Engg

Kamla Nehru Institute of technology

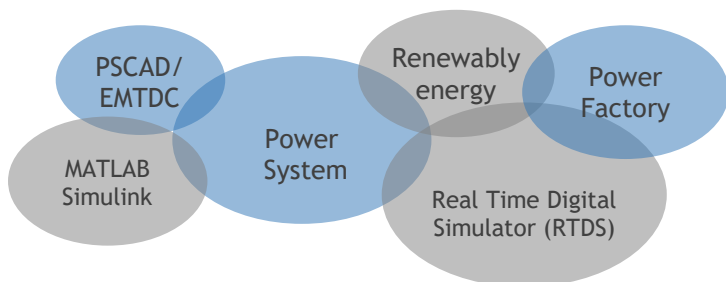
Sultanpur, Uttar Pradesh, India

Affiliated to AKTU(Formerly, UPTU)



KEY POSITIONS & SKILLS

Student Co-ordinator (GIAN 2017), Volunteer in various short term courses and International IEEE conference Events organised by Institute.



EXPERIENCE (6+ Years)

➤ Assistant Professor

April 2021- Till Date

Department of Electrical Engineering

G H Raisonni Institute of Engineering and Technology,
Nagpur, Maharashtra 440028

➤ Senior Research Fellow

July 2017-July2020

MN-NIT Allahabad, Prayagraj, U.P. India 211004

Project :

- **Project Titled: “ Study on Some Aspects of Stability and Protection Scheme of Grid Interactive Offshore Wind and Marine Current Farm”**

➤ Junior Research Fellow

July 2015 to July 2017, MNNIT Prayagraj, U.P. India
211004

Project: Modelling and Simulation of DFIG based Offshore Wind turbine

➤ Teaching Assistant

(July2015- July2020), MNNIT Prayagraj, U.P. India
211004

Professional Memberships

GMIEEE, IEEEYPM, IEEEPES, IAENG, IEEECPM

Professional Networks Links

Google Scholar :

<https://scholar.google.com/citations?hl=en&user=1MUOfMAAAAJ>

Research Gate :

https://www.researchgate.net/profile/Satendra_kushwaha

Academia :

<https://mnnit.academia.edu/Satendrakushwaha>

Linked In :

<https://www.linkedin.com/in/satendra-kushwaha-44a01055/>

ORCID ID :

<https://orcid.org/0000-0002-7385-4627>

PUBLICATIONS

- SCI Journals-03
- Scopus- 01
- Book Chapters-01
- International Conferences-06

REFEREES

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Professor

Dept of Electrical Eng

MNNIT Allahabad, India

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Dr. S. R. Mohanty

Associate Professor

Dept. of Electrical Eng

IIT-BHU, Varanasi, India

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Mob: +91-9554575150

Work Experience and Responsibilities:

➤ Assistant Professor

April 2021- Till Date

Department of Electrical Engineering

G H Raisoni Institute of Engineering and Technology, Nagpur, Maharashtra 440028

(An Autonomous Institute & NAAC Accredited with A⁺)

NBA COORDINATOR and Criteria In-charge:

Worked as an NBA Coordinator and Criteria in-charge in the EE Department and Successfully

Conducted the NBA visit in our department on **14-16Jan 2022**.

Renewable Club In-charge and R&D Coordinator:

I am In-charge of Renewable Club in our Institute under which we organized hands on practice, Industrial visit and Webinar on renewable resources to our students. Also, I am R&D departmental coordinator in our institute.

