Conference Program

SPIES 2024

2024 6th International Conference on Smart Power & Internet Energy Systems

Khalifa University, Abu Dhabi, UAE

December 4-6, 2024

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https://www.icspies.org/

Table of Content

Welcome Message

On behalf of the organizing committees, it is our honor to extend a heartfelt welcome to all attendees of 2024 6th International Conference on Smart Power & Internet Energy Systems (SPIES 2024), taking place in Abu Dhabi, UAE during December 4-6, 2024.

The SPIES conference series is held annually to provide an interactive forum for presentation and discussion on Smart Power, Intelligent Energy Systems and related fields. SPIES 2024 is sponsored by Khalifa University, UAE, IEEE Industry Applications Society, IEEE Power, and Energy Society. It is also technically supported by University of Vaasa, Macquarie University, Chiang Mai Unversity, Université de Bretagne Occidentale, University of Nottingham and University of Technology of Belfort-Montbéliard.

After more than one year's preparation, we received more than 140 submissions from United Arab Emirates, China, Brazil, Denmark, United States, Sweden, Australia, Egypt, Germany, Ireland, India, Qatar, Canada, Greece, Kuwait and other countries. More than 150 Technical Program Committee Members participated in the review process. Thanks for their great efforts and excellent work.

There are 4 keynote speeches, 2 tutorials, 1 panel discussion and 10 technical sessions in SPIES 2024 conference program. We believe that over the three days you'll get the theoretical grounding, practical knowledge and personal contacts that will help you build long-term, profitable and sustainable communication among researchers and practitioners working in a wide variety of scientific areas with a common interest in Smart Power and Internet Energy Systems.

We sincerely would like to thank all the authors as well as the technical program committee members and reviewers. Their high competence, enthusiasm, time and expertise knowledge enabled us to prepare the high-quality final program and helped to make the conference become a successful event.

General Chair

Prof. Ahmed Al Durra
Khalifa University, UAE
December 2024

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Rakibuzzaman Shah, Federation Universtiy, Australia

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Onsite Conference Notice

Conference Venue

Khalifa University, UAE

Address: Shakhbout Bin Sultan St - Hadbat Al Za'faranah - Zone 1 - Abu Dhabi - United Arab Emirates

Dress Code

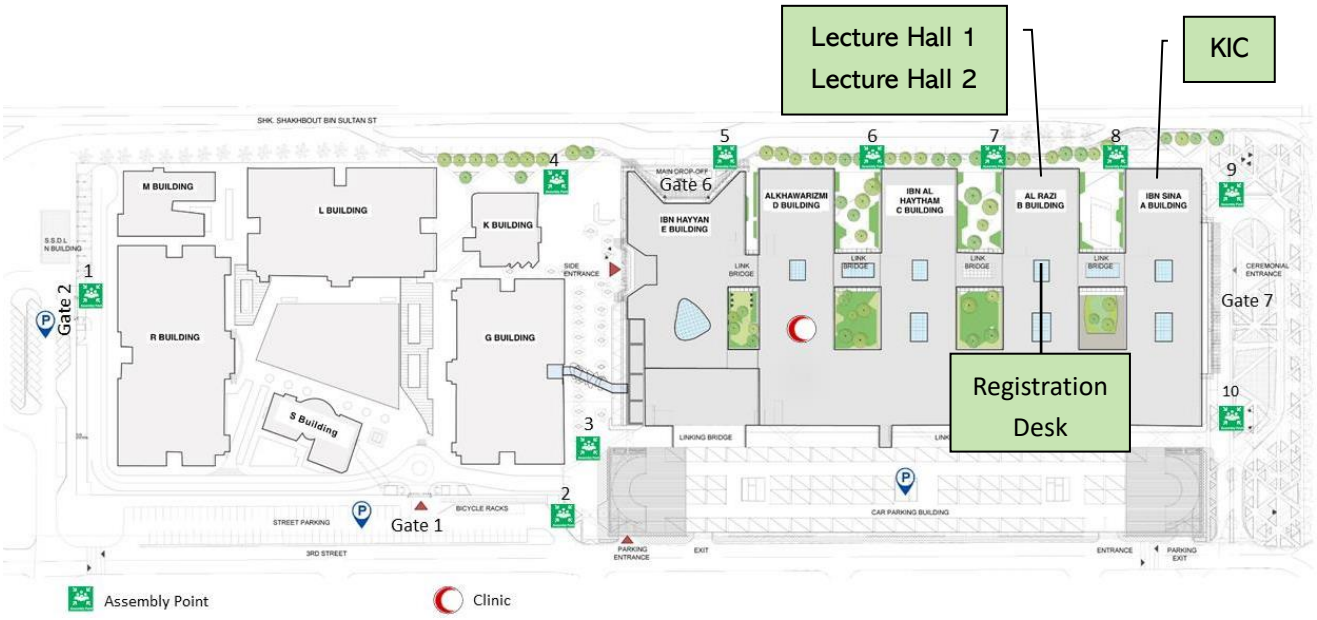
Male Visitors Dress Code

- Male visitors must wear a shirt and long trousers/jeans. Shorts and sleeveless shirts must be avoided.
- Clothes displaying offensive/objectionable writings/drawings/pictures must be avoided.
- Visible tattoos and piercings must be avoided.

Female Visitors Dress Code

- Female visitors must dress conservatively wearing long-sleeved shirts/blouses with long and loose fitting skirts/slacks, or a long-sleeve loose fitting long dress.
- Shorts, short skirts and sleeveless/low-cut neckline shirts must be avoided.
- Clothing that is tight, transparent, or short and shows too much skin or exposes the waist, back, or legs must be avoided.
- Clothes displaying offensive/objectionable writings/drawings/pictures must be avoided.
- Visible tattoos and piercings must be avoided. This does not include generally acceptable items such as earrings and henna.

Conference Rooms Information



Rooms	Activities
Lecture Hall 1-B-00107	Registration
	Tutorial 1 & 2
	Keynote Speeches & Panel Discussion
	Session 1 & Session 4
	Closing and Award Ceremony
Lecture Hall 2-B-00055	Session 2 & Session 5
Lecture Hall 3-KIC	Session 3 & Session 6

About Onsite Presentation

• Timing: a maximum of 15 minutes total, including speaking time and discussion. Please make sure your presentation is well timed.
• Each speaker is required to meet her / his session chair in the corresponding session rooms 10 minutes before the session starts and copy the slide file (PPT or PDF) to the computer.
• It is suggested that you email a copy of your presentation to your personal in box as a backup. If for some reason the files can't be accessed from your flash drive, you will be able to download them to the computer from your email.
• Please note that each session room will be equipped with a LCD projector, screen, point device, microphone, and a laptop with general presentation software such as Microsoft Power Point and Adobe Reader.
• Poster Presenters should bring your poster to the conference venue and put it on designated place.

Name Badge

For security purposes, delegates, speakers, exhibitors and staff are required to wear their name badge to all sessions and social functions. Lending your participant card to others is not allowed. Entrance into sessions is restricted to registered delegates only. If you misplace your name badge, please ask the staff at the registration desk to arrange a replacement.

Gentle Reminder

• Please ensure that you take all items of value with you at all times when leaving a room. Do not leave bags or laptops unattended. The conference organizer does not assume any responsibility for the loss of personal belongings of the participants.
• Accommodation is not provided. Delegates are suggested make early reservation.
• Please show the badge and meal coupons when dining.

Internet

Free Wi-Fi access is available throughout the venue.
Network: KU-EVENTS
Password: events@ku

Online Conference Notice

Platform: Zoom

Download Link: https://zoom.us/download

Sign In and Join

***Join a meeting without signing in.**

A Zoom account is not required if you join a meeting as a participant, but you cannot change the virtual background or edit the profile picture.

***Sign in with a Zoom account.**

All the functions are available.

Time Zone

GMT+4

***You're suggested to set up the time on your computer in advance.**

Online Room Information

Zoom 1 ID: 892 9423 5542 (Main Conference)

Zoom Link: https://us02web.zoom.us/j/89294235542

You can scan QR code to enter:

Zoom 2 ID: 858 2797 3324

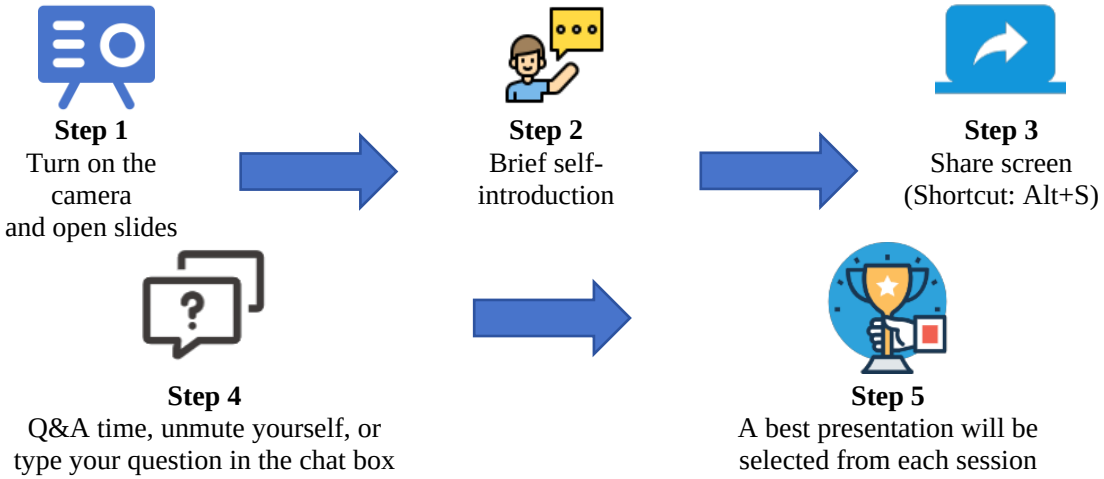
Zoom Link: https://us02web.zoom.us/j/85827973324

You can scan QR code to enter:

1. You can download the virtual background here.
2. Prior to the formal conference, presenter shall join the test room to make sure everything is on the right track
3. Note: Please rename your Zoom Screen Name in below format before entering meeting room.

Role	Format	Example
Conference Committee	Position-Name	Conference Chair-Name
Keynote/ Invited Speaker	Position-Name	Keynote/Invited Speaker-Name
Author	Session Number-Paper ID-Name	S1-SI0001-Name
Delegate	Delegate-Name	Delegate-Name

Presentation Process by Zoom Meeting



About Presentation

• Every presenter has 15 minutes, including Q & A. Each presentation should have at least 10 minutes.
• The best presentation certificate and all authors' presentation certificates will be sent after conference by email.
• It is suggested that the presenter email a copy of his / her video presentation to the conference email box as a backup in case any technical problem occurs.

Environment & Equipment Needed

• A quiet place; Stable Internet connection; Proper lighting and background
• A computer with internet and camera; Earphone

Conference Recording

• We'll record the whole conference. If you do mind, please inform us in advance. We'll stop to record when it's your turn to do the presentation.
• The whole conference will be recorded. It is suggested that you should dress formally and we appreciate your proper behavior.
* The recording will be used for conference program and paper publication requirements. It cannot be distributed to or shared with anyone else, and it shall not be used for commercial nor illegal purpose.

Simple Program

December 4th (Wednesday)

For Onsite Participants

Onsite Registration & Materials Collection for Onsite Participants
Time: 8:30-16:00 (GMT+4)
Venue: Lecture Hall 1, Khalifa University, United Arab Emirates
Address: Shakhbout Bin Sultan St - Hadbat Al Za'faranah - Zone 1 - Abu Dhabi - United Arab Emirates
Registration Steps:
1. Arrive at the **Lecture Hall 1-B-00107** of Khalifa University;
2. Inform the conference staff of your paper ID;
3. Sign your name on the Participants list;
4. Sign your name on Lunch & Dinner requirement list;
5. Check your conference kits;
6. Finish registration.

For Online Participants

Zoom Test for Online Participants	
Zoom: 858 2797 3324	
Zoom Link: https://us02web.zoom.us/j/85827973324	
Online Test (GMT+4)	
9:00-9:20	Prof. Xinghuo Yu, Royal Melbourne Institute of Technology, Australia
9:20-9:40	Session 7
15:40-16:00	Session 8
16:00-16:20	Session 9
16:20-16:40	Session 10
You can attend the test in another session if you cannot manage it in your given time.	

December 4th (Wednesday)

Morning Sessions		
Tutorial Room: Lecture Hall 1-B-00107 Zoom Link: https://us02web.zoom.us/j/89294235542		
9:00-12:00	**Tutorial 1**	**Dr. Muhammad Bakr Abdelghany**, Khalifa University, United Arab Emirates
12:00-13:30	**Lunch Time** Venue: B-00055 Foyer Area	
Afternoon Sessions		
Opening Remark, Keynote Speech & Tutorial Room: Lecture Hall 1-B-00107 Zoom Link: https://us02web.zoom.us/j/89294235542		
13:30-13:40	**Host & Opening Remark**	**Prof. Ahmed Al Durra**, Khalifa University, United Arab Emirates
13:40-14:30	**Keynote Speech I**	**Prof. Akshay Kumar Rathore,** Singapore Institue of Technology, Singapore
14:30-14:50	**Break Time**	
14:50-17:50	**Tutorial 2**	**Dr. Ryan Ahmed,** McMaster University, Canada

December 5th (Thursday)

<table>
<tr><th colspan="4">Morning Sessions</th></tr>
<tr><td colspan="4">Keynote Speeches & Panel Discussion
Room: Lecture Hall 1-B-00107
Zoom Link: https://us02web.zoom.us/j/89294235542</td></tr>
<tr><td>9:00-9:40</td><td>Keynote Speech II</td><td colspan="2">Prof. Nikolaos Hatziargyriou, National Technical University of Athens, Greece</td></tr>
<tr><td>9:40-10:20</td><td>Keynote Speech III</td><td colspan="2">Prof. Claudio Cañizares, University of Waterloo, Canada</td></tr>
<tr><td>10:20-10:30</td><td colspan="3">Award Ceremony for Keynote Speakers</td></tr>
<tr><td>10:30-10:50</td><td colspan="3">Group Photo & Coffee Break</td></tr>
<tr><td>10:50-11:50</td><td colspan="3">Panel Discussion</td></tr>
<tr><td>11:50-13:30</td><td colspan="3">Lunch Time
Venue: B-00055 Foyer Area</td></tr>
<tr><th colspan="4">Afternoon Sessions</th></tr>
<tr><td colspan="4">Onsite Parallel Sessions</td></tr>
<tr><td></td><td>< B-00107 ></td><td>< B-00055 ></td><td>< KIC ></td></tr>
<tr><td>13:30-15:30</td><td>Session 1
Chair: Prof. Mahmoud Amin
Manhattan University, USA
Topic: Power Supply Systems and Power Devices in Power Electronics
(SI0021, SI0116, SI0006, SI0113, SI0054, SI0128, SI0119, SI2004)</td><td>Session 2
Chair: Prof. Mohamed El Moursi
Khalifa University, UAE
Topic: Modern Power Systems and Control Technologies
(SI0017, SI0095, SI0110, SI0050, SI0052, SI0056, SI0058, SI0112)</td><td>Session 3
Chair: Dr. Mostafa Shaaban
American University of Sharjah, UAE
Topic: Dispatching Analysis and Control of High Penetration Renewable Energy System
(SI0004, SI0022, SI0016, SI0032, SI0041, SI0090, SI0049, SI0097)</td></tr>
<tr><td>15:30-15:50</td><td colspan="3">Coffee Break & Poster Session
Chair: Dr. Tarek EL-Fouly, Khalifa University, UAE
Topic: Intelligent Power Control System Model, Reliability Analysis and Safety Evaluation
(SI0010, SI0019, SI0062, SI0064, SI0066, SI0091, SI0094, SI0129, SI0136-A, SI2001)</td></tr>
<tr><td>15:50-17:50</td><td>Session 4
Chair: Prof. Hatem Zeineldin
Khalifa University, UAE
Topic: Fault Diagnosis and Reliability Analysis in Power Systems
(SI0014, SI0015, SI0104, SI0140, SI0020, SI0105, SI0143, SI0103)</td><td>Session 5
Chair: Prof. Hany Hasanien
Ain Shams University, Egypt
Topic: Microgrid Optimization Operation and Stability Monitoring
(SI0124, SI0083, SI0125, SI0026, SI0086, SI0080-A, SI0008)</td><td>Session 6
Chair: Dr. Hany Farag
York University, Canada
Topic: New Battery Energy Storage and Health Status Estimation
(SI0098, SI0079, SI0099, SI0144, SI0121, SI2002, SI0122, SI0126)</td></tr>
</table>

17:50-18:00	**Closing and Award Ceremony** Room: Lecture Hall 1-B-00107
18:00-19:30	**Dinner Time** Venue: Shangri-La and Traders Qaryat Al Beri, Abu Dhabi

December 6th (Friday)

<table>
<tr><td colspan="3">Morning Sessions</td></tr>
<tr><td colspan="3">Online Keynote Speech & Online Session
Time Zone: GMT+4
Zoom Link: https://us02web.zoom.us/j/89294235542</td></tr>
<tr><td>9:00-9:40</td><td>Keynote Speech IV</td><td>Prof. Xinghuo Yu, Royal Melbourne Institute of Technology, Australia</td></tr>
<tr><td>9:40-10:30</td><td colspan="2">Break Time</td></tr>
<tr><td>10:30-12:15</td><td colspan="2">Session 7
Chair: Assoc. Prof. Gheorghe Grigoras, Gheorghe Asachi Technical University of Iasi, Romania
Topic: Smart Grid Control and Reliability Analysis
(SI0001, SI0012, SI0057, SI0082, SI0087, SI0089, SI0132)</td></tr>
<tr><td colspan="3">Afternoon Sessions</td></tr>
<tr><td colspan="3">Online Sessions
Time Zone: GMT+4
Zoom 1: https://us02web.zoom.us/j/89294235542
Zoom 2: https://us02web.zoom.us/j/85827973324</td></tr>
<tr><td></td><td>< Zoom 1 ></td><td>< Zoom 2 ></td></tr>
<tr><td>14:00-15:45</td><td>Session 8
Chair: Dr. Foo Yi Shyh Eddy
Nanyang Technological University, Singapore
Topic: Data Feature Analysis and Safety Management of Power Systems
(SI0003, SI0040, SI0060, SI0071, SI0009, SI0084, SI0120)</td><td>Session 9
Chair: Dr. Rakibuzzaman Shah
Federation Universtiy, Australia
Topic: New Energy Development and Energy Market Analysis
(SI0117, SI0018, SI0059, SI0068, SI0100, SI0107, SI0063, SI0007, SI2007)</td></tr>
<tr><td>15:45-15:50</td><td colspan="2">Break Time</td></tr>
<tr><td>15:50-17:20</td><td>Session 10
Chair: Assoc. Prof. Eduardo Coelho Marques da Costa
University of São Paulo, Brazil
Topic: Smart Electrical Design and Device Design
(SI0044, SI0051, SI0101, SI0106, SI0093, SI0096)</td><td></td></tr>
</table>

Detailed Program

Tutorial 1

Time	**9:00-12:00, December 4**	**Zoom ID**	**892 9423 5542**
Room	**Lecture Hall 1-B-00107**	**Zoom Link**	**https://us02web.zoom.us/j/89294235542**

Dr. Muhammad Bakr Abdelghany

(IEEE Senior Member)

Khalifa University, UAE

Muhammad Bakr Abdelghany (Senior, IEEE) received the B.Sc. degree in Computer and Systems Engineering and the M.Sc. degree in Electrical Engineering from the Faculty of Engineering, Minia University, Minia, Egypt, in 2010 and 2015, respectively, and the Ph.D. degree in Systems and Control Engineering from the University of Sannio, Benevento, Italy, in 2022. In 2010, he served as a Teaching Assistant with the Department of Computer and Systems Engineering at Minia University, Egypt. He is currently with Khalifa University of Science and Technology (Tenure-track Researcher) and on leave from Minia University (Assistant Professor). His research interests include control synthesis, cyber-physical systems, computer-controlled systems, green hydrogen production, renewable energy systems, and embedded systems. Dr. Abdelghany has supervised/co-supervised 15 Ph.D./Master's students. He is a reviewer for various reputed journals, including the Control Community, Power and Energy Society, and Robotics and Automation Society. He is also a guest editor for a special issue under IEEE Trans. on Industry Applications on control applications in hydrogen energy systems. He was honored with prestigious academic awards, such as an outstanding Reviewer for IEEE Trans. on Sustainable Energy in 2023. Dr. Abdelghany is a senior researcher in several international projects, such as HAEOLUS, H2GLASS, and H2STEEL.

