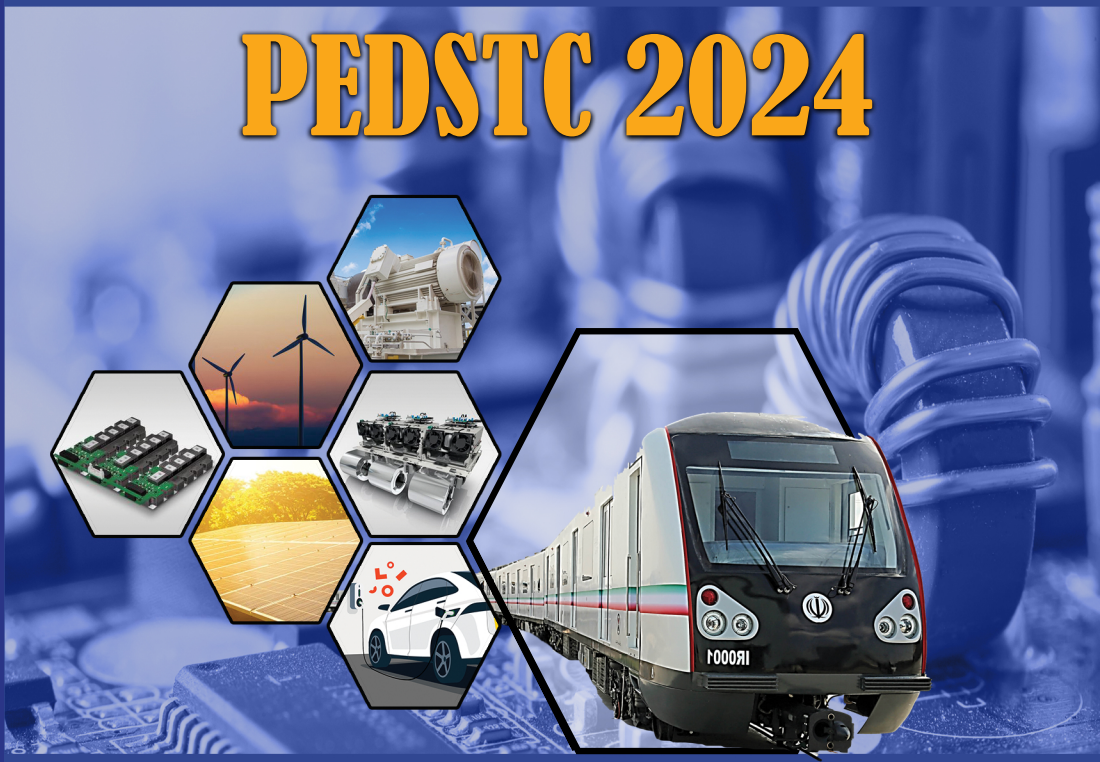
Book of Abstracts

15th Power Electronics & Drives: Systems and Technologies Conference

PEDSTC 2024



PESI Power Electronics Society of Iran

JDEVS

دانشگاه علم و فرهنگ

IEEE IRAN SECTION

ISC Islamic World Science Citation Center

SID Scientific Information Database

30 Jan. - 1 Feb.

Tehran - Iran

In the name of God

JDEVS
Technology Solution Provider

Ministry of Science, Research and Technology

University of Science and Culture

15th Power Electronics & Drives: Systems and Technologies Conference

PEDSTC 2024

30 Jan.–1 Feb.

Tehran, IRAN

Message from General Chair

On behalf of the 15th Power Electronics & Drives: Systems and Technologies Conference (PEDSTC 2024) Committee, I am delighted to welcome you to the Conference, which brings together experts and academics from the field of power electronics. It has been a real honor and privilege to serve as the General Chair of this conference, "PEDSTC 2024". The conference this year has brought together a tremendous diversity of authors and speakers from universities, government, and industry to share ideas and new perspectives on a wide range of topics covered by the conference, addressing new technical issues essential to advancing today's engineering and technological environments.

The Power Electronics & Drives: Systems and Technologies Conference (PEDSTC), which is the flagship annual conference of the Power Electronics Society of Iran (PELSI) this year is held at the University of Science and Culture (USC), in Tehran, Iran, on 30 Jan. - 1 Feb. 2024. PEDSTC 2024 is organized jointly by the JDEVS branch of ACECR, USC, and PELSI. The aim of this year's edition of PEDSTC is to provide a platform for researchers, engineers, academics, and industrial professionals to present and share their recent research work and to explore future trends in various areas of power electronics, and their applications in different industries. The conference is technically sponsored by the IEEE Iran Section and is supported by the Islamic World Science Citation Center (ISC) and Scientific Information Database (SID). It is noteworthy that the PEDSTC 2024 benefited from the submission of papers by authors from Iran and 13 overseas countries; while it is the

first time in the post-COVID era that the conference is held in person, few papers will still be presented through the Internet. The full program is composed of fifty-three papers, two invited keynote speeches and several workshops. We believe that PEDSTC 2024 will yield fruitful results through presentations and discussions by the distinguished participants.