➤ Senior Research Fellow

July 2017-July2020

MN-NIT Allahabad, Prayagraj, U.P. India 211004

➤ Junior Research Fellow

July 2015-July2017

MN-NIT Allahabad, Prayagraj, U.P. India 211004

Research Work in MNNIT ALLAHABAD

1. **Modelling and Simulation of integrated a large offshore wind farm and marine current farm and its impact on the power system stability with regard to steady-state, dynamic, and transient stability followed by possible remedial measures.**
 - a. Especially developed a simulation base dynamic model of OWF and MCF with systematic representations of parametric uncertainties and develop a linear matrix inequality (LMI)-based H_{∞} controller with a given control strategy under parametric uncertainties to provide enough support for the improvement of system dynamic-stability after a grid disturbance or faults.
 - b. Further developed a control scheme for stability assessment of grid-interactive OWF and MCF using STATCOM and BFCL under parametric uncertainties in RTDS platform.
2. **Analyzing the Impact of STATCOM and BFCL on Performance of Distance relay and its improvement by adaptive setting for Grid Interactive Offshore Wind and Marine Current Farm.**
 - a. Especially developed a PSCAD/EMTDC based simulation model to analyzed the impact of dynamic impedance of STATCOM and BFCL on the performance of distance relay.
 - b. Further developed an adaptive setting of distance relay to take corrective action and mitigate the adverse effect of STATCOM and BFCL on the relay operation.

List of Publication

International Journals

- [1] Satendra Kr Singh Kushwaha, S. R. Mohanty and Paulson Samuel "Robust H_{∞} control for stability assessment in grid-connected offshore wind and marine current hybrid system," *IET Renewable Power Generation*, vol. 13, no. 2, pp. 318-329, 2019.
- [2] Satendra Kr Singh Kushwaha, S. R. Mohanty and Paulson Samuel "Impact of STATCOM and BFCL on Performance of Distance relay and its improvement by adaptive setting for Grid Interactive Offshore Wind and Marine Current Farm" *IET Generation, Transmission & Distribution*, vol. 14, no. 23, pp. 5547 – 5557, 2020.

- [3] Satendra Kr Singh Kushwaha, S. R. Mohanty and Paulson Samuel "Stability Assessment and robust controller design of Grid Interactive Offshore Wind Farm and Marine Current Farm with STATCOM and BFCL" *Automatika*, Vol. 62, no. 2, 197–209, 2021 DOI:10.1080/00051144.2020.1860377
- [4] D. R. Karthik, B. Mallikarjuna Reddy, Satendra Kr Singh Kushwaha and Akbar Ahmed "Application of FPGA Controller in Multidevice Interleaved DC/DC Boost Converter for Air Craft Electrical Systems" *Indian Journal of Science and Technology*, Vol. 9, no. 44, pp. 1-7, 2016

Book Chapter

- [5] Satendra Kr Singh Kushwaha, S. R. Mohanty and Paulson Samuel "Stability analysis of an offshore wind and marine current farm in grid connected mode using SMES" *Intelligent Computing Techniques for Smart Energy Systems, Lecture Notes in Electrical Engineering, Springer*, vol 607, Dec. 2019.
- [6] Satendra Kumar Singh Kushwaha, Satyprakash, Akhilesh Kumar Gupta, Akbar Ahmad, Bandi Mallikarjuna Reddy, Narendra Kumar Ch "Techno-Economic Issues of Grid Connected Large Photovoltaic Plants of Smart City Prayagraj to the EV Charging Station: A Case Study (A Case Study of 5 MW Photovoltaic Power Plant at Prayagraj)" Book Chapter in *Smart Charging Solutions for Hybrid and Electric Vehicles*, Wiley, pp. 419-436, March 2022.