Course Summary

Energy Transition towards Renewable and Green Hydrogen Energy Systems: Technologies and Prospectives

Abstract: The course ''Optimal control of renewable and green hydrogen energy systems for grid services" provides an in-depth technical foundation for understanding the role of hydrogen in achieving net zero emissions. It addresses the integration of renewable energy sources and the decarbonization of the transportation, industrial, and heating sectors. Participants will engage with the economic considerations of green hydrogen production via water electrolysis, examining cost drivers such as technological advancements and economies of scale. The course delves into key hydrogen technologies, including electrolyzers for hydrogen production, storage systems for gaseous hydrogen, and fuel cells for power and heat generation. Learners will explore advanced modeling methodologies, focusing on the time-dependent dynamics, accuracy constraints, and computational requirements necessary for efficient system design. Optimization strategies, including hybrid dynamical systems and model predictive control (MPC), will be applied to hydrogen energy systems, with in-depth case studies demonstrating their application in real-world scenarios. By combining theoretical knowledge with practical examples, this course equips participants with the technical expertise to optimize hydrogen systems for effective renewable integration and grid service management, contributing to the development of sustainable energy infrastructures.

Opening Remark

Time	13:30-13:40, December 4	Zoom ID	892 9423 5542
Room	Lecture Hall 1-B-00107	Zoom Link	https://us02web.zoom.us/j/89294235542

Prof. Ahmed Al-Durra (IEEE Senior Member)

Khalifa University, UAE

Prof. Ahmed Al-Durra received his BSc, MSc, and PhD in ECE from Ohio State University in 2005, 2007, and 2010, respectively (with Summa Cum laude in all three degrees). He joined the Electrical Engineering Department at the Petroleum Institute (PI), UAE, as an Assistant Professor in 2010; he was promoted to Associate Professor in 2015. Since 2020, he is a Professor at the Electrical Engineering & Computer Science Department, Khalifa University, UAE. His research interests are applications of control and estimation theory on power systems stability, micro and smart grids, renewable energy systems and integration, and process control. He is now the Associate Provost for Research in Khalifa University.

Dr. Al-Durra has accomplished and has been working on several research projects at international and national levels (exceeding 25M USD). He is the head of the Energy Systems, Control & Optimization Lab at ADRIC and the Industry Engagement Theme lead for the Advanced Power & Energy Center. He has one US patent, one edited book, 12 book chapters, and over 280 scientific articles in top-tier journals and refereed international conference proceedings. He has supervised/co-supervised over 30 PhD/Master students. He is an Editor for IEEE Transactions on Sustainable Energy and IEEE Power Engineering Letters, and Associate Editor for IEEE Transactions on Industry Applications, IET Renewable Power Generation, and IET Generation Transmission & Distribution. In 2014, he obtained the PI Research & Scholarship Award for Junior Faculty, and he was elevated to the grade of IEEE Senior Member. He was awarded the UAE Pioneers Award – UAE Scientists (2018), and he is the winner of the prestigious Khalifa Award for Education - Distinguished University Professor in Scientific Research (2018-2019). He was awarded the Faculty Research Excellence Award-Khalifa University, 2020.

Keynote Speech I

Time	13:40-14:30, December 4	Zoom ID	892 9423 5542
Room	Lecture Hall 1-B-00107	Zoom Link	https://us02web.zoom.us/j/89294235542

Prof. Akshay Kumar Rathore (IEEE Fellow)

Singapore Institute of Technology, Singapore

Akshay Kumar Rathore (IEEE Fellow) is an expert in power electronics and control of electrical motor drives. He received the Gold Medal for securing the highest academic standing in his Master's degree among all electrical engineering specializations at Indian Institute of Technology (BHU) Varanasi, India. He had two subsequent postdoctoral research appointments with the University of Wuppertal, Germany (2008-2009), and the University of Illinois at Chicago, USA (2009-2010). From November 2010 to February 2016, he served as an Assistant Professor at the Department of Electrical and Computer Engineering, National University of Singapore. From March 2016-Dec 2021, he served as an Associate Professor at the Department of Electrical and Computer Engineering, Concordia University, Montreal, Canada where he was listed in the Provost Circle of Distinction in 2021. He served as Graduate Program Director and Chair of Graduate Awards during 2020-21.

His research is mainly focused on the analysis and design of novel current-fed converters (topologies and modulation), soft-switching design and modulation schemes for the dc/dc converters, pulsating DC link (electrolytic capacitorless) inverters, and control of multilevel inverters. He supervised 11 PhD theses and 14 MASc (research) theses.

Dr. Rathore is a recipient of the 2013 IEEE IAS Andrew W. Smith Outstanding Young Member Achievement Award, 2014 Isao Takahashi Power Electronics Award, 2017 IEEE IES David Irwin Early Career Award, 2019 IEEE IES Publications Service Recognition Award, 2020 IEEE IAS Outstanding Area Chair Award, 2020 IEEE Bimal Bose Award for Industrial Electronics Applications in Energy Systems and 2021 Nagamori Award. He published about 285 research papers in international journals and conferences, including 96 IEEE TRANSACTIONS.

He is currently serving as a co-Editor-in-Chief of the IEEE Transactions on Industrial Electronics, the Awards Department Chair of the IEEE Industry Applications Society, AdCom Member-at-Large and Fellow Evaluation Committee member of the IEEE Industrial Electronics Society. He is serving as the Chair of IEEE IAS Renewable and Sustainable Energy Conversion Systems Committee. He led and chaired the IEEE IAS Industrial Automation and Control Committee (2018-19) and IEEE IAS Technical Committee on Transportation Electrification (2016-17). He served as a member of IEEE IES Publications Committee (2016-2021) and IEEE IAS Andrew W Smith Outstanding Young Member Achievement Award Committee (2014-2019). He served as the Chair of IEEE IAS Montreal Chapter from 2017-2021 and received the best Chapter award in 2017 from IEEE Montreal Section for its activities.

He served as the Paper Review Chair (eq. to co-EIC) of IEEE Transactions on Industry Applications (2016-17 and 2020-21), Editor-in-Chief of IEEE IES Technology News (ITeN) (2016-18), Associate Editor of various journals, i.e., IEEE Transactions on Industrial Electronics (2014-19), IEEE Transactions on Industry Applications (2013-present), IEEE Transactions on Transportation Electrification (2014-19), IEEE Journal of Emerging Selected Topic in Power Electronics (2013-19), IEEE Transactions on Vehicular Technology (2016-19), IEEE Transactions on Sustainable Energy (2014-2021) and IET Power Electronics (2015-19). He edited 5 special issues on the topics of electric transportation, EV charging, marine systems, more electric aircraft, machine learning in power electronics, and renewable energy conversion in different IEEE Transactions as a guest associate editor and as guest-EIC of 2 special issues. He served as the distinguished lecturer (2017-18) and prominent lecturer (2019-21) of the IEEE IAS society.

Speech Contents

Advanced & Simplified Power Electronic Systems for Transportation Electrification and Renewable Integration

Abstract: Transportation Electrification and Renewable Integration are the key topics of Research and Development to accomplish the goals of decarbonization, net zero, and clean mobility. Power electronics is the key technology enabler for the development, operation, and integration of technologies for transportation electrification and renewable integration. Reliability, efficiency, and density of power electronics are crucial in deciding the life cycle cost and robust operation of the system. This talk will present some of the novel developments that produced simplified power electronics with merits of high-density, high-efficiency, and reduced components count. Experimental results and benchmarking of the advanced power electronics will be presented to demonstrate their merits over state-of-the-art power electronics solutions.

Tutorial 2

Time	**14:30-17:30, December 4**	**Zoom ID**	**892 9423 5542**
Room	**Lecture Hall 1-B-00107**	**Zoom Link**	**https://us02web.zoom.us/j/89294235542**

Dr. Ryan Ahmed

McMaster University, Canada

Dr. Ryan Ahmed is an Assistant Professor at McMaster University, deputy director of the Center for Mechatronics and Hybrid Technologies (CMHT), and co-lead faculty advisor for the Battery Workforce Challenge (BWC) . He received his M.A.Sc., Ph.D., and MBA from McMaster University in 2011, 2014, and 2018 respectively. He has held several senior positions in Electric and Autonomous vehicles at General Motors, Samsung, and Stellantis in Canada and the United States. Dr. Ahmed has taught over half a million learners from 160 countries on Udemy and Coursera, and he has over 250,000 subscribers on his YouTube channel titled “Prof. Ryan Ahmed,” where he teaches people AI, data science, and ML fundamentals. Dr. Ahmed is a Udemy Instructor Partner, Professional Engineer (P.Eng.) in Ontario, and Stanford Certified Program Manager. He is the principal author/co-author of over 40 journal and conference papers in artificial intelligence, battery systems, electric and hybrid powertrains, and autonomous systems. Dr. Ahmed is the co-recipient of two best papers awards at the IEEE Transactions on Industrial Electronics (2018) and the IEEE Transportation Electrification Conference and Expo (ITEC 2012) in Detroit, MI, USA.

Course Summary

Managing Li-Ion Battery Systems in Electric Vehicles

Abstract: This short course is designed to provide learners with a comprehensive understanding of managing Li-Ion battery systems in Hybrid Electric Vehicles (HEVs) and Battery Electric Vehicles (BEVs). The course covers essential topics in Battery Management Systems (BMS), including battery modeling, analysis, aging, thermal management, and the estimation of state of charge and state of health. Learners will explore advanced concepts such as artificial intelligence and machine learning (AI/ML), parameter estimation, system identification, optimization, filtering, and control theory, all applied to battery systems. The course emphasizes a hands-on approach, ensuring students learn through practical experience and real-world applications.

Keynote Speech II

Time	**9:00-9:40, December 5**	**Zoom ID**	**892 9423 5542**
Room	**Lecture Hall 1-B-00107**	**Zoom Link**	**https://us02web.zoom.us/j/89294235542**

Prof. Nikolaos Hatziargyriou (IEEE Life Fellow)

National Technical University of Athens, Greece

Nikos D. Hatziargyriou (Life Fellow, IEEE) is with the National Technical University of Athens (NTUA), since 1984, Professor in Power Systems, since 1995, and Professor Emeritus, since 2022. He is Part-time Professor at the University of Vaasa, Finland. He has over 10 years of industrial experience as the Chairman and the CEO of the Hellenic Distribution Network Operator (HEDNO) and as the Executive Vice-Chair and Deputy CEO of the Public Power Corporation (PPC), responsible for the Transmission and Distribution Divisions. He has participated in more than 60 R&D projects funded by the EU Commission, electric utilities and industry for fundamental research and practical applications. He has authored or coauthored more than 300 journal publications and 600 conference proceedings papers. He was the Chair and Vice-Chair of ETIP-SNET. He is past EiC of the IEEE Transactions on Power Systems and currently EiC-at-Large for IEEE PES Transactions. He is included in the 2016, 2017 and 2019 Thomson Reuters lists of top 1% most cited researchers. He is the 2020 Globe Energy Prize laureate, recipient of the 2017 IEEE/PES Prabha S. Kundur Power System Dynamics and Control Award and recipient of the 2023 IEEE Herman Halperin Electric Transmission and Distribution Award.

Speech Contents

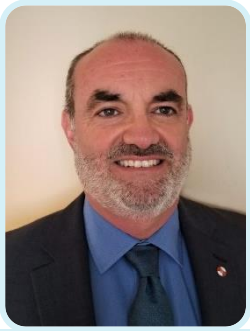
Data-Driven Frequency Secure Unit Commitment for Isolated Systems

Abstract: The replacement of directly connected synchronous generators with power electronics interfaced generation has led to a decrease in system's inertia posing a significant challenge on frequency dynamics. In particular, in isolated systems with reduced inertia predefined limits for renewable penetration and primary reserves are frequently set for dynamic security purposes. This approach might not ensure dynamic security or can prove conservative in certain conditions. Furthermore, these approaches rarely consider the capabilities of inverter based renewable generation to provide frequency services. In this presentation, a data driven approach, based on optimal classification trees is described to extract, from a detailed dynamic model of the system, the constraints for a frequency dynamic unit commitment formulation. Hence, both dynamic security and optimal exploitation of renewable and conventional units for power production and frequency support can be achieved. The advantages of the proposed method compared to conventional and state of the art approaches in frequency security are validated through dynamic simulations on a realistic model of Rhodes island. Its economic performance, computational overhead and modelling complexity is compared to alternative approaches.

Despite the benefits however, system operators may be reluctant to embrace these solutions, as the models may be challenging to interpret, perceived as black boxes. Additional concerns may arise regarding the adequacy of testing under realistic conditions. In the presentation these concerns are addressed by introducing a digital twin designed for the realistic testing of dynamic security assessment applications in the system of Rhodes. The developed digital twin incorporates two options for the virtual model of the island: an interface with a commercial RMS/EMT software and a real time simulator together with an industrial under frequency load shedding protection equipment. The settings of the actual field devices in the island are tested through a hardware in the loop interface.

Keynote Speech III

Time	**9:40-10:20, December 5**	**Zoom ID**	**892 9423 5542**
Room	**Lecture Hall 1-B-00107**	**Zoom Link**	**https://us02web.zoom.us/j/89294235542**



Prof. Claudio Cañizares (IEEE Fellow)

University of Waterloo, Canada

Dr. Claudio Cañizares is a University Professor and the Hydro One Endowed Chair at the Electrical and Computer Engineering (E&CE) Department, and the Executive Director of the Waterloo Institute for Sustainable Energy (WISE) at the University of Waterloo, where he has held various academic and administrative positions since 1993 and has received multiple recognitions, in particular the 2021-2022 Awards of Excellence in Graduate Supervision from both the University and the Faculty of Engineering. He obtained the Electrical Engineer degree from the Escuela Politécnica Nacional (EPN) in Quito-Ecuador in 1984, where he held different academic and administrative positions between 1983 and 1993, and his MSc (1988) and PhD (1991) degrees in Electrical Engineering are from the University of Wisconsin-Madison. His research activities focus on the study of stability, control, optimization, modeling, simulation, and computational issues in bulk power systems, microgrids, and energy systems in the context of net-zero, competitive energy markets, smart grids, and energy access. In these areas, he has led or been an integral part of multiple grants and contracts from government agencies and private companies worth over $92 million dollars, and has collaborated with various industry and university researchers in Canada and abroad, supervising/co-supervising close to 190 research fellows and graduate students. He has authored/co-authored over 380 publications with in excess of 33,300 citations at an 81 H-index, including journal and conference papers, technical reports, book chapters, disclosures, and patents, and has been invited to deliver keynote speeches, seminars, tutorials, and presentations at many prestigious venues worldwide. He is the Editor-In-Chief of the Institute of Electrical & Electronic Engineering (IEEE) Transactions on Smart Grid since 2020; the 2022-2023 IEEE Division VII Director of the IEEE and Power & Energy Society (PES) Boards; and a Fellow of the IEEE, a Fellow of the Canadian Academy of Engineering, a Fellow of the Royal Society of Canada, where he was the Director of the Applied Science and Engineering Division of the Academy of Science from 2017 to 2020, and a Foreign Fellow of the Chinese Society for Electrical Engineering. He is also the recipient of the 2017 IEEE PES Outstanding Power Engineering Educator Award, the 2016 IEEE Canada Electric Power Medal, and of multiple IEEE PES awards and recognitions, holding leadership positions in several IEEE and PES Committees, Working Groups, and Task Forces.