Again, it is a great pleasure and an honor to welcome you to an inspiring and enjoyable program at the conference. We hope that you will find the conference informative and enjoyable, and to take the opportunity to establish future research collaboration both nationally and internationally.

General Chair

A/Prof. H. R. Sadegh Mohammadi

About JDEVS

JDEVS is a public non-governmental organization which has been active since 1980 with the aim of localizing and producing technical knowledge in the field of designing and manufacturing industrial products, providing specialized services, and conducting applied research in the field of power and mechanics. With the establishment of specialized services centers and research groups in power and mechanics, this collection could take effective steps toward supplying the research needs, user research, engineering services, as well as designing and manufacturing the products needed by the industry by establishing appropriate communication with universities and scientific centers of the country and attracting qualified specialists.

The successful presence of this unit in the oil, gas, refineries, petrochemicals, railways, cement, and mining industries, the production of non-ferrous metals, copper, aluminum and steel and the signing of numerous contracts with employers demonstrates the trust of industries to this knowledge collection. The most important products of this unit include the design and manufacture of high voltage and high voltage industrial rectifiers, uninterruptible power supplies including all types of UPS and industrial chargers, moderate-voltage motor rounds control, power system and oil drill rig control, high voltage laboratory equipment, types of industrial dust collectors such as electrostatic filters and baghouses, oil drilling rigs, marine oil loading arms, oil spill containment systems, and electrostatic oil desalting systems conducted by numerous employers in various industries. Guaranteeing the quality system in accordance with the ISO 2015/9001 standard, achieving a rank in seven periods of the Kharazmi Festival, and obtaining the conformity of product

quality indicate the dynamism and professional performance of JDEVS in the industry. This collection is supported by 400 personnel including the faculty members of four research groups (Iranian Research Institute for Electrical Engineering) and six engineering and technical service centers for industrial design and manufacturing.

About University of Science and Culture

University of Science and Culture (USC) was founded in 1994 as a non-governmental university by Iranian Academic Center for Education, Culture and Research (ACECR) with a special permit by Ministry of Science, Research and Technology, Iran. USC is one of the largest and most prestigious of non-governmental universities in Iran. USC has 105 full-time faculty members, approximately 400 part-time faculty members and a student body of approximately 9,000. In domestic courses, the university admits top students who pass national entrance examinations (called concourse) in 20 undergraduate programs, six graduate programs and 15 technical courses. Admission rules differ for international courses. The USC is active in education through its faculties in engineering technology, humanities, and arts. Because USC is connected to ACECR, the school is obliged to develop scientific and higher education systems at national and international levels, as well as expand non-state higher education, train students in theory and practice in different majors and courses, and provide specialized human resources in line with the 20-year national plan of the IRI.

The university's main campus is in Tehran's west district; additional campuses are in Isfahan, Rasht, Hamedan, Tehran, and Kashmar. There are two building complexes at the USC. The education building complex is at the central building, which is part of the art faculty and the postgraduate education buildings. In addition to the library facilities, the USC is connected to information banks. They have enabled the use of the latest scientific sources and local and international scientific research magazines for the members of the board of education and the students. There are equipped laboratories and workshops required by different departments in

faculties on the campus. The research activities at USC are done at the related research centers which consist of Royan Research Institute, Technology Development Institute, Culture and Art Institute, and Social Studies and Humanities Institute. The Department of Research at USC is responsible for helping students and board members research, especially postgraduate students.

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Keynote Speaker I:

Prof. Gevork B. Gharehpetian
SMIEEE
Amirkabir University of Technology

Possible Applications of FACTS Devices in Iran Power System

Biography:

G. B. Gharehpetian received his BS, MS, and PhD degrees in electrical engineering in 1987, 1989, and 1996 from Tabriz University, Tabriz, Iran, and Amirkabir University of Technology (AUT), Tehran, Iran, and Tehran University, Tehran, Iran, respectively, graduating all with First Class Honors. As a Ph.D. student, he received a scholarship from DAAD (German Academic Exchange Service) from 1993 to 1996 and he was with High Voltage Institute of RWTH Aachen, Aachen, Germany. He held the Assistant Professor position at AUT from 1997 to 2003, the position of Associate Professor from 2004 to 2007, and has been Professor since 2007. He was selected by the Ministry of Science Research and Technology as the distinguished professor of Iran, by IAEEE (Iranian Association of Electrical and Electronics Engineers) as the distinguished researcher of Iran, by Iran Energy Association (IEA) as the best researcher of Iran in the field of energy, by the MSRT, by the Academy of Science of the Islamic Republic of Iran as the distinguished professor of electrical engineering, by National Elites Foundation as the laureates of Alameh Tabatabaei Award and was awarded the National Prize in 2008, 2010, 2018, 2018, 2019 and 2019, respectively. Based on the Web of Science database (2005-2022), he is among the world's top 1% of elite scientists according to the ESI (Essential Science Indicators) ranking system. Prof. Gharehpetian is a distinguished, senior and distinguished member of CIGRE, IEEE, and IAEEE, respectively. Since 2004, he has been the Editor-in-Chief of the Journal of IAEEE. He is the author of more than 1400 journal and conference papers. His teaching and research interests include Smart Grid, Microgrids, FACTS and HVDC Systems, Monitoring of Power Transformers and its Transients.

Keynote Speaker II:

Prof. Mohamed Benbouzid
IEEE Fellow
University of Brest

Exploring the Future of Tidal Stream Turbine Drivetrains: A Journey into Technology Options

Biography:

Mohamed Benbouzid received a Ph.D. degree in electrical and computer engineering from the National Polytechnic Institute of Grenoble, Grenoble, France, in 1994, and the Habilitation à Diriger des Recherches degree from the University of Amiens, Amiens, France, in 2000.

After receiving the Ph.D. degree, he joined the University of Amiens, Amiens, France where he was an Associate Professor of electrical and computer engineering. Since September 2004, he has been with the University of Brest, Brest, France, where he is a Full Professor of electrical engineering. Prof. Benbouzid is also a Distinguished Professor and a 1000 Talent Expert at the Shanghai Maritime University, Shanghai, China. His main research interests and experience include analysis, design, and control of electric machines, variable-speed drives for traction, propulsion, and renewable energy applications, and fault diagnosis of electric machines. Prof. Benbouzid has been elevated as an IEEE Fellow for his contributions to the diagnosis and fault-tolerant control of electric machines and drives.

He is also a Fellow of the IET. He is the Editor-in-Chief of the INTERNATIONAL JOURNAL ON ENERGY CONVERSION and the APPLIED SCIENCES (MDPI) Section on Electrical, Electronics and Communications Engineering. He is a Deputy Editor for the IET RENEWABLE POWER GENERATION.

Time Table of the 15th Annual Power Electronics & Drives: Systems and Technologies Conference (PEDSTC 2024) The first day – Wednesday 31 Jan. 2024		
09:00-10:30	Opening Ceremony	
10:30-11:00	Break	
11:00-12:00	Keynote Speech I	
12:00-13:30	Lunch	
Sessions		**Paper IDs**
13:30-15:00	Session W1-A: Power Converters and Control (I)	1007, 1012, 1025, 1034, 1035, 1037
	Session W1-B: Electrical Machines and Drives (I)	1005, 1017, 1024, 1026, 1042, 1045
15:00-15:30	Break	
15:30-17:15	Session W2-A: Power Converters and Control (II)	1040, 1041, 1043, 1044, 1046, 1047, 1099
	Session W2-B: Power System and Renewable Energy	1031, 1050, 1059, 1086, 1087, 1089, 1097

Time Table of the 15th Annual Power Electronics & Drives: Systems and Technologies Conference (PEDSTC 2024) The second day – Thursday 1 Feb. 2024		
09:00-10:30	Session T1-A: Power Converters and Control (III)	1049, 1052, 1054, 1057, 1062, 1067
	Session T1-B: Electrical Machines and Drives (II)	1019, 1033, 1051, 1060, 1080, 1083
10:30-11:00	Break	
11:00-12:00	Keynote Speech II	
12:00-13:30	Lunch	
13:30-15:15	Session T2-A: Power Converters and Control (IV)	1023, 1068, 1069, 1071, 1073, 1074, 1075
	Session T2-B: Power Converters and Control (V)	1013, 1028, 1085, 1090, 1091, 1092, 1095, 1096
15:15-15:45	Break	
15:45-17:00	Closing Ceremony	

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15th Power Electronics & Drives: Systems and Technologies Conference (PEDSTC 2024)
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Paper Code: PN1005

A Method for Motor Synchronous Transfer in Cascaded NPC-Bridge-based Drive Systems

A. Lahooti Eshkevari, A. Keshavarzian, I. Abdoli, M. Farzi, and S.M. Zeinalhosseini

This paper proposes a motor synchronous transfer (MST) method for motor transmission between the VSD and the utility. It has been developed based on the discrete Fourier transformation (DFT), is easily added to the existing motor control strategies, and determines the fundamental component of the grid voltage. As a result, stability against noise, harmonics, and unusual and DC-polluted waveforms is ensured. Unlike the previous algorithms, it lacks filters and additional PI controllers for phase detection. It does not need further hardware like decoupling inductances as the method makes a condition for short-time paralleling of VSD and utility. This article practically evaluates the performance of the proposed method using a cascaded NPC-Bridge inverter. Results confirm that it accurately detects the grid voltage phase and magnitude and transfers the motor with a limited transient overshoot (<1.5×nominal current), tolerable for the grid and VSD. Also, mathematical operations are reduced by up to 60%.