International Conferences

- [7] Satendra Kr Singh Kushwaha, S. R. Mohanty and Paulson Samuel, "Stability Assessment and Robust Controller Design of Grid Interactive Offshore Wind Farm and Marine Current Farm using STATCOM," *IEEE International Conference on Energy, Systems and Information Processing (ICESIP)*, Chennai, India, 2019, pp. 1-6, 2019.
- [8] Satendra Kr Singh Kushwaha, S. R. Mohanty and Paulson Samuel, "Non-linear H-infinity Control for Grid-interactive Offshore Wind Farm and Marine Current Farm," *IEEE International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES)*, Delhi, India, pp. 420-425, 2018.
- [9] Satendra Kr Singh Kushwaha, Paulson Samuel and S. R. Mohanty "Transient Stability Analysis of SCIG based Marine Current Farm and Doubly Fed Induction Generator based offshore wind farm using Bridge Type Fault Current Limiter" *IEEE Uttar Pradesh Section International Conference on Electrical, Computer and Electronics, Mathura*, pp. 494-499, 2017.
- [10] K. Sekhar, S. K. S. Kushwaha, D. R. Karthik, V. M. Reddy and B. M. Reddy "Transient stability analysis of large-scale grid integration of offshore wind and marine current farm connected to grid using STATCOM," *Innovations in Power and Advanced Computing Technologies (I-PACT)*, Vellore, pp. 1-6, 2017.
- [11] D. R. Karthik, B. M. Reddy and S. K. S. Kushwaha, "A PSCAD simulation on integration of multi-level converters with DC-DC converter for AC drive applications," *International Conference on Circuit, Power and Computing Technologies (ICCPCT)*, Nagercoil, 2016, pp. 1-6
- [12] S. K. S. Kushwaha and S. T. Nagarajan, "Stability analysis of off shore marine current farm connected to grid," *IEEE International Conference on Technological Advancements in Power and Energy (TAP Energy)*, Kollam, 2015, pp. 466-471, 2015.

Workshop & STTP Attended

- [1] Networked and Embedded Control of Energy & Systems, October 14-15, 2016 EED MNNIT Allahabad 2016
- [2] Photovoltaics: Technology and Business Overview, March 04-06, 2017 Physics and EED, MNNIT Allahabad 2017
- [3] Advances in Power Electronics and Renewable Energy Resources, 21-23 July, 2017 EED MNNIT Allahabad 2017
- [4] Global Initiative of Academic Networks (GIAN) on "Power System Voly/VAR Control and Voltage Stability" during 26-30 December, 2017 in the Department of electrical engineering, MNNIT Allahabad, India
- [5] Modelling and Simulation of renewable energy systems, May 28- June 3, 2018 EED, MNNIT Allahabad 2018.
- [6] UNPACKING E-MOBILITY TECHNOLOGIES FOR INDIA, November 20 - 24, 2021 MNNIT Allahabad 2021.

I hereby declare that the information provided above is correct to the best of my knowledge

Date : Jan. 2022

Place : Nagpur, Maharashtra INDIA

Satendra Kr Singh Kushwaha

मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद

विद्या परिषद् की अनुशंसा पर



सतेन्द्र कुमार सिंह कुशवाहा

को

दिसम्बर 2020 में शोध-प्रबंध के सफल पक्षपोषण के उपरान्त

डॉक्टर ऑफ फिलॉसफी

की संस्थान मुद्रा अंकित यह उपाधि समस्त सम्मानों, विशेषाधिकारों व दायित्वों के साथ आज ३१ दिसम्बर २०२० को प्रयागराज (भारत) में प्रदान करता है।

Motilal Nehru National Institute of Technology Allahabad

*on the recommendation of the Senate
hereby confers on*

SATENDRA KUMAR SINGH KUSHWAHA

*on successful defence of the thesis in December, 2020
the Degree of*

Doctor of Philosophy

*with all Honours, Privileges and Obligations thereunto pertaining on this
day the 31st December 2020, under Seal of the Institute at Prayagraj (INDIA).*

**Thesis: Study on Some Aspects of Stability and Protection Scheme of Grid Interactive
Offshore Wind and Marine Current Farm**



D. P. Singh

अध्यक्ष, प्रशासकीय परिषद्
Chairperson, Board of Governors



Sateendra Kumar

K. Singh

अध्यक्ष, विद्या परिषद्
Chairman, Senate

क्रम संख्या
Serial No.

33414



अनुक्रमांक
Roll No.