Speech Contents

The Energy Transition in Canada and Ontario

Abstract: This talk will provide an overview of Canadian provincial and remote community power grids, and a detailed discussion of Ontario's provincial grid, market, and future expansion plans, in the context of zero-emission power systems as the backbone of the energy transition. A critical overview of the decarbonization status and policies for energy systems in Canada will be also presented, focusing on zero-emission power grid, EV, and Hydrogen plans and strategies to enable a Net-Zero 2050, and concluding with a personal plea for a commitment to eliminating emissions in our daily energy use.

Panel Discussion

Time	10:50-11:50, December 5	Zoom ID	892 9423 5542
Room	Lecture Hall 1-B-00107	Zoom Link	https://us02web.zoom.us/j/89294235542

Title

Energy Transition Towards Renewable Energy Integration and Transportation Electrification

Moderator:

Prof. Ehab Fahmy El-Sadaany (IEEE Fellow)

Khalifa University, UAE

Participants:

Prof. Nikolaos Hatziargyriou (IEEE Life Fellow)

National Technical University of Athens, Greece

Prof. Akshay Kumar Rathore (IEEE Fellow)

Singapore Institute of Technology, Singapore

Prof. Mohamed El Moursi (IEEE Fellow)

Khalifa University, UAE

Dr. Mazher Syed

Power Systems Lead, Scotland, Energy Advisory, WSP

Keynote Speech IV (Online)

Time	**9:00-9:40, December 6**	**Zoom ID**	**892 9423 5542**
Room	**N/A**	**Zoom Link**	**https://us02web.zoom.us/j/89294235542**

Prof. Xinghuo Yu (IEEE Fellow)

Royal Melbourne Institute of Technology, Australia

Xinghuo Yu is an Associate Deputy Vice-Chancellor, a Vice-Chancellor's Professorial Fellow, and a Distinguished Professor at RMIT University (Royal Melbourne Institute of Technology), Melbourne, Australia. He is a Fellow of the Australian Academy of Science, an Honorary Fellow of Engineers Australia, and a Fellow of the IEEE, Australian Computer Society, and Australian Institute of Company Directors. He was the President of IEEE Industrial Electronics Society in 2018 and 2019. He received BEng and MEng degrees from the University of Science and Technology of China, Hefei, China, in 1982 and 1984, and PhD degree from Southeast University, Nanjing, China in 1988, respectively. His main research areas include control systems, intelligent and complex systems, and power and energy systems. His work has received more than 54,000 Google Scholar citations with an H-index 112. He has been recognised a Clarivate's Highly Cited Researcher in Engineering every year since 2015. He received many awards and honours for his contributions, including 2018 MA Sargent Medal from Engineers Australia, 2018 Australasian AI Distinguished Research Contribution Award from Australian Computer Society, and 2013 Dr.-Ing. Eugene Mittelmann Achievement Award from IEEE Industrial Electronics Society.

Speech Contents

AI-empowered Cyber-Physical Systems for Smart Energy Future

Abstract: Cyber-Physical Systems (CPS) represent a broad range of complex, physically aware engineered systems which integrate information and communication technologies (ICT) into physical systems for their automation, control, planning and management. Artificial Intelligence (AI) as an intelligent systems technology has a big role to play to make CPS more efficient and effective. The recent advances in CPS and AI have provided a powerful platform technology for Smart Energy Systems (SES) to deal with demands for deeper control, increased cross connectivity, embedded generation, smart metering and information exchange to embrace a clean energy future. On the other hand, SES will present enormous technical challenges for CPS and AI to address as well.

In this talk, we will first review recent developments in CPS and AI and their applications in SES. We will then examine emerging technical issues associated with synergetic interplay between CPS and AI for SES. We will also touch on potential new thinking paradigms beyond the current CPS and AI technologies to deal with spatial and temporal complexity arising from SGs, speculating potential innovative methodologies inspired by the Nature for a clean energy future. Several real-world problems we have tackled will be used as case studies to inform the discussions.

Session 1

December 5, 2024
Time Zone: GMT+4

Topic: Power Supply Systems and Power Devices in Power Electronics
Time: 13:30-15:30 (Duration for Each Presentation: 15 minutes)
Room: Lecture Hall 1-B-00107
Session Chair: Prof. Mahmoud Amin, Manhattan University, USA

Onsite

SI0021

A comprehensive methodology for assessing the economic viability of EV charging infrastructure in Brazil

Daywes Pinheiro Neto[1], António Paulo Coimbra[2], Aníbal Traça de Almeida[2], Tony Richard Almeida[2], Pedro Moura[2], Letícia Chaves Ucker[1], Raphael Aquino Gomes[1] and Alana Silva Magalhães[1]
1. Federal Institute of Goiás, Brazil
2. University of Coimbra, Portugal

Abstract-This study proposes a comprehensive methodology to assess the economic viability of electric vehicle (EV) charging infrastructure projects in Brazil, specifically targeting connections with a capacity of up to 112.5 kW, which are subject to flat electricity tariffs. The methodology employs a novel EV energy consumption model, integrates the regulatory framework of net metering and relevant tax considerations, explores the potential cost-saving benefits of photovoltaic (PV) system integration, and utilizes key economic indicators like Net Present Value and Discounted Payback Time to quantify project profitability. By accounting for a set of EV demand scenarios (low, moderate, and high), the methodology provides a multifaceted assessment of project viability. A case study demonstrates the methodology's application, highlighting the potential economic benefits of such investments. The results suggest that the minimum charging service fee required for economic viability ranges from 0.17 to 0.29 USD/kWh, with a clear cost advantage associated with PV integration observed across all scenarios.

SI0116

Adaptive Fractional-Order Model-Free Control for Permanent-Magnet Linear Synchronous Motor Drive System via Reinforcement Learning

Fayez F. M. El-Sousy[1], **Mahmoud Amin**[2] and Osama A. Mohammed[3]
1. Prince Sattam bin Abdulaziz University, Saudi Arabia
2. Manhattan University, USA
3. Florida International University, USA

Abstract-In this paper a novel adaptive fractional-order model-free integral sliding-mode control (AFO-MFISMC) scheme for permanent magnet linear synchronous motor (PMLSM) drive is proposed. First, A fractional-order ultra-local model (FOULM) is developed to formulate PMLSM dynamics for simplifying the controller design. Next, a FO-ISMC is designed to stabilize the PMLSM. To enhance the transient behavior, the total disturbance is

estimated using high-accuracy fractional-order extended state observer (FO-ESO). For improving the robustness of the proposed control scheme, a new adaptive updating algorithm based on reinforcement learning (RL) approach is developed for online estimation of the FO-ESO parameters and control input gains. An actor/critic learning structure is utilized for the adaptive autotuning mechanism. Besides, a single radial-basis function network (RBFN) is established to approximate the policy function of actor and the value function of critic concurrently for increasing the learning efficiency and decreasing the required storage space. The temporal difference (TD) error performance index and gradient-descent algorithm are utilized for updating rules of RBFN kernel function and network weights in an adaptive manner. The stability and convergence conditions of the proposed AFO-MFISMC is proved by Lyapunov function. The validation results ensure the effectiveness and superiorities of the AFO-MFISMC compared with sliding-mode control.

SI0006

Operational Challenges Faced by Distribution Utilities in the Era of Climate Change

Omar Reyadh AlAhmad and **Maha Ismail Aldahmi**
Al Ain Distribution Company, United Arab Emirates

Abstract-This paper explores the operational challenges faced by electricity distribution utilities in the context of climate change. Due to climate change, distribution utilities encounter severe damages and interruptions to their infrastructure and services' reliability as a result of the increase in the frequency and intensity of extreme and adverse weather events, rising temperatures, and shifting rainfall patterns. Globally, key challenges include damage from storms and floods, increased strain on equipment during heatwaves, and the threat of wildfires. Additionally, the integration of intermittent and weather dependent renewable energy sources as well as the compliance with evolving regulatory requirements add complexity to utility operations under adverse weather conditions. To address these issues, utilities must invest in resilient infrastructure, adopt advanced monitoring and control systems, and implement strategic planning and sustainability practices. By understanding and mitigating these challenges, distribution utilities can enhance their resilience and continue to provide reliable service in an increasingly unpredictable climate events. The paper illustrates the challenges faced by AADC during the last adverse weather conditions that had the highest amount of rainfall in 75 years and the extreme hot temperatures reached in the last few summers.

SI0113

Design and Multi-Objective Optimization of a Ferrite-Less Wireless Power Transfer System for Electric Vehicles

Nasser Jamal AlSaif and Jamal Al Sawalhi
Khalifa University of Science and Technology, United Arab Emirates

Abstract-Wireless Power Transfer (WPT) is becoming recognized as an effective method for charging Electric Vehicles (EVs), especially for its capacity to provide both fixed and dynamic charging. Designing these systems necessitates overcoming a variety of stringent technical limitations.This paper outlines a design approach for a ferrite-less WPT system that relies on evolutionary optimization. The absence of ferrites simplifies the design and lowers costs, but it also demands sophisticated optimization to achieve efficient power transfer. Key factors in the optimization process include power requirements, coil dimensions, and the spacing between the coils. A prototype operating at 400 W was tested in the lab, yielding an 83.12% DC-DC, and 92.6% WPT efficiency while the system

is built for 3.7 kW. Additionally, a multi-objective optimization was conducted to produce a Pareto optimal front, enabling an analysis of trade-offs among various design parameters to arrive at the best possible compromises. This methodology shows the system's potential while also pointing toward areas for further improvement.

SI0054

Development of Measurement Device Applied to Radiometric Systems

THAIR Ibrahim Abdel Hamid Mustafa[1], Sergio H. L Cabral[1], Hugo D. Almaguer[1], Luiz Henrique Meyer[1], Ciro Pitz[2], Cleiton Gili[3] and Marcel V. T. Fischer[4]
1. University of Blumenau, Brazil
2. Federal University of Santa Catarina, Brazil
3. Gili Energy Electronics, Brazil
4. CPFL Transmission, Brazil

Abstract-This work presents the main stages of the development of a new radiometric system, based on a new measurement device for replacing the digital oscilloscope. Once triggering principles of the commercially available digital oscilloscopes are not adequate for totally guaranteeing the recording of the irradiated electromagnetic field from the circuit breaker chambers, the main topic of this paper. This achievement represents a new generation of radiometric measurement systems applied to the assessment of power circuit breakers. Because of the non-invasive nature of this kind of assessment radiometric measurements are likely to be widely deployed in power systems because it eliminates the need for equipment under analysis in stopping its operation. Moreover, results obtained from the deployment of the new system on power substations are shown.

SI0128

Capacity Planning Model for a Multi-Rate Fast Charging Stations Using Generalized Queuing Concept

Madathodika Asna, Hussain Shareef and Achikkulath Prasanthi
United Arab Emirates University, UAE

Abstract-While fast charging stations for electric vehicles (EVs) aim to replicate the convenience of traditional gasoline stations, they currently lack the flexibility in allowing users to choose their preferred charging power. As the demand for charging infrastructure continues to rise, the development of fast chargers with adjustable power levels can significantly enhance user charging experience. These flexible chargers allow users to choose between a slower, more economical charge or a faster, more time-efficient option based on their needs. In this paper, we present a capacity planning model for optimizing the allocation of multi rate fast chargers to enhance the user charging experience. The proposed multi rate fast charging solution provides greater convenience by balancing both charging time and cost. Additionally, optimizing station capacity (number of multi rate fast chargers and waiting slot) aims to minimize user waiting time and maximize station operator profits. The dynamics of EV charging within the station are modelled using generalized queuing theory. Simulation results demonstrate that integrating a multi-rate charging facility, along with effective station capacity planning, can greatly improve the overall charging experience, while ensuring good quality of service for EV users and good profitability for station operators.

SI0119

Development of an Enhanced Performance Model Reference Adaptive System for Speed Estimation of Standalone PMSG Wind-Generating Systems

Mahmoud M. Amin[1], Aleena Jacob[1], Mahmoud F. Elmorshedy[2,3], Fayez F. M. El-Sousy[4], M. S. Bhaskar[2], Dhafer Almakhles[2]

1. Manhattan University, Manhattan, USA
2. Prince Sultan University, Saudi Arabia
3. Tanta University, Egypt
4. Prince Sattam bin Abdulaziz University, Saudi Arabia

Abstract-This paper discusses a speed estimation approach that eliminates the need for mechanical sensors to measure the speed of Permanent Magnet Synchronous Generators (PMSGs), commonly utilized in stand-alone power generation systems. The method described utilizes a sensorless technique stemming from an adaptive model reference system (MRAS) to estimate speed. The proposed system includes a wind turbine, switching rectifier, battery storage system, PMSG, bidirectional converter, LC filter, voltage source inverter (VSI), and a three-phase load. Its three primary objectives are to achieve maximum power point tracking (MPPT), regulate the DC link voltage, and preserve a constant magnitude and frequency of the output load voltage. The MRAS not only estimates the PMSG speed but also provides feedback for the MPPT control loop, employing a flow-chain approach. The success of the suggested control strategy and system is validated through various simulations and experiments, which demonstrate the reliability of the estimation method and control approach.

SI2004

From Storage to Mobility: Addressing Battery Issues in Qatar’s Energy Storage and Electric Vehicle Sectors

Kenza Maher and Ameni Boumaiza

Qatar Environment and Energy Research Institute (QEERI), Hamad Bin Khalifa University (HBKU), Qatar Foundation (QF), Qatar

Abstract-Qatar's strategic vision for sustainability and energy diversification has significantly emphasized developing energy storage systems (ESS) and electric vehicles (EVs) to integrate renewable energy sources and reduce carbon emissions. However, the successful implementation of these technologies faces unique challenges due to Qatar's extreme environmental conditions and exceptionally high temperatures, which impact battery performance, durability, and safety. This paper investigates the critical battery-related challenges within Qatar’s ESS and EV sectors, focusing on thermal management issues, battery resilience, and enhanced infrastructure, including optimized charging systems. Solutions to improve lithium-ion batteries' long-term performance and sustainability in this context are explored to support Qatar's efforts to align with global trends in clean energy and electric mobility. By addressing these challenges, Qatar can strengthen its role in the worldwide energy transition and contribute to the fight against climate change.

Session 2

December 5, 2024
Time Zone: GMT+4

Topic: Modern Power Systems and Control Technologies
Time: 13:30-15:30 (Duration for Each Presentation: 15 minutes)
Room: Lecture Hall 2-B-00055
Session Chair: Prof. Mohamed El Moursi, Khalifa University, UAE

Onsite

SI0017

Harmonic Detection in Power Electronic Converters using Machine Learning
Mohammad Suhail, Mohamed Shawky El Moursi and Khalifa Hassan Al Hosani
Khalifa University, UAE

Abstract-Ensuring precise classification of a Power Quality Disturbance (PQD) signal is crucial for maintaining the safety of power system networks. Non-linear loads introduce harmonics into the system, causing distortion in voltage and current signals. This study introduces a method for identifying power quality issues by decomposing the voltage waveform in the frequency domain and applying Kernel Support Vector Machines (SVM) to the preprocessed voltage data. The research compares the performance of AI-based classification of power quality events using time-domain data and data preprocessed with the Fourier transform, followed by machine learning techniques on an optimized model to evaluate its accuracy. Simulation results indicate that Kernel-based SVM outperforms traditional probabilistic algorithms in detecting harmonics in PQD signals.

SI0095

Assessment of Insulator Surface Pollution Severity Using Frequency Domain Spectroscopy (FDS)
Arailym Serikbay, Venera Nurmanova, Azamat Mukhamediya, Amin Zollanvari, Mehdi Bagheri
Nazarbayev University, Kazakhstan

Abstract-Insulators are vital isolating tools in power transmission lines that usually function under harsh weather conditions. Undesirable operating conditions risk insulator surface contamination and consequential issues, such as leakage current and power outages. Therefore, the accurate condition assessment and maintenance of the high-voltage insulators remain important tasks. This paper attempts to use the frequency domain spectroscopy method for the first time in a high-voltage glass and porcelain insulator surface pollution severity analysis. To achieve this goal, 34 tests were conducted in two steps: pre-contamination and frequency domain spectroscopy measurements. First, a pollution solution was applied to the insulators, assigning each test to a specific pollution type. Next, the frequency domain spectra of these insulators were measured. The dielectric dissipation factor (tanδ) values for the different contamination levels were clearly different at very low frequencies (10 μHz to 100 μHz). The pollution level can be predicted with 0.004 ± 0.003 MSE for glass insulators and 0.002 ± 0.002 MSE for porcelain insulators using deep learning.

SI0110

Novel DPC Strategy for Large Stack PEM Electrolyzers

Wahab Ullah, Hany Hamed, Khalifa Al Hosani and Mohamed El Moursi
Khalifa University, UAE

Abstract-The global transition to sustainable energy has accelerated the adoption of hydrogen as a clean energy vector, particularly in hard-to-abate sectors such as heavy industry and transportation. Proton exchange membrane electrolyzer (PEMEL) is more robust and efficient for hydrogen production as compare to other electrolyzer (EL) technologies and are characterized as high dynamic loads. However, the inherent sensitivity of these ELs to grid-side power quality issues such as harmonic distortions, voltage sags and transient instabilities, presents significant challenges for maintaining operational stability and high-efficient hydrogen production. These perturbations, if inadequately managed, can severely affect the operational stability of ELs, leading to inefficiencies in hydrogen production and degradation of power-electronic interfaces. In this paper, a novel power conversion architecture tailored for large-scale PEM is designed to ensure stable ELs operations and maximize hydrogen production efficiency. A three-level neutral-point clamped converter, employing a direct power control strategy, is integrated with an isolated bridge DC-DC converter to ensure fast dynamic response, scalability, and sustain power quality at the PCC and DC-link. This advanced topology provides galvanic grid isolation, stabilizes DC-link voltage, and offers robust dynamic response, ensuring efficient hydrogen production under variable grid-induced power quality disturbances. The detailed MATLAB/Simulink model is developed to analysed and validate the performance of the proposed architecture. The simulation results confirm that the proposed converter topology significantly enhances the operational stability and efficiency of the PEMEL, providing a scalable, high robustness and dynamic performance solution for integrating large-scale hydrogen production into modern grid infrastructure.

SI0050

VPP Economic Assessment for Harnessing Rooftop PV (RT-PV) Ancillary Services in Dubai Region

Hamad Mohamed Albeshr, **Gagandeep Singh Dua**, Faisal Sattar, Ali Husnain, Ali Almarzooqi, Sajan Kaduvetty and Tareg Ghaoud
Dubai Electricity and Water Authority, United Arab Emirates

Abstract-Utilizing Rooftop Photovoltaic (RT-PV) systems for ancillary services in power grids offers promising benefits such as improving grid stability and reducing operational and capital costs. This study explores the technical feasibility and economic viability of using distributed RT-PV systems in traditional ancillary services framework through virtual power plants, with a particular focus on voltage support and spinning reserves. This study has been conducted as an outcome from the RT-PV Shams Dubai initiative and the VPP pilot project in the Dubai region. Through a comprehensive economic analysis and assessment of the reactive power capabilities and active power curtailment of PV inverters, this work highlights the impact of the aggregation of distributed RT-PV systems to enhance grid stability, reduce operational expenses, and defer investment costs to the utility. Additionally, the reduction in CO2 emissions is calculated to reflect the environmental benefits of incorporating PV systems and their alignment with global environmental sustainability goals. The findings underscore that incorporating RT-PV for ancillary services proves to be a cost-effective strategy to optimize grid operations while promoting sustainable energy practices.

SI0052

Towards a Digital Twin Power System: A Case Study for Wind Power Forecasting

Cheng Chen[1], Gang Yang[1], Wenshan Hu[2] and **Xiaoran Dai[2]**
1. Naval University of Engineering, China
2. Wuhan University, China

Abstract-This paper presents a significant step towards realizing a digital twin power system, focusing on a case study for wind power forecasting. We propose a novel framework that integrates digital twin technology with a Gated Recurrent Unit (GRU) neural network, termed DT-GRU. This approach leverages real-time data processing capabilities and adaptive modeling to enhance wind power forecasting accuracy. Based on the digital twin based forecasting framework, the online learning mechanism is tailored to update the DT-GRU model in real time.Using real-world high-resolution data, we evaluate the DT-GRU model against traditional machine learning approaches for one-hour and two-hour ahead forecasts. Results demonstrate that our digital twin-based model consistently outperforms conventional methods across multiple error metrics, particularly in capturing rapid fluctuations in wind power output.

SI0056

Design, Analysis and Prototyping of High Voltage Nanosecond Solid-State Marx Generator

Saleh Omar Saleh Edhah[1], Ameer Ibrahim[1], Musaab Salih[1], Jamal Alsawalhi[1], Balanthi Beig[1], Noureddine Harid[1], Gideon Nimo Appiah[2], Andrei Barysevich[2], Fernando Albarracin[2] and Felix Vega[2]
1. Khalifa University, UAE
2. Technology Innovation Institute, UAE

Abstract-Solid-state pulse power generators have initiated a major revolution in the field of high-power power electronics, leading to efficient generation and control of high voltage and high frequency pulses for a number of applications such as microwave applications, water and food treatment and some medical applications such as electroporation. This paper presents analysis and design of a 5.0 kV solid-state Marx generator with a nanosecond rise time. The equivalent circuits during charging mode and discharging mode are established which are then used to analyze the performance of the circuit analytically and using simulation tool. A number of parametric studies are then conducted which aid in understanding the effect of the parasitic elements on the output pulse magnitude and rise time. Lastly, a lab-scale prototype is built and tested which proves that pulses of 5.0 kV magnitude and 40 ns rise time are obtained using 500 V input voltage and ten stages.

SI0058

Optimizing Industrial Energy Systems: A Multi-Objective Approach to Decarbonization and Cost Efficiency

Simon Kammerer, Constantin Chaumet, Christian Rehtanz and Jakob Rehof
TU Dortmund University, Germany

Abstract-The transition to a renewable energy (RE) based future necessitates transformative changes in the industrial sector's energy infrastructure. As industries strive to maintain economic viability while achieving decarbonization goals, there is a pressing need for innovative strategies that integrate renewable energy sources, enhance energy efficiency, and optimize energy procurement. This paper presents a comprehensive approach that

leverages a combination of simulation and optimization methods to address the challenges of designing and operating complex future industrial energy systems. A nested optimization approach is proposed, which combines Mixed-Integer Linear Programming (MILP) for operational optimization with black-box optimization techniques. The approach enables exploration of solutions for optimal infrastructure investment as well as operational strategies, allowing companies to benchmark a wide range of infrastructure and contractual options. This provides these companies with the means to determine long-term, cost-effective pathways that minimize CO2 emissions, avoid malinvestments, and ensure the sustainable operation of energy systems. A case study involving a German waste processing company illustrates the practical application of our approach, highlighting how strategic decisions in asset dimensioning, energy flexibility utilization, and renewable integration can significantly impact both costs and emissions.

SI0112

Protection Solutions for Embedded Distribution Networks

M Aizaz Farid, Pema Wangchuk, Inam Nutkani, Lasantha Meegahapola, Nuwantha Fernando
RMIT University, Australia

Abstract-Conventional protection schemes based on nondirectional overcurrent relays (OCRs) cannot provide adequate protection against bidirectional and relatively small fault currents from Distributed Generators (DGs) connected to the distribution system. To address this limitation, various solutions involving the placement of relays based on reliability indices and economic factors have been proposed. However, the performance efficacy and applicability of these solutions in embedded networks where parts of the network may continue to operate during fault contingencies have not been thoroughly investigated. This paper addresses this gap by proposing a range of protection solution scenarios involving different combinations of additional OCRs and directional overcurrent relays (DOCRs). These solutions aim to provide protection against bidirectional faults while allowing parts of the embedded network to operate in islanded mode. The placement of relays in each scenario is determined based on the equal distance of network segments. Additionally, this paper comprehensively assesses the techno-economic performance of new solution scenarios, mainly the impact on supply reliability and economic benefits compared to a baseline scenario with conventional OCR protection. The analysis shows that the proposed solution scenarios significantly enhance supply reliability and lead to substantial savings in energy-not-supplied (ENS) costs.

Session 3

December 5, 2024
Time Zone: GMT+4

Topic: Dispatching Analysis and Control of High Penetration Renewable Energy System
Time: 13:30-15:30 (Duration for Each Presentation: 15 minutes)
Room: Lecture Hall 3-KIC
Session Chair: Dr. Mostafa Shaaban, American University of Sharjah, UAE

Onsite

SI0004

Optimal Operation of Multi-Vector Energy Systems Considering Multiple Uncertainties

Mohammad Kiani-Moghaddam[1], Mohsen N. Soltani[1], Saltanat Kuntuarova[2] and Ahmad Arabkoohsar[3]
1. Aalborg University, Denmark
2. Technical University of Munich, Germany
3. Technical University of Denmark, Denmark

Abstract-This paper develops a mixed-integer nonlinear programming model to optimize the operation of multi-vector energy systems (MESs) under different sources of uncertainty. Considering nonlinear components and uncertainties, the operation of the MESs is a complicated challenge because conventional methods cannot be used in this condition. The proposed model relies on the energy hub tool and the Monte Carlo experiment as its key elements to alleviate this challenge. The former reflects the degrees of freedom in the structure of MESs, which can be used for optimization by creating links between multi-carrier energy resources and energy demands through conversion, storage, condition, and distribution processes. The latter augments the reliability and resilience of the model's forecasts, resulting in more informed decision-making under high-impact uncertainties related to multi-carrier energy demands, the price of electricity and gas, and renewable power production capacity. The performance of the model was assessed through various case studies on an industrial building. The results proved the effectiveness of the model.

SI0022

Integrating Renewable Energy into the Electric Railway System in Dense Urban Regions

Ahmed Mohamed, **Rohama Ahmad** and Bonny Xavier
CUNY City College of New York, USA

Abstract-This paper presents a unique application of renewable energy into an electric railway system to meet tractive power needs. A case study is presented using New York City's (NYC) subway system, the world's largest rapid transit system by number of stations. The research explores the feasibility of incorporating solar photovoltaic (PV) systems and electric vehicle (EV) charging within the existing subway infrastructure. The integration not only supports the subway system's operation without any hindrance but also enables the successful charging of three to six EVs per station, contributing towards the worldwide shift to zero-emission transportation. A financial study is also presented, which demonstrates promising economic outcomes with a profitability index of up to 1.4

and a net present value of at least $224,099, all achieved with a relatively short payback period of approximately four years.

SI0016

Secure Solar Forecasting: Deep Learning Approaches for Cyber Attacks Detection and Mitigation

Ahmed Abughali, Mohamad Alansari, Ameena Saad Al-Sumaiti and Mohamed Shawky El Moursi
Khalifa University, UAE

Abstract-Due to the increasing integration of solar energy into the energy infrastructure, solar power forecasting has become an attractive target for malicious attackers. However, existing studies in the literature primarily focus on detecting a single type of cyberattack, namely False Data Injection Attacks (FDIAs), and they lack recovery approaches. This paper proposes two deep learning-based security schemes: a two-stage detection approach and a mitigation approach. The proposed schemes are designed to accurately detect and recover stealthy FDIAs and Denial of Service (DoS) attacks. The first stage in the detection model determines whether the sample has been attacked, while the second stage categorizes the type of attack if an attack is present. After identifying the attack type, the proposed mitigation model recovers the corrupted measurements. For comparative analysis, the performance of three different deep learning models is evaluated for both tasks: detection and mitigation. The proposed models are tested utilizing a real Global Horizontal Irradiance (GHI) dataset collected from Abu Dhabi between 2017 and 2019. The two-stage detection approach yielded significantly better results than tackling the problem directly as a multiclass classification task. Specifically, the best-performing two stage detection model, the Long Short Term Memory (LSTM) model, showed an average improvement of 6.52% across the Area Under the Curve (AUC). Additionally, the best-performing proposed mitigation method, LSTM, substantially recovered the corrupted measurements by 92.53% for FDIAs and 99.62% for DoS attacks.

SI0032

Performance Analysis of Bifacial Photovoltaic Panels under Different Albedo Effects: A Case Study in Abu Dhabi, UAE

Furkan Dincer[1] and Emre Ozer[2]
1. Kahramanmaras Sutcu Imam University, Turkiye
2. Gaziantep Islam Science and Technology University, Turkiye

Abstract-The use of bifacial photovoltaic technology has become increasingly prevalent in recent years. The ability of bifacial panels to capture sunlight from the back surface allows them to generate additional electricity compared to single surface panels. The reflection of light by the ground (albedo) represents a significant factor in the performance of bifacial photovoltaic panels. Therefore, analyzing this parameter is critical to determine the highest efficiency. The present study analyzed and compared the performance of bifacial panels in a simulation environment using the PVsyst demo software. A grid-connected photovoltaic power system with 99 kWp capacity, designed in Abu Dhabi, UAE, utilizes bifacial photovoltaic panels with a nominal power of 550 Wp. The study examined a range of albedo values. Thus, the effect of different ground samples on the performance is evaluated and compared. These findings are of significant value to researchers and users alike, as they provide insight into the selection of ground for the efficacy of bifacial solar panel systems.

SI0041

Multicriteria Decision-Making Under Multiple Deep Uncertainties: A Building-Level Integrated Energy System Application

Mohammad Kiani-Moghaddam[1], Mohsen N. Soltani[1], Philip D. Weinsier[2] and Ahmad Arabkoohsar[3]
1. Aalborg University, Denmark
2. Bowling Green State University, USA
3. Technical University of Denmark, Denmark

Abstract-The operation of building-level integrated energy systems (BL-IESs) faces multiple deep uncertainties. Nevertheless, most studies use deterministic frameworks that overlook uncertainties and potentially result in suboptimal operational plans. To make optimal operational decisions, it is critical to comprehend the impacts of uncertainties. In this paper, then, the authors develop a bi-level multicriteria decision-making framework to incorporate, model, and investigate deep uncertainties in the operation of BL-IESs. The upper level simultaneously optimizes the horizon of quadruple uncertainties, considering their interactions through information-gap decision theory and non-dominated sorting genetic algorithm II. The lower level uses the energy hub concept to characterize the building as an IES. The operation problem is then developed as a mixed-integer linear optimization problem to minimize energy and emission costs within technical constraints. This framework was applied and showcased in an industrial building. The results showed the framework's ability to effectively scrutinize the effects of uncertainties on the operation of BL-IESs.

SI0090

Performance Enhancement of Photovoltaic Systems Using Parrot Optimization Algorithm-Based Optimal Control Scheme

Ayedh H. Alqahtani[1] **and Hany Mohamed Hasanien**[2]
1. Public Authority for Applied Education and Training, Kuwait
2. Ain Shams University, Egypt

Abstract-This paper presents an optimized control strategy for enhancing the low-voltage-ride-through (LVRT) capability of photovoltaic (PV) systems. The proposed method employs a proportional-integral (PI) controller, which is designed using the Parrot Optimization Algorithm (POA). The PV system is connected to the grid via a DC boost chopper and a grid-side inverter. The incremental conductance method is applied to track the maximum power of the PV system. A cascaded control strategy is implemented to control the grid-side inverter. The effectiveness of the POA-PI controller is tested under various symmetrical and asymmetrical fault conditions, demonstrating significant performance improvements. The results are compared with those obtained from a genetic algorithm-PI control system. Numerical simulations are carried out using PSCAD/EMTDC software, illustrating the robustness of the proposed approach.

SI0049

PV and Energy storage Roles in Advancing Hospital Power Stability under Regular Power Outages

Rana El Sibai, Eva Barbulescu, Habiba Ahmed and **Mohamad Nassereddine**
University of Wollongong in Dubai, United Arab Emirate

Abstract-The energy sector, with a specific focus on electricity, plays a crucial role in fostering economic development, healthcare, education, and industrial progress. Unanticipated power interruptions, particularly prevalent in developing regions like the MENA area, stem from a variety of factors such as natural disasters, economic and political instability, conflicts, and aging power infrastructure. Hospitals, in particular, heavily depend on a consistent power supply to ensure patient well-being and safety. Nevertheless, unforeseen power outages present significant obstacles by disrupting healthcare services and negatively impacting patient health and welfare. In response to this challenge, hospitals have traditionally turned to diesel generators as alternative energy sources. However, these generators encounter issues related to pollution as well as high operational and energy expenses. This research undertakes a thorough feasibility assessment for two proposed photovoltaic (PV) systems, with the support of a case study utilizing hospital energy consumption data. The results highlight the viability of integrating PV systems with electric vehicles (EVs) and energy storage solutions to enhance the quality and reliability of hospital power supply.

SI0097

Power Quality Classification with S-Transform and Ensemble Learning for Multi-Class Complex Analysis

Rami Moustafa Ahmed and **Hussain Shareef**
United Arab Emirates University, United Arab Emirates

Abstract-Power quality (PQ) disturbances are major challenges in modern electrical power systems, requiring an accurate classification method to assure reliability system. To address this issue, this paper presents an approach using ensemble machine learning with bagging techniques for the classification of complex PQ disturbances. The methodology involves the application of the Stockwell Transform (ST) for feature extraction from simulated power quality signals, capturing both time and frequency domain information important for disturbance analysis. Through experimentation involving simulated complex signals, we successfully classified 16 distinct power quality disturbance classes with an overall accuracy of 99%. This approach offers a promising solution for real-world application in power systems for the reliable detection and classification of PQ disturbances.

Session 4

December 5, 2024
Time Zone: GMT+4

Topic: Fault Diagnosis and Reliability Analysis in Power Systems
Time: 15:50-17:50 (Duration for Each Presentation: 15 minutes)
Room: Lecture Hall 1-B-00107
Session Chair: Prof. Hatem Zeineldin, Khalifa University, UAE

Onsite

SI0014

Improving Isolated Microgrid Inverter Lifetime with Reinforcement Learning-based Energy Management
Ahmed Refaat Mohamed Attia Elshamy, Adham Osama Ahmed, Mohammed Tagelsir Barakat Elsir, Sami Muhaidat, Khalifa Hassan Al Hosani, Mohamed Shawky El Moursi and Ameena Saad Al-Sumaiti
Khalifa University, UAE

Abstract-This paper proposes a novel method for including the inverter reliability as an objective in the isolated microgrid scheduling. Inverter switches degradation modelling is highly non-linear. With the unlimited scenarios of solar irradiance, ambient temperature and load, building an optimal controller or policy becomes sophisticated. This work proposes using reinforcement learning (RL) as the energy management system (EMS) of an isolated microgrid. The isolated microgrid is successfully formulated as a Markov decision process, with 4-step ahead scheduling. The resulting formulation included the accumulated IGBT degradation in the reward function by converting it to a cost based on expected failure limit. Soft Actor-Critic is then trained on summer period from actual environmental and loads datasets. Having achieved the required training criteria, the proposed RL-based EMS is then tested on 10 days. Testing shows the proposed EMS reduces the IGBT damage by 21% compared to base EMS, while still extracting more energy from the Photovoltaic plant.

SI0015

Real-Time Fault Detection, Classification and Location in Power Distribution Systems Using D-PMU Enabled Hardware-in-the-Loop Testbed
Sajan K. Sadanandan, Mayank Nagendran, Gagandeep Singh Dua, Lorenzo Zanni, Paolo Romano and Tareg Ghaoud
Research and Development Centre, Dubai Electricity and Water Authority, UAE

Abstract-This paper presents a real-time hardware-in-theloop (HIL) testbed designed for fault detection, classification, and location (FDCL) in power distribution systems, utilizing Distribution Phasor Measurement Units (D-PMUs) and the OPAL-RT simulator. The testbed integrates D-PMUs and the OPAL-RT platform to generate time-synchronized measurements at strategic locations within a medium voltage (MV) grid. The FDCL algorithm leverages these measurements along with a digital twin model of the grid to enhance fault management capabilities. The algorithm uses the D-PMUs data to accurately identify faulted areas and estimate fault locations, regardless of fault type, grid topology, or grounding system. A series of test cases, involving various fault types,

resistances, and locations, were conducted to validate the performance of the FDCL system. Results demonstrate the algorithm's efficacy in quickly and accurately identifying and locating faults, thus minimizing outage durations and improving grid reliability.