2K13/PSY/17

दिल्ली प्रौद्योगिकी विश्वविद्यालय DELHI TECHNOLOGICAL UNIVERSITY



मास्टर ऑफ टेक्नोलॉजी

विश्वविद्यालय की शैक्षणिक परिषद की अनुशंसा पर

सतेन्द्र कुमार सिंह कुशवाहा

को पॉवर सिस्टम में मास्टर ऑफ टेक्नोलॉजी

की उपाधि प्रदान की जाती है, जिन्होंने इस उपाधि को प्रदान किए जाने हेतु विश्वविद्यालय के अध्यादेशों के तहत निर्धारित अपेक्षाओं को वर्ष 2015 में 10 अंकीय मापक्रम पर 8.05 संख्या कोटि अंक माध्य (सी.जी.पी.ए.) के साथ सफलतापूर्वक पूर्ण कर लिया है। इन्हें उक्त उपाधि से तृतीय दीक्षांत समारोह में 8 दिसंबर 2016 को विभूषित किया गया।

MASTER OF TECHNOLOGY

Upon the recommendation of the Academic Council of the University

SATENDRA KUMAR SINGH KUSHWAHA

is awarded the degree of

Master of Technology in Power System

who has successfully completed the requirements prescribed under the ordinances of the University for the award of this degree with a Cumulative Grade Point Average (CGPA) of 8.05 on a 10 point scale in the year 2015.

He/She is admitted to the said degree at the 3rd Convocation held on December 8, 2016.

कुलसचिव
Registrar

दिल्ली, (भारत) दिनांक
Delhi, (India) dated the

December 8, 2016

कुलपति
Vice-Chancellor

Sateendra Kumar



(पूर्ववर्ती उत्तर प्रदेश प्राविधिक विश्वविद्यालय, लखनऊ)
विश्वविद्यालय की विद्या परिषद् की अनुशंसा पर

सतेन्द्र कुमार सिंह कुशवाहा

को इलेक्ट्रिकल इंजीनियरिंग विद्या में प्रौद्योगिकी की स्नातक उपाधि

प्रथम श्रेणी में

उनको द्वारा इस उपाधि की अवाप्ति हेतु
विश्वविद्यालय द्वारा विहित अपेक्षाओं को सफलतापूर्वक पूरा करने पर
एतद्वारा सन् 2012 में प्रदान की जाती है।

Gautam Buddha Technical University

(Formerly Uttar Pradesh Technical University, Lucknow)

*Upon the recommendation of the Academic Council,
the University hereby confers the degree of*

Bachelor of Technology in Electrical Engineering
upon

SATENDRA KUMAR SINGH KUSHWAHA

*who has successfully completed the requirements prescribed by the University
for the award of this degree in
First Division
in the year 2012.*

लखनऊ, (उ.प्र.), भारत
Lucknow, (U.P.), India
दिनांक: / Dated: January 05, 2013



RK Khandal

(आर. के. खान्डल)
कुलपति
(R. K. Khandal)
Vice-Chancellor

Satendra Kumar

Robust H^∞ control for stability assessment in grid-connected offshore wind and marine current hybrid system

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Abstract: The geographic suitability brings the offshore wind farm (OWF) and marine current farm (MCF) together with their aggregated power fed to grid simultaneously in most relevant energy harnessing infrastructures. However, stability assessment of the integrated system is a major concern due to the integration of stochastic and intermittent sources with parametric uncertainty. Bridge-type fault current limiter (BFCL) has consolidated their application for a suitable enhancement of stability margin for most modern supply systems. In this article, a detailed modelling of the integrated system is carried out in the presence of BFCL along with consideration of uncertainty as well. A robust H^∞ controller design strategy for stability assessment of grid-connected OWF and MCF in the presence of parametric uncertainties is presented in this article. Linear matrix inequality (LMI) conditions are derived in the context of evaluating the robust controller gain with respect to desired robust stability margin. The efficacy of the controller design is compared with that of H^∞ loop shaping and conventional P-I control through different case studies with simulation followed by real-time digital simulator (RTDS) validation.