SI0104

Data-Driven Fault Diagnosis and Localization in Multiphase Induction Drives

Hammad Hasan, Omar Al Zaabi, Khalifa Al Hosani, Mohamed El Moursi
Khalifa University, United Arab Emirates

Abstract-This study introduces a neural network-based ap- proach for diagnosing faults in multiphase induction drives. The primary objective is to enhance the computational time, reliabil- ity, and operational efficiency of the drive systems. To achieve this, we have developed a neural network trained on a dataset generated with a five-phase field-oriented controlled drive. The dataset includes stator currents of different faulty scenarios along with the speed of the drive system. The simulation model using a five-phase inverter connected with a five-phase machine, recording stator currents under different fault conditions, is used for collecting the data. The main focus is on inverter faults in a drive system, specifically open-circuit (OC) and open-switch (OS) faults.

SI0140

Fault Compensations in Compensated Distribution Networks to Mitigate Powerline Bushfires using a Backstepping Nonsingular Integral Sliding Mode Controller

Tushar Kanti Roy[1], **Md Apel Mahmud[2]** and Amanullah Maung Than Oo[1]
1. Macquarie University, Australia
2. Flinders University, Tonsley, Australia

Abstract-A hybrid nonlinear control scheme combining the backstepping and nonsingular integral terminal sliding mode control schemes is presented for the residual current compensation (RCC) inverter in a compensated distribution network. The main control objective is to swiftly compensate fault characteristics to avoid powerline bushfire risks in bushfire prone areas. The proposed control scheme is developed considering a second-order dynamical model of RCC inverters, comprising the neutral voltage and neutral current dynamics. The new control scheme is developed in a way that the neutral voltage tracking error is considered as the basis for developing the virtual control input for tracking the neutral current. At the same time, both tracking errors are considered to determine the nonsingular integral terminal sliding surface based on which the overall control law is derived for the RCC inverter. The performance of the proposed controller is evaluated in terms of compensating fault characteristics and compared with a nonsingular integral terminal sliding mode controller.

SI0020

Switched Reluctance Motor with Permanent-Magnet Embedded Rotor Ring for Torque Enhancement in High Speed Applications

Aydin Yousefi Javid[1], Alireza Sohrabzadeh[2], Hossein Torkaman[2], **Solmaz Kahourzade[3]**, Amin Mahmoudi[4] and Wen Soong[5]
1. Islamic Azad University, Iran

2. Shahid Beheshti University, Iran
3. University of South Australia, Australia
4. Flinders University, Australia
5. The University of Adelaide, Australia

Abstract-High speed motors are gaining more popularity thanks to their having various applications. Switched Reluctance Motors (SRMs) can be considered suitable candidates for high speed applications because of their simplicity and reliability. However, relatively low values of the produced torque due to design requirements are sometimes considered among their problems. In this paper, a novel, high-torque, and high-efficiency topology for high speed SRMs is proposed which uses a Permanent Magnet (PM) Ring in the Rotor of SRM and is labeled by PMRRSRM. After a brief explanation of design, finite element methods (FEM) are conducted to identify the most proper geometry compared to other configurations in PMRRSRM, as well as to calculate multiple key features like torque profile, current profile, flux density, efficiency, etc. Then, to verify performance in vast operation points, results are extracted per different excitations and speeds. The presented motor seems to be a good candidate for high speed applications which benefit from the inherent characteristics of the SRMs and also the use of PM for torque increment.

SI0105

Artificial Neural Network Controller for DC-DC Boost Converter: A Design and Performance Analysis

Amulya Viswambharan, **Rachid Errouissi**, Sarada Phani Kiranmai and Mahdi Debouza
United Arab Emirates University, United Arab Emirates

Abstract-This study introduces an artificial neural network (ANN)-based machine learning controller for the DC-DC boost converter. The primary controller is a Disturbance Observer based Feedback Linearization controller, which serves as an expert to provide training data for the proposed ANN. After fine-tuning the ANN is seamlessly integrated into the feedback loop, directly facilitating boost converter control. The key advantage is in the ANN ability to enhance system identification, reduce model errors, and accommodate uncertain parameters. MATLAB/Simulink simulations validate the high performance of the ANN controller, showcasing its capability to follow dynamic reference commands fast, maintain output stability amidst input voltage variations, and effectively handle constraints on maximum duty-ratio and current.

SI0143

Gaussian Naïve Bayes Algorithm Based Transmission Line Fault Classification by Using Single-Ended Parameters

T Venkata Pavan Kumar and Vivek Pandya
Pandit Deendayal Energy University, India

Abstract-The transmission line is the most important component of the power system. Classifying the faults occurring on the transmission line helps the system operator activate the mechanism of unsymmetrical tripping of the circuit breaker. In this work, different types of faults occurring on the transmission line are classified with the help of singleended parameters only. Firstly, the data required to generate features is created by simulating the practical transmission line in PSCAD software. The data consists of all three phase voltages and currents on one

side of the transmission line when the line is subjected to all possible faults including no fault condition. While simulating the faults on the transmission line, parameters such as fault resistance, fault inception angle, and fault location are varied in all types of faults. The generated data is uploaded to Python software to calculate different features such as time series parameters and frequency series parameters. This feature set is applied to different machine learning algorithms to classify the faults on the transmission line. The performance of the different algorithms is compared to select the best algorithm.

SI0103

Impact of High VRE Penetration on the Transient Stability of Rajasthan Power System in India

Gaurab Dash, Priyam Jain, Raj Kishan, Rahul Shukla, **Goodelli Madhukar**, Vivek Pandey and S Usha
National Load Despatch Centre, Grid Controller of India Limited, India

Abstract-Modern power systems with very high penetration of Variable Renewable Energy (VRE) sources may face several issues such as reduced inertia and instability. There has been significant renewable energy capacity addition in the Indian Power System in recent years. Rajasthan is one of the renewable-rich states in India where multiple large-capacity RE plants (mostly PV solar) are being pooled at EHV/UHV stations. The generation getting pooled at these UHV stations is evacuated through long-distance transmission lines. This paper presents a case study to analyze the impact of large-scale renewable energy penetration in Rajasthan on the transient stability of the system. The network of the IBR-dominated state of Rajasthan in India is modelled in detail and the system's behaviour is studied under various faults at different locations under both active and reactive power priority modes of operation of the RE plants. The severity of large contingencies on the RE complex of Rajasthan is studied and suitable measures for improvement of the transient stability of the region are explored. The paper also draws inferences from the simulation studies and attempts to correlate them with the real-time experiences observed during large grid events that have taken place in the complex in the recent past.

Session 5

December 5, 2024
Time Zone: GMT+4

Topic: Microgrid Optimization Operation and Stability Monitoring
Time: 15:50-17:35 (Duration for Each Presentation: 15 minutes)
Room: Lecture Hall 2-B-00055
Session Chair: Prof. Hany Hasanien, Ain Shams University, Egypt

Onsite

SI0124

BMS for Wind-Battery Powered Standalone Microgrid by LSTM-ANN Controllers
Utkal Ranjan Muduli, Mohamed Shawky El Moursi, Khalifa Al Hosani and Ahmed Al Durra
Khalifa University, UAE

Abstract-The battery bank unit is essential in all power supply systems, particularly those powered by renewable energy sources. Wind energy conversion systems are operational in numerous locations for a wide range of applications. Unfortunately, wind energy depends on weather conditions and unpredictable. The power generated by wind energy conversion systems is inconsistent and fluctuates rapidly over time. Therefore, it is imperative to utilize a battery energy storage system in order to maintain stability in the power output of the wind power production system, particularly when operating in standalone mode. It is essential to establish an effective energy management system in order to properly distribute energy between generation, battery, and load. In order to guarantee prompt and efficient reactions to unexpected changes in the power supply system, the suggested control strategies of the system are put into action utilizing LSTM-ANN controllers across different converters. The wind power conversion system and battery bank units are linked to a shared dc-link via their individual converters. Consequently, a new control strategy has been created to manage the voltage at the dc-link while overseeing the energy management system. LSTM-ANN controllers are employed in the suggested control approaches in this research paper to obtain timely and valuable feedback amidst rapid changes in the system, whether it is on the generation or load aspect. The paper emphasizes the diverse outcomes and knowledge acquired through the execution of Hardwarein-the-Loop simulations on the OPAL-RT platform.

SI0083

Hybrid Voltage and Current Control of Distributed Energy Resources for Harmonic Compensation of Single-Phase AC Loads in DC Microgrids
Mehdi Bharizadeh[1], Neda Keshavarzi[2], Mohammad Sadegh Golsorkhi[1] and Thomas Ebel[1]
1. Centre for Industrial Electronics, Institute of Mechanical and Electrical Engineering, University of Southern Denmark, Denmark
2. Khomeinishahr Branch, Islamic Azad University, Iran

Abstract-In DC microgrids, AC loads are supplied through inverters. Single-phase AC loads create oscillatory instantaneous power, which results in a harmonic current on the DC side with twice the fundamental component's

frequency. The flow of these harmonic currents in DC lines leads to increased losses and reduced voltage quality. This paper addresses the compensation of the harmonic current generated by local single-phase AC loads in DERs within DC microgrids. To achieve this, a novel control method for DERs is proposed, which simultaneously regulates the DC component of their output voltage and the harmonic component of their output current. This hybrid voltage and current control method (HCM) combines two decoupled outer loops for DC voltage and harmonic current regulation, along with an inner current loop. The operation of the proposed control is discussed in detail, and its effectiveness is validated through simulation results.

SI0125

Fuzzy Controllers based BMS with Multiport DC to DC Converter for DC Microgrid

Utkal Ranjan Muduli, Mohamed Shawky El Moursi, Khalifa Al Hosani and Ahmed Al Durra
Khalifa University, UAE

Abstract-Power supply systems that harness a range of renewable energy sources possess the ability to provide reliable electricity. Employing a successful control method alongside suitable converters can guarantee a stable power source for various types of equipment. The rising demand for DC-Microgrid systems linking various renewable sources highlights the need for a reliable control strategy to guarantee efficient energy management. Typically, a battery bank system needs to be incorporated into the DC-Microgrid in order to uphold energy management within the system. Therefore, this paper presents the development of a highly effective battery energy management system (BEMS). This paper has opted for a multiport DC to DC converter because it facilitates the integration of multiple renewable energy power generating units, battery banks, and loads. A shared DC bus connects a solar facility, a wind power facility, and a battery bank. A novel control unit has been introduced for a multiport DC to DC circuit. The primary goal of this control unit is to guarantee effective BEMS operation and uphold a stable voltage on the DC bus. The suggested control approach utilizes Takagi-Sugeno Fuzzy controllers to improve the efficiency of the proposed system in the face of sudden changes in system parameters, including wind speed, solar irradiance, and load current. OPAL-RT modules are employed to demonstrate different results in various operational scenarios, thus aiding in the advancement of Hardware-in-the-Loop.

SI0026

Particle Swarm Optimization and Genetic Algorithms for Optimal Management of Network of Microgrids Based Renewable Energy and Diesel Generators

Adel Merabet[1,2], Ahmed Al-Durra[2], Tarek El Fouly[2] and Ehab F. El-Saadany[2]
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2. Khalifa University of Science and Technology, United Arab Emirates

Abstract-In this paper, particle swarm optimization and genetic algorithms are applied for the optimization of a network of microgrids based on renewable energy and diesel generators. The problem is formulated based on networked microgrids by developing the equalities, inequalities and bounds constraints using specific design variables and an objective function. These metaheuristic optimizations are applied based on the formulated problem to operate the network of microgrids during a day (24 hours). Simulations are conducted to operate a network of three microgrids by optimizing the diesel generators usage and the power exchange between the microgrid in the network. Results are provided to show optimization outcomes, of the two metaheuristic

algorithms, using the formulated problem of the network of microgrids.

SI0086

Black-start Capability with Advanced Control Strategies for Hybrid PV Power Plant

Mohamed Atef Shahboob, Mohamed Shawky El Moursi, Tarek El Fouly and Ahmed Al Durra
Khalifa University, UAE

Abstract-This paper explores the potential of a large-scale hybrid Photovoltaic-Battery Energy Storage System (PV-BESS) to deliver black-start ancillary services, which are essential for restoring the power system following blackouts. A novel black- start control strategy is introduced, leveraging both grid-forming (GFM) and grid-following (GFL) converters, unlike conventional strategies that predominantly use grid-forming converters. The study's findings highlight the robustness of the proposed control strategy in addressing key challenges such as mitigating trans- former inrush current during transformer energization, main- taining frequency stability during load pickup, and achieving seamless synchronization with the grid. Additionally, DC link dynamics are considered and a fault is simulated during the black-start to test the control strategy's robustness. Overall, the proposed black-start strategy demonstrates significant advance- ments in the control and operation of large-scale hybrid PV- BESS, ensuring efficient and reliable power system restoration.

SI0080-A

Cybersecurity Induced Vulnerabilities in Inverter Dominated Microgrids

Alkistis Christina Kontou[1], Mazheruddin Syed[2], Alexandros Paspatis[3] Charalambos Konstantinou[4] and Nikos Hatziargyriou[1]
1. National Technical University of Athens (ICCS-NTUA), Greece
2. Energy Advisory, WSP, UK
3. Metropolitan University of Manchester, UK
4. King Abdullah University of Science and Technology, Saudi Arabia

Abstract-The transition of power networks to achieve net-zero targets is dependent upon proliferation of inverter interfaced sources and extensive digitization of power systems. The stability, efficiency and optimal operation of such an inverter dominated network remains a challenge. While the incorporation of information and communications technologies have aided their advanced control and optimal operation, the cyber layer adds another layer of vulnerability, i.e., make them prone to cyber-attacks. Communications and control networks may introduce new vulnerabilities in microgrids that an adversary can exploit to maliciously alter the behavior of the system or even cause stability issues in the physical layer. The impact of those cyber-attacks may differ significantly and depend on the type of inverter (grid forming vs grid following) and the attacked element, device, measurement or control function. In this presentation, the impact of a widely used control mechanism, droop control, and network parameters, e.g. the line impedances, on the severity of a cyber-attack targeting grid forming and grid following inverters will be presented. Cyber-attacks on the secondary and primary control of inverters will be demonstrated. Through this, aspects related to the interactions between the cyber layer and the physical layer as well as the different vulnerabilities introduced from grid forming and grid following inverters will be presented. This in turn is crucial for the reliable operation of microgrids and can inform the design to enhance the cyber resiliency of microgrids and therefore of power systems.

SI0008

Enhancing Microgrid Stability and Performance Using Dynamic Q − V Controller for VSG

Shraf Eldin Sati, Ahmed Al-Durra, Hatem H. Zeineldin, Tarek H. M. EL-Fouly and Ehab F. El-Saadany
Khalifa University of Science and Technology, UAE

Abstract-The active power droop gain determines the stability margin of a Microgrid (MG). Increasing this margin enhances MG's transient performance and robustness. However, prior research on virtual synchronous generators (VSGs) has focused on improving MG stability through either parameter selection or $P-\omega$ control loop adjustments, jeopardizing the dynamic characteristic and neglecting the outer voltage control loop impact. This paper proposes a practical approach to enhance MG stability and performance by embedding a dynamic reactive power derivative controller into the VSG static voltage control loop. The proposed derivative controller is structured using local measurements without adding a new derivative controller, thereby avoiding the complexities of derivative controller implementation in the real world. The controller is designed through small-signal stability to maximize MG marginal stability. The paper also provides design guidelines for selecting the proposed controller's parameter depending solely on time-domain simulation reflection, thereby eliminating the need for time-consuming small-signal models in large systems. Furthermore, the effects of the dynamic voltage control loop on power response, rate of change of frequency (RoCoF), and voltage profile are investigated. The results show significant improvements in MG stability and reactive power oscillations damping while maintaining desired RoCoF levels.

Session 6

December 5, 2024
Time Zone: GMT+4

Topic: New Battery Energy Storage and Health Status Estimation
Time: 15:50-17:50 (Duration for Each Presentation: 15 minutes)
Room: Lecture Hall 3-KIC
Session Chair: Dr. Hany Farag, York University, Canada

Onsite

SI0098

Coordinated Flexible PV Operation and Fuel Cell Efficiency Tracking for Stable Microgrids with Grid-Forming Battery

Ammar Atif Abdalla and Mohamed Shawky El Moursi
Khalifa University, UAE

Abstract-Microgrids with grid-forming Battery Energy Storage Systems (BESS) face voltage and frequency stability challenges due to fluctuating loads and intermittent sources, such as photovoltaic power plants (PVPP). Especially when the BESS's state of charge (SOC) reaches its minimum limit (SOCmin), causing under-frequency and battery depletion, leading to either load shedding or BESS damage. Conversely, over-frequency and overcharging occur when SOC reaches its maximum limit (SOCmax) due to excess PV generation, often mitigated by curtailing PV output through direct load following control, resulting in instability under rapid weather changes. This paper proposes two innovative strategies. First, to avoid load shedding at SOCmin, we propose the integration of a fuel cell (FC) equipped with a flexible efficiency tracking controller based on a polynomial fitting technique, providing efficient power support without sacrificing fuel cell efficiency. Second, when SOC reaches SOCmax, we investigate coordinated flexible operation among multiple PVPPs with different irradiance conditions to manage excess generation without inducing stability issues. The proposed controller was rigorously tested across various scenarios.

SI0079

Analysis and Design of Battery Energy Storage System for a Commercial Building in Dubai

Kannan Thirugnanam, Juan David Barbosa, Ali Saberi Derakhtenjani and Tareg Ghaoud
Dubai Electricity and Water Authority, UAE

Abstract-The grid-connected distributed energy resources (DERs) received significant attention in recent years due to the technical and economic benefits they bring to the grid such as increased energy efficiency, improved grid reliability, increased resiliency and flexibility, reduced cost of energy generation, and decreased carbon dioxide (CO2) emission. This paper presents a methodology to analyze and design a battery energy storage (BES) system for a commercial building in Dubai. The commercial site is equipped with solar photovoltaic (PV) system and building load power demand (LPD). The objective of this study is to model the DERs and their impact on the supplying power to the building LPD, propose a methodology for the sizing of a suitable BES, and design an

energy management system (EMS) to manage the DERs by reducing the energy consumed from the grid. In this study, the DERs are modelled at the system level rather than the component level. This would be sufficient for the purpose of this analysis producing the energy cost savings, CO2 emission, and the energy demand reduction. Then, the BES sizing and economic assessment modelling has been developed to estimate its impact on the energy saving cost when managed in coordination with the site DERs. Finally, an EMS has been proposed with multiple modes-of-control. This EMS has shown to provide significant benefits to the grid and also to the commercial site. One year of historical real-time data of weather and building LPD have been used to demonstrate the benefits of these DERs to the grid and the site.

SI0099

Integration of Multi-Function BESS Based on Coordination Strategy to Simultaneously Support Multiple Ancillary Services

Mohamed Montasir Babiker, Khalifa Hassan Al Hosani, Mohamed Shawky El Moursi and Ameena Saad Al Sumaiti
Khalifa University, UAE

Abstract- The intermittent nature of renewable energy sources (RES) can be mitigated by Battery Energy Storage Systems (BESS) providing ancillary services. However, the high cost of BESS remains a significant barrier to its utilization. This paper proposes a solution by utilizing BESS to provide multiple ancillary services simultaneously, maximizing their value and efficiency. Several control loops are implemented for frequency response, voltage support, and wind power smoothing. Moreover, a novel coordination strategy is proposed based on a dynamic PQ chart for the grid-side inverter. This strategy coordinates voltage and frequency outer regulation loops, optimizing the active and reactive power support with consideration of inverter power limits and State of Charge (SoC), allowing for the simultaneous provision of multiple ancillary services. The proposed system's functionality and capability to provide the required support are validated through MATLAB simulations, demonstrating the effectiveness of the coordination strategy in mitigating the effects of generation intermittency and load variation and enhancing renewable energy (RE) integration.

SI0144

Comparative Analysis of Artificial Intelligence and Statistical Models for Li-ion Battery Cells State Estimation in Electric Vehicles

Rasha Tabasha[1], Abdulla Ismail[1], Haris Khalid[2] and Jinane Mounsef[1]
1. Rochester Institute of Technology- Dubai, UAE
2. University of Dubai, UAE

Abstract-This paper presents a comparative study of statistical modeling and Artificial Intelligence (AI) approaches for estimating essential parameters of lithium-ion (Li-ion) batteries in electric vehicles (EVs). The key parameters estimated in this study are voltage, current, and temperature of Li-ion battery cells in EVs. A precise state estimation is required to ensure safety operation, to optimize the Battery Management System (BMS), and to enhance the battery life. Variations in EVs batteries parameters may occur due to different reasons such as sensor faults or attacks. As a result, obtaining an accurate estimation is essential to maintain EV battery efficiency. Using real-word measurements data, a statistical model presented by Linear Kalman Filter (KF) is obtained for each

parameter. Furthermore, by taking the advantages of Machine Learning (ML) and AI, models using linear regression and Support Vector Regression (SVR) are extracted for each parameter. The performance of the three different models is evaluated based on the Mean Squared Error (MSE). The results demonstrate the strengths and weaknesses of each model in estimating every parameter. This work offers contribution to the state estimation of EV battery, promoting safety, reliability, and enhanced operation of EV battery.

SI0121

Super Twisting SMC based 5L-NPC for Medium Voltage Grid Connected PV-Battery System

Kalpana Beura[1], Omar Al Zaabi[2] and **Mohamed Alkhatib[1]**

1. UAE University, UAE

2. Khalifa University, UAE

Abstract-Medium voltage drives, particularly those for induction motors, are regularly using in various industrial tasks. The efficient management of induction motors is crucial in nuclear power plants. Induction motors are often controlled using direct torque control (DTC) to achieve smoother speed torque characteristics in comparison to other available control methods. Nevertheless, traditional DTC encounters numerous challenges due to the need to uphold a consistent reference flux across all speed ranges. Therefore, this paper presents the implementation of two innovative super twisting sliding mode (STSM) controllers in a novel DTC system. The induction motor is driven by a 5L-NPC: five level neutral point clamped inverter operating in three phases. The connection to the dclink is made via a 36-pulse converter. Additionally, a photovoltaic (PV) system is added with a battery bank to ensure uninterrupted power supply in off-grid situations. A constant dc-link voltage is maintained through the use of a dc bidirectional circuit that links the dc-bus with the battery. The suggested regulation of the dc bidirectional converter has the potential to minimize the oscillations and ripples in the dclink caused by the 36 pulse converter when the grid voltages are unbalanced. In order to identify best vector location, whale optimization methodology has been implemented. This paper presents practical responses by implementing hardware-inthe-loop (HIL) using OPAL-RT circuits. The results obtained from HIL are examined across multiple case studies.

SI2002

Thermal Management Challenges in Lithium-Ion Batteries: Understanding Heat Generation Mechanisms

Kenza Maher[1], Ameni Boumaiza[1] and Ruhul Amin[2]

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2. Energy and Transportation Science Division, Oak Ridge National Laboratory, USA

Abstract-Thermal management is crucial for the performance, safety, longevity, and heavy-duty applications of lithium-ion batteries (LIBs) used in electric vehicles (EVs) and electric vertical takeoff and landing (EVTOL) vehicles. This paper investigates the heat generation mechanisms in Panasonic LIB cells and the thermal management challenges posed by their high energy density and complex electrochemical processes. Heat generation in these cells originates from reversible processes related to entropy changes during charge and discharge cycles and irreversible processes, such as ohmic losses and charge transfer resistance. These thermal effects can degrade battery performance, accelerate aging, and increase the risk of thermal runaway if not effectively managed. Using isothermal calorimetry and electrochemical impedance spectroscopy (EIS) at three

different temperatures, this study highlights the importance of understanding and optimizing thermal behavior to enhance battery efficiency, safety, and durability. The findings contribute to developing improved thermal management strategies that mitigate risks associated with high-temperature operation, ensuring the reliability of LIB systems in demanding applications.

SI0122

Novel Battery Management System of PV-Battery based Standalone Power System

Kalpana Beura[1], Omar Al Zaabi[2] and **Mohamed Alkhatib[1]**
1. UAE University, UAE
2. Khalifa University, UAE

Abstract-The paper presents an innovative Battery Management System (BMS) for a standalone power system based on a PV-Battery hybrid setup. As solar energy becomes more affordable, PV systems are increasingly being used to meet residential and agricultural power demands. However, these systems often face challenges due to unbalanced loads between single-phase and three-phase requirements, particularly with the use of induction motors for water pumping. To address this, the system employs a three-phase inverter to ensure stable AC power across diverse loads. A key focus is maintaining reliable power quality at the load bus under varying solar conditions and load imbalances. The proposed BMS integrates advanced control methodologies, including a 3DOF-PID controller, which outperforms traditional PI and Fuzzy controllers in achieving faster, more accurate responses. Additionally, the system utilizes a perturb and observe algorithm to optimize PV generator performance at maximum power. Hardware-in-the-Loop (HIL) simulations, performed using OPAL-RT modules, demonstrate the effectiveness of the proposed control strategies. The study highlights the critical role of adaptable, innovative BMS in enhancing the efficiency and reliability of PV-Battery standalone systems for both residential and agricultural applications.

SI0126

Modeling and Parameters Estimation of Battery Bank by Using Modified Grey Wolf Optimization

Utkal Ranjan Muduli, Mohamed Shawky El Moursi, Khalifa Al Hosani and Ahmed Al Durra
Khalifa University, UAE

Abstract-Batteries are used for many applications including transport, home, energy storage purpose, grid integration, industries and many more. Battery bank consists of multiple batteries arranged in series-parallel combination depending on requirement. It is crucial to develop a model with modeling of the battery bank in order to enhance comprehension of extensive battery energy storage systems. The task is highly intricate due to the fact that packs may consist of thousands of cells that vary and degrade unevenly. A precise battery model is necessary on a simulation platform to advance an efficient battery system. A battery model has been constructed using the MATLAB/Simulink platform in the course of this research. Hence, it is essential to create a precise battery model and a dependable state of charge (SOC) estimator in order to prevent the battery from being overcharged or overdischarged. Many investigations have been undertaken to explore the modeling of lithium-ion battery cells and to make estimations of their SOC. Various researches have investigated differences in the quantity of RC networks in the model and diverse estimation techniques. There are multiple factors to consider when modeling the battery bank. This paper introduces a new optimization method called modified grey wolf optimization

(MGWO) to accurately estimate different parameters and achieve the desired response. The details of MGWO's approach to estimating battery parameters are outlined. Various responses are presented in this paper under different operating conditions.

Poster Session

December 5, 2024
Time Zone: GMT+4

Topic: Intelligent Power Control System Model, Reliability Analysis and Safety Evaluation
Time: 15:30-15:50
Session Chair: Dr. Tarek EL-Fouly, Khalifa University, UAE

Onsite

SI0010

Capacitor Isolated Vehicle-to-Vehicle Energy Sharing Converter Based on Electric Vehicle Motor Winding and Inverter

Guanqun Qiu, Vinod Khadkikar and Bashar Zahawi
Khalifa University, United Arab Emirates

Abstract-Vehicle-to-vehicle (V2V) energy sharing is an approach that can help alleviate the range anxiety of electric vehicle (EV) drivers because it can solve the “last kilometer” problem that can prevent an EV with a low charged battery arriving at a destination or a charging station. V2V chargers utilizing the motor winding and inverter are preferred because they can achieve higher transmission powers at no extra cost. However, compared with onboard chargers that use isolation transformers to share energy between vehicle and vehicle, these converters (that make use of the motor winding and inverter) provide no isolation and cannot stop the propagation of a fault from one vehicle to the other. To solve this problem, a capacitor-isolated V2V converter that utilizes the drive motor winding and inverter is proposed in this paper, based on the principle of capacitor isolation in the gate driver chip. A 400W laboratory prototype is used to experimentally verify the performance and feasibility of the proposed method.

SI0019

Small Axial-Flux Induction Motor for Electric Vehicles

Emad Roshandel[1], **Amin Mahmoudi[1]**, Brendan Larkin[1], Solmaz Kahourzade[2] and Wen Soong[3]
1. Flinders University, Australia
2. University of South Australia, Australia
3. The University of Adelaide, Australia

Abstract-Axial-flux (AF) electric machines can offer higher efficiency and power density compared to radial flux machines for electric vehicle applications. While AF permanent magnet (AFPM) machines have received the most attention, the AF induction machine (AFIM) can be a suitable alternative. In this paper, an AFIM is designed in a same size and volume as a 4.5kW commercial AFPM machine and its 3D finite-element simulated performance are compared over a wide range of torque and speed and shows promising results. The manufacturing of the closed rotor slots for AFIM has been a challenging issue and this paper discusses the possible approaches for the rotor construction.

SI0062

An Efficient Droop Control Strategy for Reactive Power Sharing Improvement and Stability Margin Enhancement in Islanded Microgrids

Adham Osama, Tarek H.M. EL-Fouly, Hatem H. Zeineldin and Ehab F. El-Saadany
Khalifa University, UAE

Abstract-In islanded microgrids, distributed generation (DG) units employing the conventional droop tend to have a remarkable mismatch in the reactive power-sharing accuracy. This issue mainly arises from mismatches in line impedances. Besides, the imbalance in reactive power sharing can potentially compromise the overall stability of the system. Thus, this article proposes a control strategy that utilizes communication links to adaptively tune reactive power droop gains (nq) to achieve accurate reactive power sharing among DG units while enhancing the stability margin of the microgrid. Unlike previous studies that mainly focused on the active power droop gain to control the stability of microgrids, this study offers a novel examination of the nq parameter by highlighting its influence on both the stability margin of microgrids and the reactive power-sharing accuracy. The proposed approach was tested on a 34-bus microgrid benchmark and compared to three widely used control strategies: the conventional droop control, virtual impedance-based control, and a modified droop control introduced in the literature. The proposed control approach showed superior performance compared to other controllers and managed to achieve precise reactive power sharing while improving the stability margin by 137% compared to the conventional droop benchmark.

SI0064

Application of Utility Scale Hydrogen Electrolyzers for Virtual Renewable Power Smoothing

Mohamed Ashraf Kamal Hafez, Abdallah Fawzy El-Hamalawy and **Hany Essa Zidan Farag**
York University, Canada

Abstract-This paper examines the application of hydrogen electrolyzers in the context of virtual renewable power smoothing, particularly when the renewable power plant and hydrogen generation unit are geographically separated. A dynamic model of the hydrogen generation facility is developed, and the performance of Proton Exchange Membrane (PEM) and alkaline electrolyzers is compared using the Anderson 9-bus benchmark system. The study reveals significant differences in response times between the two technologies, highlighting the limitations of alkaline electrolyzers in handling rapid power fluctuations and the advantages of PEM electrolyzers in achieving smoother power integration.

SI0066

Impact of Denial-of-Service Cyberattacks on Hydrogen Refueling Stations in An Integrated Transportation and Electric Power System

Ahmed Abd Elaziz Elsayed and **Hany E. Z. Farag**
York University, Canada

Abstract- Expanding hydrogen stations is vital for green energy and reducing carbon emissions, but their high costs require efficient operation. Integrating these stations with transportation and power systems can help use excess renewable energy effectively, generate profits, and provide grid services. However, this integration involves

sharing sensitive data with the Energy Management System (EMS), which can expose the system to cyberattacks, potentially affecting financial stability and slowing down growth. This paper examines the impact of Denial-of Service (DoS) cyberattacks on the profitability of hydrogen refueling stations (HRSs). First, the effect of DoS on each critical information signal is analyzed. Based on the signals' vulnerability to cyberattacks, a Distributed Denial-of-Service (DDoS) model is developed to target multiple signals simultaneously, amplifying financial losses for the stations. The results show that a DoS attack on a single signal of hydrogen tank State of Charge (SOC), hydrogen station demand, and grid services signals can cause a damage of 4-5%, 9-10.5%, and 29% respectively, while a DDoS attack over local station measurements can reduce revenue up to 17%. In both cases, the profitability of the hydrogen station falls below the acceptable margin.

SI0091

Feasibility of Energy Recovery from Exhausted Air of HVAC Systems

Anwur Alenezi[1], Abouelyazed Kuliab[2] and Yousef Alabaiadly[3]
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2. New & Renewable Eneergy Authority, Ministry of Electricity & Renewable Energy, Egypt
3. Ministry of Electricity and Water, Ministries Zone, Kuwait

Abstract-This paper investigates directly the feasibility of recovering energy from exhaust air from central air conditioning plants experimentally. A mini vertical axis small wind turbine is connected directly with the exhaust air of the condenser fan. The exhaust air energy recovery unit includes air rotor blades and a generator. The electricity produced from the recovery unit is based on the fan speed and its air flow rate (CFM). The exhaust air from different types of central A/C systems is measured experimentally. The results showed that the speed of the air exhausted from a central A/C package unit with a capacity of 5-ton refrigeration (TR) reached 8–15 m/s based on the rotation speed (RPM) of motor. A small vertical wind turbine was installed on the exhaust of air flowing from the condenser fan of the central A/C package unit with 10-ton refrigeration (TR). The proposed exhaust air energy recovery unit produced 35–40% of the total energy consumption in a building having an A/C plant.

SI0094

A Hybrid MPC-PI Control Strategy for Grid-Connected Modular Multilevel Converters Using LS-PWM and Y-Matrix State Selection

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1. National Institute of Technology Puducherry, Karaikal, India, India
2. Khalifa University, United Arab Emirates

Abstract-In the grid-connected Modular Multilevel Converter (GC-MMC) system, it is challenging to simultaneously achieve three goals, such as suppressing circulating current, balancing capacitor voltage, and regulating grid current, due to the complexity of the control system. The integration of pulse width modulation (PWM) techniques with model predictive control (MPC) in GC-MMC system is a very challenging task, which requires complicated duty cycle calculation process. It also necessitates the use of additional sorting algorithms to find the optimal switching states. Considering these issues, this paper proposes a hybrid algorithm based on MPC and PI (HMPCPI) control with a simple level shifted PWM (LS-PWM) and Y-matrix based state selection approach. The idea behind the proposed method is to employ the LS-PWM concept to generate the control logic

for grouping the switching states in Y-matrix row selector in accordance with the steps of the output voltage produced by MMC. The proposed controller generates optimal PWM signals by merely selecting switching state from each group in the Y-matrix. With the help of HMPC-PI algorithm, it is possible to formulate the optimal control problem to meet multiple control objectives. The effectiveness of the HMPC-PI algorithm is validated using extensive simulations.

SI0129

Microgrid Adaptive Protection: Decentralised Hybrid Schemes for Islanding Detection

Pema Wangchuk, **M. Aizaz Farid**, Kazi N. Hasan, Inam Nutkani
RMIT University, Australia

Abstract-Passive schemes for islanding detection and adaptive protection offer potential benefits due to their simplicity and cost-effectiveness. However, these schemes have limitations in accuracy. Moreover, most were developed and tested in a grid dominated by inverter interfaced-renewable (IBRs), without adequately considering the substantial presence of emerging technologies like grid-forming (GFM) type of distributed generations (DGs). This paper comprehensively evaluates the performance of passive islanding detection schemes in a future grid with GFM DGs, using three indices, namely, rate of change of frequency (RoCoF), rate of change of voltage (RoCoV), and rate of change of phase angle (RoCoPA). The analysis highlights the performance limitations of individual passive schemes. To address these limitations, two hybrid schemes are proposed: one that uses a traditional approach for combining the three passive methods with AND-logic and another that computes a new composite index derived from the three indices. While both schemes are found to be effective, the composite index-based hybrid scheme demonstrates superior performance and a smaller non-detection zone (NDZ). Extensive testing is conducted in DIgSILENT PowerFactory software for various practical scenarios to assess the performance of the individual and proposed hybrid islanding detection schemes, confirming the superior performance of the later.