Nomenclature

$\omega_{\text{owt}}, \omega_{\text{mct}}$	angular velocity of the wind turbine and marine current turbine
ρ_w, ρ_m	density of wind and marine current, respectively
$\lambda_{\text{dqs}}, \lambda_{\text{dqr}}$	flux linkage of stator and rotor, respectively
J_{mct}	moment of inertia of the marine current turbine
$T_{\text{me}}, T_{\text{eo}}$	mechanical and electrical output torque of generator
$C_{pw}(\lambda_{\text{wt}}, \beta_w)$	power coefficient of offshore wind turbine
$C_{p\text{-mct}}(\lambda_{\text{mct}}, \beta_{\text{mct}})$	power coefficient of marine current turbine
$R_{\text{tw}}, R_{\text{mct}}$	radius of wind and marine current turbine
$\omega_{\text{ref}}, \omega_r$	reference and rotor angular speed of DFIG
$i_{\text{dqs}}, i_{\text{dqr}}$	stator and rotor current of SCIG in d - q frame of reference, respectively
i_s, i_r	stator and rotor current of DFIG
r_s, r_r	stator and rotor resistance of DFIG
v_s, v_r	stator and rotor voltage of DFIG
ψ_s, ψ_r	stator and rotor linkage flux of DFIG
V_{dqs}	terminal voltage of SCIG in d - q frame of reference
V_w, V_m	velocity of wind and marine current

1 Introduction

In recent years, research on alternate resources has gained momentum mostly as a fall out of rising world temperature and depleting fossil fuels. The intention is to address amicably the trade-off between rising power demand worldwide and concerns for green environment. The ocean has huge untapped energy resource in the form of offshore wind, tidal wave, geothermal energy etc. available relatively easily at different geographical locations. Extracting the offshore wind and oceanic current energy has the potential to meet our future energy needs to a large extent. Currently, both offshore wind and ocean energy has been combined together in the UK [1]. The grid integration of the offshore wind farm (OWF) and marine current farm (MCF) raises some serious challenges in regard to grid code requirement [2, 3], power quality, grid stability [4, 5], and fault ride through capability [6]. The process will augment nicely by using a robust control technique to

deal with the stochastic nature of wind and marine current speed, non-linear plant dynamics, and the presence of parameter uncertainties.

Doubly fed induction generators (DFIGs) are generally used in OWF with the merits of independent active and reactive power control, small size, lower cost, and wide range of operating speed. Voltage fluctuations and unbalance loading cause series of problems to DFIG, such as overheating of generator winding with unbalance currents, change of flux density, and saturation effects [7]. Parameter uncertainty is another challenge for controller design of DFIG [8]. It affects the controller performance, stability, and reliability of the system. Various current control techniques have been developed to address the voltage fluctuation, steady-state stability, and transient stability of the system. The common use of control strategy is to add more regulators to the existing proportional integral (PI) controller. Some typical control strategies are PI plus resonant (PIR) control, dual current control, and proportional plus resonant (PR) control [9–11]. The simplest control strategies are based on single-input, single-output (SISO) control theory and require the generator model to be the simplified to first-order nominal model of DFIG. They achieve good performance as nominal model and may give satisfactory performance if the parameter uncertainty is not considered. However, the robust performance for all possible uncertainty in system parameter is not guaranteed. There are two approaches which allow the uncertainty in OWF and disturbance: adaptive and robust control. The adaptive control estimates the parameter and calculates the controller accordingly, but it involves online design and is computationally intensive. The second approach is to incorporate the uncertainty tolerances in the design of the controller and make it immune to the uncertainty in the parameter and disturbance. Such schemes are fuzzy logic control [12, 13], sliding mode control [14, 15], and predictive direct power control [16, 17]. However, the parametric uncertainty robustness is not fully achievable through these methods. The H^∞ robust control is a multi-input, multi-output (MIMO) structure where the system stability and robust performance can be guaranteed by H^∞ norms to consider all possible uncertainties into a bound [18, 19]. An H^∞ controller design is proposed in this paper to improve robustness in the presence of perturbation due to parametric uncertainty and or high stochastic wind speed.

Impact of STATCOM and BFCL on the performance of distance relay and its improvement by adaptive setting for grid-interactive offshore wind and marine current farm

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Abstract: This study explores the impact of the dynamic impedance of static synchronous compensator (STATCOM) and bridge type fault current limiter (BFCL) on the performance of distance relay and its improvement by adaptive setting for Grid Interactive Offshore Wind and Marine-Current Farm. For assessments, analytical results are presented under different STATCOM settings, low voltage ride through (LVRT) condition, and different types of fault conditions. Moreover, the presence of STATCOM and BFCL significantly changes the apparent impedance characteristic of the studied system. It is also seen that the presence of STATCOM likely to induce an under reach and overreach problem of distance relay. Further, the LVRT capability is significantly affected as STATCOM supplies reactive power to offshore wind generators during a short circuit on the grid side. It is found that the grid integration of OWF and MCF with STATCOM and BFCL is likely to induce mis-coordination and subsequently deteriorate the performance of distance relay, leading to system security problems. Therefore, this study proposed an adaptive setting in order to eliminate the simultaneous influence upon the dynamic impedance due to incorporation of STATCOM and BFCL on the distance relay setting. The simulation results show the efficacy of the proposed adaptive setting.

Nomenclature

V_s, V_r	stator and rotor voltages of DFIG
r_s, r_r	stator and rotor resistances of DFIG
i_s, i_r	stator and rotor currents of DFIG
ψ_s, ψ_r	stator and rotor linkage fluxes of DFIG
ω_{ref}, ω_r	reference and rotor angular speed of DFIG
V_{dqms}	terminal voltage of SCIG
i_{dqms}, i'_{dqms}	stator and rotor currents of SCIG
$\lambda_{dqms}, \lambda'_{dqms}$	flux linkage of stator and rotor
$I_{TL1}^+, I_{TL1}^-, I_{TL1}^0$	positive, negative and zero sequence current of transmission line
$I_{sh}^+, I_{sh}^-, I_{sh}^0$	positive, negative and zero sequence current of STATCOM
I_f	fault current
I_{sta}	STATCOM current
$V_{R1}^+, V_{R1}^-, V_{R1}^0$	positive, negative and zero sequence voltage at relay terminal
$I_{R1}^+, I_{R1}^-, I_{R1}^0$	positive, negative and zero sequence current of distance relay
Z_{bfcl}	apparent impedance of BFCL
Z_{R1}	apparent impedance is seen by the distance relay
Z_{owf}, Z_{mcf}, Z_g	equivalent impedances of OWF, MCF and grid
$E_{owf}, E_{mcf}, V_{grid}$	equivalent terminal voltages of OWF, MCF and grid

1 Introduction

In recent decades, the participation of renewable resources in electricity generation is rapidly increased due to higher demand for electricity day by day and limited availability of conventional resources. In particular, offshore wind farm (OWF) and marine current farms (MCFs) are attached to the distribution network and national grid in many countries [1]. The number of wind turbine integration and energy penetration in the power system is steadily

increased and plays a major contribution to energy sharing and energy balance. Incorporation of wind and marine energy resource into the national grid entails several new challenges regarding power system stability and protection. The installation of flexible alternating current transmission system (FACTS) devices and fault current limiters (FCLs) enhanced the low voltage ride through (LVRT) capability, voltage stability and reactive power support and the expected increase of power demand [2, 3]. It also enhanced the overall stability and power oscillation damping by regulating the active and reactive power flow of an integrated system. Apart from the stability issues, protection issues pose challenges in the grid integration of renewables [4]. In the context of enhancement of the LVRT capability, reactive power compensation, the performance of the protective relays gets affected [5]. The distance relay is one of the key protective devices deployed at the point of common coupling (PCC) with respect to interconnection of renewables and the rest of the power network. Thus, it ought to investigate the impact of FACTS controllers and FCLs on the performance of the distance relay followed by possible remedial measures in order to enhance the dependability and security of the grid.

Several works of literature reported the impact of the FACTS controller on distance protection strategies and possible remedial measures. The work done in [6, 7] evaluated the impact of shunt FACTS parameters and its location on the performance of distance relay and its tripping boundaries. In [8], Ghorbani *et al.* investigated the impact of static VAR compensator (SVC) on the operation of impedance-based protection relay under steady-state and fault conditions. The authors in [9, 10] presented the impact of the VSC-based FACTS controller on the distance relay. The work in [11, 12] discussed the apparent impedance calculation of transmission line consisting of a unified power flow controller and evaluated the impact of mode of operation and its control parameters on relay operation. In [13], an adaptive protection scheme is proposed to improve the performance of a shunt compensated line connecting wind farm. In [14], Singh *et al.* proposed a digital impedance pilot relaying scheme for a shunt