SI0136-A

Synthesis and evaluation of transition metal oxides (TMOs) into carbon nanofibers (CNFs) as anode materials for lithium-ion batteries

Xiaoying Lu, Wei Liu and Xuejuan Cui
Technological and Higher Education Institute of Hong Kong, Hong Kong

Abstract-The encapsulation of transition metal oxides (TMOs) within electrospun carbon nanofibers (CNFs) presents a promising strategy to enhance the electrochemical performance of lithium-ion batteries (LIBs). This approach leverages the high surface area, electrical conductivity, and structural integrity of CNFs, while simultaneously mitigating the challenges associated with the aggregation and dissolution of TMOs during cycling. This study explores the synthesis of TMO@CNF composites through a combination of electrospinning and subsequent thermal treatment, focusing on the effects of fiber morphology and TMO loading on the electrochemical properties. Characterization techniques, including scanning electron microscopy (SEM) and transmission electron microscopy (TEM), reveal the uniform dispersion of TMOs within the carbon matrix. Electrochemical evaluations demonstrate significant improvements in capacity retention and rate capability compared to bare TMOs. The TMO-CNFs anode delivers a reversible specific capacity as high as 850 mA h g−1 at

0.1 A g−1. Meanwhile, the TMO-CNFs anode shows good cycling stability with a retention of more than 80% capacity after running 30 cycles. These findings highlight the efficacy of TMO encapsulation in CNFs, paving the way for the development of high-performance anode materials for next-generation LIBs.

SI2001

Lithium-ion Battery State of Health Estimation Based on Time-Frequency Image Fusion and KAN

Jiwei Fang, Guifeng Wu, Mingtao Xie, Pantao Ding, Xiuyi Xia and Kailu Dong
Yangzhou University, China

Abstract-This paper proposes a method for estimating the SOH of lithium-ion batteries based on improved time-frequency image fusion and Kolmogorov-Arnold network (KANs). First, the time-frequency feature extraction process is simplified by employing weighted average image fusion and one-dimensional unfolded Euclidean distance calculation. Second, for the regression estimation task, The KANs are optimized using tensor operations and regularization simplification. Experiments conducted on the CALCE datasets demonstrate that the KANs model outperforms other comparative models in terms of estimation accuracy, computational efficiency, and generalization ability. On the CALCE dataset, the lowest root mean square error (RMSE) and mean absolute error (MAE) are 0.53% and 0.35%, respectively, while the highest coefficient of determination (R^2) reaches 0.9962., confirming the effectiveness and superiority of the proposed method.

Session 7

December 6, 2024
Time Zone: GMT+4

Topic: Smart Grid Control and Reliability Analysis
Time: 10:30-12:15 (Duration for Each Presentation: 15 minutes)
Zoom Link: https://us02web.zoom.us/j/89294235542
Session Chair: Assoc. Prof. Gheorghe Grigoras, Gheorghe Asachi Technical University of Iasi, Romania

Online

SI0001

Improving Small-Signal Stability of Grid-Connected Inverters based Phase-Locked Loop Compensation Under Weak Grid

Yukai Huang[1], Shilong Lei[1], Songtao Huang[1], Jinbang Xu[1], Bingying Zheng[2] and Zhuang Li[2]
1. Huazhong University of Science and Technology, China
2. Kings College London, United Kingdom

Abstract-In weak grid scenarios, the dynamic behavior of the phase-locked loop (PLL) can adversely affect system stability due to the influence of weak grid impedance. Establishing a small-signal output impedance model of grid-connected inverters is common practice for studying oscillation instability issues between the inverter and the weak grid. This paper proposes a stabilizing control strategy based on symmetric compensation of feed-forward perturbations to address the impact of PLL small perturbation coupling on current loop control. The strategy takes into full consideration the characteristics of small perturbation coupling in the control coordinate system and formulates a system of equations to derive the expression of the small perturbation feedforward compensation controller. By inversely compensating the small perturbation components that lead to current loop destabilization, the stability of the system under weak grid conditions is improved. Simulation results demonstrate that this strategy does not require adjusting controller parameters and directly compensates for disturbance components.

SI0012

Vehicle-to-Grid and Grid-to-Vehicle scheduling based on load leveling and peak shaving

Mohamed Mahmoud Nour El Deen and Noha Shouman
German International University, Egypt

Abstract-This paper introduces peak shaving and load leveling techniques in the electrical power system by utilizing the vehicle to grid (V2G) and grid to vehicle (G2V) technologies as one of the ways to decrease power system over all operational cost and absorb excess electrical energy in the hours of low electrical demand. The IEEE 24 bus system is utilized and modified while taking into account the presence of electric vehicles and renewable energy power stations in the system. A novel vehicle aggregation system is employed to facilitate the implementation of peak shaving and load leveling techniques. The system is tested across the span of 24 hours while considering power system and vehicle constraints which include: power transmission, power balance, generation limits and state of charge of vehicles (SoC). The scheduling problem is solved by utilizing hybrid mean

variance mapping optimization technique (MVMO-SH). The obtained results show that the integration of load leveling and peak shaving techniques in the system was successful, and these results suggest that the integration of the vehicle aggregation system will be beneficial to the grid system as it saved 3.6% of total system run cost.

SI0057

TrustUP: A Trust Evaluation Scheme in Unmanned Aerial Vehicle Networks for Power Line Inspections

Zhiqi Li[1,2], Weidong Fang[1,2], Menghao Lin[3], Wentao Chen[3], Wuxiong Zhang[1,2]
1. Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, China
2. University of Chinese Academy of Sciences, China.
3. State Grid Xinjiang Company Limited Electric Power Research Institute, China

Abstract-Unmanned aerial vehicles (UAVs) are crucial for inspecting power line. However, UAVs are susceptible to malicious hacking, which can result in the dissemination of false information and service disruptions. To secure data transmission, most current methods utilize Advanced Encryption Standard (AES) for data encryption and Virtual Private Networks (VPNs) to safeguard data. However, the trust of UAVs has not been fully considered. We propose a trust evaluation scheme specifically in UAV networks for power line inspections to enhance security. By evaluating overall trust and implementing a trust threshold, the scheme filters out malicious UAVs from the network. A series of experiments are conducted to evaluate the scheme's performance in detecting malicious UAVs. The results demonstrate that the trust evaluation scheme effectively increases the trust level within the UAV network, ensures the reliability of data during transmission and storage, and significantly improves the security of power line inspection tasks.

SI0082

Empowering Energy Future: Unleashing the potential of Gross Metering in weak distribution grids: A case study of Pakistan

Ahmad Sala, Sohrab Mirsaeidi, Muhammad Zubair Iftikhar and Syed Ali Abbas Kazmi
USPCAS-E, National University of Sciences and Technology (NUST), Pakistan

Abstract-Gross metering in the power industry refers to the entire amount of electricity generated by a renewable energy system before it is used by the system owner/prosumer. This paper addresses gross metering deployment, benefits, problems, and prospective improvements in Pakistan's Distribution Companies (DISCOs), particularly Islamabad Electric Supply Company (IESCO), where import/export ratio (39%/61%) is totally disturbed amongst all counterparts. Given Pakistan's high renewable energy potential, gross metering could play a crucial role in improving energy security and fostering sustainable development. This paper assesses the current state of gross metering, net-metering and normal metering comparative analysis, looks at case studies, and suggests legislative and technical improvements. A case-study of Islamabad Electric Supply Company (IESCO) is presented with realistic data. The gross metering results in 31.434% reduction in revenue as compare to 60.1% reduction, when compare to normal billing. The gross metering results in 47.62% improvement in revenue collection for the utility.

SI0087

Challenges and Opportunities of Smart Grid Integration with Renewable Energy and Electric Vehicles in the

Middle East

Krishna Kumar[1], Hossein Hashemi[1], Shivam R Chauhan[2] and Emilson Silva[3]
1. Lund University, Sweden
2. Nanyang Technological University, Singapore
3. University of Auckland, New Zealand

Abstract-The Middle East, a pivotal player in global energy markets, faces a confluence of challenges and opportunities as it navigates a transition towards sustainable energy systems. This region is home to five of the top ten oil producers in the world, and three of the top twenty gas producers. Shifting dynamics in energy demand, combined with pressing concerns for mankind to address global climate change, are forcing the Middle East toward cleaner energy generation. The signs of progress are now emerging as the Middle East embraces renewable energy at a pace never seen before. In recent years, grid integration of solar photovoltaic, wind, and electric vehicle systems has been increasing owing to the desire to reduce energy costs and resulting emissions. As observed from the trends in many countries, the effect of EVs load on the grid is great and multi-dimensional. They introduce new challenges and opportunities in terms of grid management and integration. Efforts have been made to realistically assess how energy produced from solar wind power and electric vehicles would be integrated into the grid. In this paper, the integration of solar, wind, and the bidirectional flow of power in EVs (vehicle-to-grid) and their impact on the grid have been analyzed. Results show an energy demand-based tariff that may drive consumers to reduce their electricity consumption at peak periods. The pressure that comes with rapidly increasing electric vehicle adoption must be minimized through a multifaceted approach. Improved planning and demand forecasting, using better modeling tools and predictive analytics, could estimate future load growth.

SI0089

Optimization of Droop Control Coefficients in a Isolated Microgrid Cluster Using Particle Swarm Optimization

Pablo Horrillo-Quintero, Pablo García-Triviño, David Carrasco-González, Raúl Sarrias-Mena, Carlos A. García-Vázquez and Luis M. Fernández-Ramírez
University of Cádiz, Spain

Abstract-The isolated operation of microgrid clusters (MGC) must ensure proper voltage and frequency control continuously, in addition to maintaining the load and establishing an efficient distribution among the microgrids (MGs). The droop control technique is the most adopted method to perform the primary control of MGs. Therefore, the optimization of the droop control coefficients is one issue that need to be addressed to achieve the optimal MGC operation. This article presents a new objective cost function aimed at minimizing the system's total operating cost while ensuring effective voltage and frequency control within the established threshold values. The particle swarm optimization (PSO) metaheuristic optimization algorithm is used to solve the optimization problem and obtain the optimal values of the droop control coefficients that guarantee MGC stability and loss minimization. An isolated MGC is implemented in the Matlab/Simulink environment. Each MG consists of a grid-supporting inverter, an inductive-capacitive filter, a power transformer, and transmission lines connecting each MG. The results obtained in different scenarios ensure effective frequency and voltage control, as well as loss minimization by applying the optimal droop coefficients obtained through PSO.

SI0132

A Study on Cost Management for Power Grid Project Based on 3D Design Achievement

Siqi Lang and Yiting Li
City Institute of Dalian University of Technology, China

Abstract-Based on a survey of the characteristics of the Power Grid Project and the current situation of cost management, the objectives and functional requirements of the management platform were analyzed, and a research framework for achieving the Power Grid Project cost management platform was established. A digital, information-based solution was implemented in conjunction with the 3D design achievement. In substation construction, the application of 3D design technology will provide a comprehensive digital solution for project cost management, improve the efficiency of design and construction, reduce costs and risks, and optimize operation and maintenance processes. At the same time, 3D design can also achieve a seamless connection between design and construction, reducing errors and delays in information transfer.

Session 8

December 6, 2024
Time Zone: GMT+4

Topic: Data Feature Analysis and Safety Management of Power Systems
Time: 14:00-15:45 (Duration for Each Presentation: 15 minutes)
Zoom Link: https://us02web.zoom.us/j/89294235542
Session Chair: Dr. Foo Yi Shyh Eddy, Nanyang Technological University, Singapore

Online

SI0003

AI Driven Approach to Power Quality Detection and Classification

Hamad albeshr, Motamen Salih, Talada Naidu, Sajan Sadanandan and Tareg Ghaoud
Research and Development Center, Dubai Electricity and Water Authority, United Arab Emirates

Abstract-Power quality events present significant challenges to the stability and reliability of electrical grids, necessitating efficient detection methods for timely response. This enables the rapid implementation of diagnostic and mitigation methods to address disturbances quickly. Traditional approaches to detecting power quality events depend on predefined thresholds or models, which may lack the flexibility needed for diverse and evolving grid conditions. In contrast, data-driven approaches use machine learning techniques to automatically identify patterns from extensive real-world data, offering greater flexibility and accuracy. This paper introduces power quality event detection methods based on machine learning techniques. Utilizing models such as eXtreme Gradient Boosting (XGBoost), Support Vector Machines (SVM), Random Forest (RF), Neural Networks (NN), and Convolutional Neural Networks (CNN), the approach effectively identifies and classifies various power quality events, including voltage sags, swells, and interruptions. The study showcases the superiority of these AI methods in enhancing the detection process and facilitating timely mitigation strategies. A Simulink simulation model is used to evaluate the performance of various machine learning algorithms, with XGBoost and CNN demonstrating superior performance over other models. Overall, the findings underscore the potential of AI methods in improving the detection and prediction of power quality events, contributing to more resilient and adaptable electrical grids.

SI0040

Textual and Visual Features Alignment and Attention Interaction Based Multimodal Entity Alignment Method for Electric Power Operation and Inspection

Jiannan Xu[1], Huifang Xu[1], Panfei Liang[1], Zhenyuan Ma[1], Dawei Lu[2] and Yanlun Hou[3]
1. China Electric Power Research Institute, China
2. Research Institute, State Grid Information & Telecommunication Group Co., Ltd, China
3. State Grid Gansu Electric Power Company Baiyin Power Supply Company, China

Abstract-Due to the accumulation of multi-source information such as information ledgers and two invoices in the power industry, there may be situations where the same power business entities come from multiple sources of information during the construction of a multimodal knowledge graph. Therefore, multimodal entity alignment is

needed to achieve the identification and linking of equivalent entities. For multimodal entity alignment, it is crucial to study how to integrate multiple modal information of entities to obtain accurate semantic representations of multimodal entities. For multimodal entity alignment, it is very important to study how to integrate multiple modal information of entities to obtain accurate semantic representation of multimodal entities. Therefore, in order to reduce cross-modal semantic differences and extract key alignment information, this paper considers the semantic consistency and fine-grained feature interaction fusion of textual and visual modalities, and proposes a multimodal entity alignment method for electric power operation and inspection based on textual and visual features alignment and attention interaction. This paper designs the textual and visual features extraction module, the cross-modal feature fusion module, and the multimodal entity feature matching module. At the same time, by introducing contrastive learning of textual and visual modalities, attention mechanisms, and correlation calculation of textual and visual features, more accurate semantic representations of entities are obtained, thereby achieving efficient and accurate multimodal entity alignment for electric power operation and inspection. The improvement in alignment performance of the proposed method was verified through experimental comparison with the baseline control group on the power dataset.

SI0060

Smart Passive Islanding Detection Technique based on Time-varying Kalman Algorithm

Huma Umber Naz, Sohrab Mirsaeidi, Muhammad Zubair Iftikhar, **Faisal Mumtaz**, Kashif Imran and Syed Junaid Iqbal
USPCAS-E, National University of Sciences and Technology (NUST), Pakistan

Abstract-In the modern world, renewable energy-based distributed generations (REBDGs) pose many challenges. Islanding detection is one of the major problems associated with REBDGs. This paper proposes a new passive Islanding detection technique using the Time-varying Kalman Filter (TVKF) algorithm. Initially, the TVKF algorithm is applied for the state estimation of the 3-phase voltage signal at PCC. Furthermore, the Squared Sum of Voltage (SSV) is calculated as an index for islanding detection. However, the islanding event is detected when the SSV is less than the pre-defined threshold value. A standard IEEE-13 bus test system is implemented in MATLAB/Simulink for analyzing the performance of the proposed technique. It is cost-effective & results validate the accuracy and efficiency of the scheme without any non-detection zone (NDZ).

SI0071

An Unsupervised Approach to Enhance Cyber Resiliency of Power Systems Against False Data Injection Attacks on Voltage Stability

Shahriar Rahman Fahim[1], Rachad Atat[2], Abdulrahman Takiddin[3], Muhammad Ismail[4], Katherine R. Davis[1], and Erchin Serpedin[1]
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2. Lebanese American University, Lebanon
3. Florida State University, USA
4. Tennessee Tech University, USA

Abstract-The growing adoption of networked and communication technologies into power systems has brought significant advancements in grid management, efficiency, and voltage control. However, this digital

transformation also introduces new vulnerabilities, particularly to cyberattacks, such as false data injection attacks (FDIAs), which can disrupt voltage stability and compromise the operational integrity of power grids. Existing detection mechanisms for FDIAs often fall short as they overlook the complexities of cyberattacks targeting voltage stability and rely on outdated models that do not capture the dynamic interplay between power system operations and potential threats. In response to these gaps, this paper proposes a novel FDIA detection method designed specifically for voltage regulation vulnerabilities, aiming to enhance the voltage stability index. The proposed method utilizes an unsupervised learning framework capable of identifying cyberattacks targeting voltage regulation. A bi-level optimization approach is put forward to concurrently optimize the objectives of both attackers and defenders in the context of voltage regulation. The effectiveness of this approach is validated through comprehensive training and testing on a variety of attack scenarios, demonstrating superior generalization across different conditions. Extensive simulations on the Iberian power system topology, with 486 buses, show that the proposed model achieves an average detection rate of 98.11%, representing a notable improvement of 10-25% over the benchmark detectors. These results highlight the robustness and efficacy of the proposed strategy in strengthening the cyber resilience of power systems against sophisticated FDIA threats on voltage stability.

SI0009

Tree-Based Approaches for Parameter and Load Margin Estimation of Power Transmission Systems

Felipe Proença de Albuquerque[1], **Eduardo Coelho Marques da Costa[1]** and Pablo Torrez Caballero[2]
1. University of São Paulo, Brazil
2. Federal University of Acre, Brazil

Abstract-Real-time voltage stability assessment has become a prominent area of study due to the increase in load demand and the diversity of non-linear loads. Additionally, the large amount of data available allows the use of data-centric solutions. In this context, this paper proposes a comparative analysis of tree-based methods for Load Margin Estimation. The presented methodology uses a reduced number of features, avoiding the use of power flow measurements, and relies on PMU measurements from only a few buses in the system. The method was also tested considering the presence of random and systematic errors in phasor measurements. The proposed method is evaluated on the IEEE 14- bus test system. Results show that the Load P Margin (LPM) can be predicted with an error of less than 1% in the noiseless case and less than 2% in the presence of noise.

SI0084

Application of Parallel SO-KELM Optimization Algorithm in Wind Power Generation Forecasting

Tianyu Gao
University of California, United States

Abstract-Wind power generation is a critical component of smart grid systems. However, environmental factors introduce instability, leading to errors in wind power forecasting. This study addresses the challenge of improving prediction accuracy by employing an optimized Kernel Extreme Learning Machine (KELM) model, enhanced with the snake optimization (SO) algorithm. The proposed approach integrates reverse learning, somersault foraging, and a hybrid strategy to prevent local optima entrapment and enhance convergence precision. Through benchmark testing, the optimized Parallel SO-KELM algorithm demonstrates superior performance in wind power parameter prediction across various simulated weather conditions. Comparative analysis highlights the accuracy

improvements achieved, with error rates significantly reduced, confirming the efficacy of the proposed methodology.

SI0120

Expanding the Initial Dynamic Model of CE with the Nordic power system and real-time implementation

M. Ramirez-Gonzalez[1], A. Obushevs[1], S. Sanchez-Acevedo[2], F. R. Segundo1, P. Korba[1]
1. ZHAW Zurich University of Applied Sciences, Switzerland
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Abstract-This paper presents the results of a research work accomplished to expand the initial dynamic model of Continental Europe (IDMCE) with the Nordic power system model (NPSM), where a pseudo steady-state HVDC representation for electromechanical transient stability studies on the AC system was used to model the interconnection link. The appropriate response of the independent grid models was firstly verified by power flow computations and time domain simulations in PSS/E. Then, they were manually integrated as separate areas into one extended system in PSS/E and linked with a CDC4T type HVDC line. After evaluating the performance of the extended model in the initial format, it was transferred to OPAL-RT ePHASORsim for transient stability simulations in offline mode and in real-time on the RT-LAB enabled simulator. Base case scenarios were used to qualitatively assess the dynamic performance of the expanded grid considering no fault conditions and step changes on the reference signal of the converter controlling power. Real-time simulation results show expected system performance in terms of transient frequency deviations and new steady state operating points. The extended power system model is intended to be used for multiple applications, including the development and evaluation of advanced functionalities for mutual frequency support under real-time hardware-in-the-loop simulation setups.

Session 9

December 6, 2024
Time Zone: GMT+4

Topic: New Energy Development and Energy Market Analysis
Time: 14:00-16:15 (Duration for Each Presentation: 15 minutes)
Zoom Link: https://us02web.zoom.us/j/85827973324
Session Chair: Dr. Rakibuzzaman Shah, Federation Universtiy, Australia

Online

SI0117

Minigrid Clusters for Rural Electrification in Ethiopia
Sanjay Kumar Chaudhary[1], Abenezer Bekele[2], Juan C. Vasquez[1] and Josep M. Guerrero[1]
1. Aalborg University, Denmark
2. Hawassa University, Ethiopia

Abstract-Many villages in Ethiopia are remote and still not connected to the national electric grid. Hence, development of minigrids utilizing the locally available renewable energy resources can solve this problem. Furthermore, the interconnection of adjacent minigrids into clusters can allow sharing the resources. Through simulation studies, this paper corroborates that the battery energy storage systems in the individual minigrids can be shared across the cluster to absorb the mitigate the disturbances. caused by the connection and disconnection of large load units.

SI0018

Techno-economic Analysis of Hybrid Energy Storage Optimal Sizing in Self-sufficient Renewable Energy System
Muhammad Sarfraz, Tao Xu, He Meng and Jianhang Sun
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Abstract-Energy storage is crucial in the current renewable energy-dominated power system for several reasons. One critical need is effectively mitigating the uncertainty of sporadic renewable source generation and enhancing energy integration in energy systems. This paper analyzes an optimal sizing design of the hybrid energy storage connected with standalone rooftop solar photovoltaic considering precise battery and stored hydrogen usage. This study conducts a techno-economic analysis of an office building located in a temperate region. A powerful optimization tool is employed to optimize the configuration and sizing of the proposed distributed renewable energy system. The model optimization results affirm that the hybrid storage model design simultaneously leveraging battery and hydrogen fuel cell performs better than only hydrogen storage design when evaluating the levelized cost of energy, total net present cost, self-sufficiency, and reliability objective functions.

SI0059

An Integrated Model for Economic Effectiveness and Self-Sufficiency Improvement Based on the Sharing

Economy Principle in Energy Communities

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Abstract-The concept of energy communities emerges as an innovative and promising solution to address the technical, economic, environmental, and social challenges facing modern energy systems. By enabling prosumers to share assets, energy communities reduce investment costs and leverage economies of scale, thereby enhancing the efficiency and sustainability of energy systems. This paper presents an optimization model designed to balance economic efficiency and self-sufficiency within an energy community framework. Leveraging the sharing economy concept, the model manages various Distributed Energy Resources (DERs)—including electrical storage, Combined Heat and Power (CHP) systems, and thermal storage—as shared assets through an Energy Community Manager (ECM). Each prosumer is equipped with a photovoltaic system, an Electric Vehicle (EV), and other household appliances. The Mixed Integer Linear Programming (MILP) problem is applied to a one-year dataset and solved using the CPLEX solver within the GAMS environment. The results reveal key trade-offs between economic efficiency and energy selfsufficiency: operational costs are up to 31.3% lower in Summer compared to Winter, and self-sufficiency ratios can be up to 17.8% higher in Spring compared to Winter. These insights are crucial for informed energy-planning decisions within energy communities.

SI0068

Strategies for Sustainable Peer-to-Peer Energy Trading: Revenue, Grid Impact, and Investment Analysis

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International Energy Research Centre (IERC), Tyndall National Institute, Ireland

Abstract-This paper presents the development of a sustainable local electricity market (LEC) for the energy community, focusing on the effects of peer-to-peer (P2P) energy trading on consumers and prosumers. It assesses these systems' economic and technical feasibility under retail pricing and feed-in tariff (FiT) structures through the improvement of the market modelling by adding a peak demand constraint. Through modelling and simulation, the study analyses photovoltaic (PV) and battery energy storage systems (BESS) to maximise energy savings while minimising network stress. It highlights the impact of network loss factors and fees on P2P trading across different scenarios. The findings indicate that well-designed PV and BESS systems and effective P2P trading mechanisms can significantly enhance residential energy efficiency and serve as a viable revenue model. Addi- tionally, peak demand constraints reduce network stress with minimal effects on P2P trading and operating costs, showing notable cost benefits in the European Low Voltage Distribution Network (LVDN) test network analysis. This paper contributes valuable insights for policymakers, energy providers, network and market operators, and residential communities considering adopting decentralised energy solutions.

SI0100

Performance Evaluation of Deep Learning Models in Heating Load Forecasting in Building Environments under Data Integrity Attacks

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4. University of North Carolina at Charlotte, USA

Abstract-Recently, the introduction of new thermal regulations has led to a significant improvement in the energy efficiency of buildings. Consequently, a variety of deep learning-based methods have been developed to more accurately forecast the heating load demand of buildings. This paper investigates the performance of various deep learning models in forecasting heating load in building environments, particularly under the impact of data integrity attacks. Various deep learning models such as Convlutional Neural Network (CNN), Long short-Term Memory (LSTM), Bidirectional LSTM (BiLSTM), CNN-LSTM, Autoencoder (AE)-BiLSTM, and Variational AE-BiLSTM (VAEBiLSTM) are employed to forecast heating loads using real-world data. The models are evaluated based on variois performance evaluation metrics. Initially, the models are tested under normal conditions, where the VAEBiLSTM and AE-BiLSTM demonstrate superior performance with lower error rates and higher correlation values. Subsequently, a False Data Injection attack (FDIA) is simulated to assess the models' resilience under compromised data conditions. The results reveal a significant degradation in predictive accuracy for all models, with conventional architectures like CNN, LSTM and BiLSTM being most affected. However, models integrating AE-based techniques (AE-BiLSTM and VAEBiLSTM) exhibit greater robustness, maintaining relatively lower error rates and higher correlations.

SI0107

A PV-storage-charging-load coordinated scheduling strategy based on robust optimization under the demand response compensation mechanism

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2. Tsinghua University, China

Abstract-Industrial parks integrate distributed photovoltaic (PV), energy storage systems, electric vehicle (EV) charging facilities, and industrial electricity demand, etc. Traditional regulation methods cannot cope with the uncertainty of PV output, industrial electricity demand, and EV charging, which results in the negative impacts of increased economic operation costs and insufficient consumption of new energy. In this paper, the uncertainty of PV output, industrial electricity demand and EV charging contract is considered comprehensively, the internal multiple heterogeneous resources are modeled in detail, and a two-part charging power-transferring power demand-response compensation mechanism is innovatively proposed, and the Column and Constraint Generation (C&CG) algorithm is used for solving the problem to obtain the collaborative scheduling strategy of PV-storage-charging-load in industrial parks. The effectiveness of the proposed strategy is verified by case analysis.

SI0063

Evaluation and performance assessment of grid-connected photovoltaic solar power plants IN ARID ZONE OF ALGERIA

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Unité de recherche appliquées en énergies renouvelables, Algérie

Abstract-In this study, we analyze the experimental annual energetic performance of a photovoltaic system mounted on a solar tracking structure.The photovoltaic field is constituted by a polychristalin module with a peak power of 3.27 kWc, the inverter SMA Sunny Boy power of 4 kW transform all produced energy DC to AC energy and inject it on the internal power grid of Renewable Energy Applied Research Unit (REARU) of Ghardaia. The annual produced energy by the PV system is 7.995MWh, whereas the simulated anuuel energy injected on the grid is 7.042MWh, calculed by PVSYST. The performance ratio (PR) of the system is at its minimum in September with 0.69 and its maximum in May with 0.77. Annuel Pr calculated by PVSYST is 74.4. This study focuses on specific area with high solar radiation namely Noumirate on Ghardaia province. Implantation site characteristics are Latitude 32.4°, Longitude 3.80° and Altitude 468.4 m, located in the desert at 600 km south of Algiers.

SI0007

Analysis of a 8-Year Field-Tested PV Module Deployed in a Subtropical Environment

Sukanta Roy, **Alexander Stevenson** and Arif Sarwat
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Abstract-Distributed Energy Resource (DER) deployments continue to accelerate as the electric grid experiences the transformative shift to a decentralized renewable generation and distribution-based network. Photovoltaics (PV) systems in particular are an extremely attractive option for many residential and commercial owners towards electricity generation in densely populated urban areas. However, harsh environmental conditions can often accelerate the degradation of PV components which may lead to electrical issues, hazardous conditions for people and equipment, and decreases in their economic effectiveness. In this work,the failure modes and effects of PV modules are discussed as well as the inference of their effects on system reliability. Furthermore, a visual inspection and temperature analysis of a 315W solar PV module from a 8-year PV system deployed in the harsh subtropical environment of Miami, FL are performed. From these analyses, several insights on PV design are drawn at both the module and system level, and recommendations for future PV installations are provided.

SI2007

Simulation of high-power microwave coupled with solar cell system

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Abstract-Solar cells, as renewable energy, are widely used in various industries such as automobiles, power grids, railways, and shipping. High power microwaves can be coupled into the facilities they supply through solar cells and cables on the panels, causing interference to sensitive electronic devices. This article constructs a coupling simulation model for solar cell systems, analyzes the coupling effect of high-power microwaves on solar cell systems, and obtains the dominant factors and coupling laws of high-power microwaves entering the interior of facilities.

Session 10

December 6, 2024
Time Zone: GMT+4

Topic: Smart Electrical Design and Device Design
Time: 15:50-17:20 (Duration for Each Presentation: 15 minutes)
Zoom Link: https://us02web.zoom.us/j/89294235542
Session Chair: Assoc. Prof. Eduardo Coelho Marques da Costa, University of São Paulo, Brazil

Online

SI0044

Single Phase Fast EV Charger Based on Grid Connected Quasi Z-Source Inverter
Mohammad Shadnam Zarbil, Sandipan Patra and Shafi Khadem
Tyndall National Institute-IERC, Ireland

Abstract-Fast charging of electric vehicles (EVs) is crucial for the widespread adoption of EV technology and the shift to sustainable transportation. Integrating renewable sources with EV charging systems is also essential to promote sustainable energy practices and reduce carbon emissions within the transportation sector. This paper introduces a new approach by integrating energy storage (ES)-based quasi-Z-source inverter (q-ZSI) into an on-grid solar system for a single-phase EV charging application. This innovative all-in-one system provides a fast-charging solution that integrates PV, ES, EV and grid. Besides the fast charging of EVs, the q-ZSI integration system offers the advantages of q-ZSI converters, featuring a single-stage structure for voltage boost or buck capabilities. This reduces component count and system cost and improves reliability while eliminating the need for additional filtering capacitors and reducing switching ripples. The theoretical analysis and simulation results have confirmed the effectiveness of the proposed system.

SI0051

Evaluating the Droop Control Loop of the Grid-Forming Converter in an Isolated Resistive Network
Qusay Salem[1], Khaled Alzaareer[2] and Rafat Aljarrah[1]
1. Princess Sumaya University for Technology, Jordan
2. Al-Hussein Technical University, Jordan

Abstract-The increasing use of renewable energy sources in power systems brings challenges in ensuring voltage and frequency stability, particularly in isolated or weak grids. Grid-forming converters have emerged as an effective solution, capable of replicating the dynamic characteristics of synchronous machines. This paper presents an evaluation of droop control loop applied to a grid forming converter within an isolated resistive network. The study examines three main scenarios: the grid forming converter's steady-state response to a sudden load change, the influence of varying R/X ratio on the stability and performance of the droop control loop, and the grid forming converter behavior during a balanced three-phase fault. The results indicate that while droop control generally maintains system stability, its effectiveness is heavily impacted by the R/X ratio, with lower ratios posing greater challenges. The response of the grid forming converter during a three-phase fault also provides key insights into

the limitations and strengths of droop control in networks with different line resistance or fault resistance. These outcomes offer important contributions to the refinement of control strategies for grid forming converters, supporting the development of stable and reliable power systems, particularly in microgrid environments and other isolated networks with resistive nature.

SI0101

Implementation of optimization algorithms to enhance the efficiency and regulation of SEPIC converter based solar powered EV charging stations

G. Nethaji, S. Poornima and J. Kathirvelan
Vellore Institute of Technology, India

Abstract-Global warming makes it essential to switch from internal combustion engine (IC) vehicles to electric vehicles (EVs). EVs minimize the air pollution and generate less oxides compared to combustion engines. The growing number of EVs on the road relying on the traditional fossil fuel-based grid for charging is becoming increasingly uneconomical and inefficient. Sustainability, reliability, and benefits such as cost savings, energy independence, and emissions reduction motivate the shift to solar photovoltaic systems for EV charging stations using renewable resources. A solar PV system-based novel SEPIC converter regulates the output voltage by adjusting the voltage step up or step down based on the requirements. Though the sunlight varies, the converter stores energy efficiently. MATLAB Simulink simulates the converter to ensure efficient voltage regulation and fast transient response. The PID and fuzzy algorithms regulate the converter's voltage. The fuzzy logic controller-based system is used to enhance the voltage stability and performance metrics of the converter.

SI0106

Modeling and Control of Three-Phase Grid-Following Converter via Matlab/Simulink

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2. University of Vaasa, Finland

Abstract-The integration of renewable energy sources (RES) into modern power grids has necessitated the use of grid-following (GFL) converters to ensure reliable synchronization and power exchange between distributed energy resources (DERs) and the grid. GFL converters, which align their operation with the grid's voltage and frequency, play a critical role in stabilizing energy flows in these systems. This paper presents a detailed Matlab/Simulink model of a three-phase GFL converter, focusing on its structure, control unit, and performance in various operational scenarios. Specifically, the study evaluates the converter's performance under normal conditions and when a sudden step change in the real and reactive power references is occurred. Furthermore, this study explores how the number of GFL converters connected to a single feeder impacts the voltage limits allowed for grid connected converters. Unlike previous studies that address only specific aspects of converter operation, this research provides a comprehensive Simulink-based implementation of the entire control unit for GFL converter. Additionally, the simulation results highlights the scalability of the GFL converters in distributed energy networks. The simulation results offer valuable insights into optimizing network topologies for increased penetration of GFL converters into the power grid.

SI0093

Neural Network Modeling of Direct Ammonia Alkaline Anion Exchange Membrane Fuel Cell

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Abstract-Recently, there has been a growing interest in green ammonia as a feasible hydrogen-based alternative for clean energy generation. Ammonia presents various advantages such as simplified transportation and storage, higher density, and reduced flammability. Since ammonia can be used to directly generate electricity through a Direct Ammonia alkaline anion exchange membrane Fuel Cell (DAFC), an adequate model of DAFC is essential for operational studies and controller design. This paper proposes a novel neural network (NN) model for DAFC. The proposed NN model utilizes the input-output relationships of the DAFC to capture system dynamics, resulting in a rapid and highly accurate model. Traditional physics-based modeling of complex systems involving electrochemical reactions is arduous, time-consuming, and computationally intensive. Once trained and validated, this NN model is utilized to analyze the dynamic behavior of the DAFC. The research demonstrates that the NN-based approach is adept at predicting output parameters. The ability to develop precise data-driven models using solely data from validated physics-based models is demonstrated by the presented DAFC NN model, thus minimizing the need for extensive experimentation. Index Terms—Neural network, green ammonia, hydrogen, fuel cell, data-based model, control system, smart grid.

SI0096

Simulation of an Electrostatic Drum for Photovoltaic Panel Dust Removal

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2. Lawrence Technological University, USA

Abstract-Demand for electrical energy is increasing with growth in global population and development in the industrial sector. Large-scale solar power plants, including photovoltaic (PV) panels, are a clean alternative to fossil fuels and can be located in desert regions with abundant solar irradiance, such as Saudi Arabia. However, dust deposition on the PV surface is high in desert regions and limits power output. Cleaning PV panels is essential to have the benefit of the high insulation and mitigate the dust accumulation impact. In this study, an electrostatic drum, similar to those in the electrophotographic printing process, is considered for cleaning PV panels. Simulation is used to identify optimum drum parameters such as drum diameter, drum to PV air gap, drum thickness and applied voltage. The cleaning performance of the electrostatic drum is compared to existing embedded and detachable electrodynamic shields.

Notes