Stability assessment and robust controller design of grid interactive offshore wind farm and marine current farm with STATCOM and BFCL

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ABSTRACT

In the context of larger renewable energy harnessing, combining offshore wind farm (OWF) and marine current farm (MCF) at the same location is often found suitable in terms of geographical conditions and economic reasons. However, stochastic nature of wind speed and marine current speed with increased penetration level significantly affects the system stability, grid voltage and raises some control and stability problem; furthermore, the parametric uncertainty of generators brings additional challenges under grid voltage distortion. Therefore, in this article, we present a consolidated application of STATCOM and BFCL in the context of stability assessment of integrated system. Consequently, a robust H_{∞} loop-shaping controller has been proposed in the presence of parametric uncertainties. In this context, optimizing controller performance with respect to the undesired parametric uncertainties and external disturbances has been proposed. The control effort is initiated by formulating the robust H_{∞} loop-shaping controller in the context of evaluating the controller parameters and gain with respect to desired robust stability margin. The efficacy of the proposed control scheme is measured through different case studies in real time digital simulation (RTDS) environment. The comparative analysis of simulation results demonstrates the effectiveness of the proposed control strategy in the context of integrated system stability and reliability.

ARTICLE HISTORY

Received 18 October 2019
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KEYWORDS

Offshore wind farm; marine current farm; STATCOM; BFCL; real time digital simulation (RTDS)

1. Introduction

The remarkable growth of power demand worldwide and concerns for protection of environment have renewed interest in large-scale investments in non-conventional energy options. In the last couple of years, OWF has been found attractive as an energy solution and is being considered as an alternate resource for considerable electricity generation. The ocean has untapped energy resources in the form of tidal wave [1], geothermal, offshore wind etc. at different geographical locations. They form formidable energy resources especially in the Gulf Stream, Florida straight and California straight which is capable of making up for a large share of the future energy needs. OWF combined with MCF, owing to their natural availability in close proximity, would become a new kind of integrated energy generation system in near future. Further high correlation between offshore wind energy and marine current energy operating characteristic is arguably convenient of grid integration without raising much ancillary issues to address. However, the wind energy and marine current energy resources are stochastic in nature. Thus, high penetrations of OWF and MCF into the national grid rise some critical issues of stability [2,3] power quality and fault ride through

the ability of the integrated system and the grid code requirement [4,5] takes a nose dive to take care of such issues.

One of the simple methods of running an OWF is to aggregate several doubly fed induction generator (DFIG)-based generator driven by offshore wind turbine and then connected to on-shore grid through step-up transformers and under-sea cables. Similarly, to run a marine current farm (MCF), we may use an aggregated model of squirrel cage induction generator (SCIG)-based generator driven by marine current turbine, directly connected to the grid through step-up transformers and under-sea cables. Both WTs and MCTs have similar operating characteristic, but SCIG required reactive power for magnetization, while DFIG operates close to unity with the control of back to back PWM converters. The active power generated by an SCIG-based MCF is varied because the stochastic nature of marine current speed, the absorbed reactive power and terminal voltage are significantly affected. These generators are very sensitive to the voltage distortion, e.g. grid faults, when connecting large-scale high capacity OWF and MCF to the power grid a fact device or a control device is required to compensate the power fluctuations and grid voltage distortion under dynamic



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SATENDRA KUMAR SINGH KUSHWAHA

MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY,

ALLAHABAD, UTTAR PRADESH

Participated in the AICTE Recognized Short Term Course

on

MODELING AND SIMULATION OF RENEWABLE ENERGY SYSTEMS

conducted by

Electrical Engineering Department

from

28/05/2018 to 01/06/2018 (ONE WEEK)

at

M.N.N.I.T., Allahabad



Shiv S.L.

Coordinator
(NITTTR, Chandigarh)

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Coordinator
(MNNIT, Allahabad)

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Iowa State University, Ames, Iowa, United States

on

Power System Volt / VAR Control and Voltage Stability (PSCVS-2017)

during

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Department of Electrical Engineering

MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY ALLAHABAD

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