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30 Jan. - 1 Feb. 2024
Tehran - Iran

Paper Code: PN1007

A Novel RSCC for Balancing the Series Connected Battery Cells Voltages

Y. Izadi and R. Beiranvand

Conventional switched-capacitor voltage equalizers face limitations such as reduced balancing speed with an increasing number of battery pack cells, capacitor inrush currents, and electromagnetic interference (EMI) noise. To address these issues, this article introduces an innovative voltage equalizer employing a resonant structure to enhance performance. The proposed design features an optimized capacitor network capable of transferring energy between any cell to any cell (AC2AC) within a battery pack with a low path impedance, ensuring consistent balancing speeds regardless of cell count or initial voltage distribution. Moreover, the circuit incorporates soft switching conditions to minimize switching losses and EMI noise, ultimately enhancing converter efficiency. This innovative approach minimizes switching losses, enabling higher switching frequencies and reducing passive component size. The article presents results from Pspice software simulations with six series battery cells and demonstrates significant improvements in balancing speed, with a 70% increase compared to mesh structure and a 56% increase compared to delta structure. Additionally, the equalizer achieves a 94.6% efficiency rating.

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Tehran - Iran

Paper Code: PN1012

A Two-Input Nonisolated High Step-Up DC–DC Converter with Switched-Capacitors Technique

M. Vesali

A high step-up two-input DC-DC converter is presented in this paper. The soft switching condition is provided for the switches in turn on instant, so the converter efficiency is high. Due to the fact that only the capacitor is used to increase the voltage gain and there are no coupled inductors in the converter, the input current of the converter is continuous. The technique used to increase gain can be used with more stages to achieve higher voltage gain. The converter can also be used as a single input interleaved instead of two inputs, which in this case the input current ripple is reduced. The voltage stress on the switches is lower than the output voltage, so lower voltage switches can be used, which reduces the converter cost. The proposed converter is completely analyzed and in order to prove the theoretical results, an experimental prototype is implemented at 500 watts. The results of the experimental test at full load show an efficiency of about 95.5%.

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Paper Code: PN1013

Proposal of Winding Arrangements for the WR Synchros to Facilitate the 3-phase to 2-phase Conversion without Scott-T Transformer

M. R. Eesazadeh and Z. Nasiri-Gheidari

Conventional Synchro to Digital Converters (SDCs) and Digital to Synchro Converters (DSCs) primarily process signals in resolver format internally. Consequently, it is essential to transform synchro output signals into resolver format for SDCs, and conversely, to convert the internal resolver format signals back into synchro format for DSCs. Typically, these conversions are achieved through the utilization of interconnected transformers referred to as Scott-T transformers. Using this equipment increases the complexity and practically makes the use of synchros undesirable. In this article, a method based on winding arrangements is proposed to facilitate the conversion of three phases to two phases without employing Scott-T transformer. The configuration of windings is of utmost importance when it comes to influencing the accuracy and expenses associated with the synchro device. Hence, an approach is introduced to ascertain the most efficient winding configuration, with a particular focus on wound rotor (WR) synchros. This approach streamlines the process of setting up windings for synchros with varying pole pair and tooth count requirements. To validate the developed method, Time-Stepping Finite Element Method (TS-FEM) is employed.

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Paper Code: PN1017

Design and Implementation of a Robust Controller for Single Inverter Dual Induction Motor Drives under Heavy Unbalanced Load in Electric Trains

R. Ghomiawili, A. Sheikholeslami, and A. Ale Ahmad

Single inverter dual induction motor drives have gained wide currency among electric train manufacturers because of their economic advantages. Different methods have been proposed to improve system reliability in unbalanced load conditions and one of the best-presented methods is weighted vector control. Although this method performs efficiently in medium unbalanced load conditions, it doesn't guarantee system stability under heavy unbalanced loads applied to the motors. This paper presents an advanced weighted vector control strategy based on Direct Torque Control using a Space vector modulation algorithm to develop this kind of drive system. In the proposed method, a hysteresis controller is added to prevent the instability of the stressed motor under a heavy unbalanced load. A laboratory setup was designed and implemented to test the performance of the proposed controller by using a DSP microcontroller. The efficiency of the proposed method is proved by simulation and experimental results.

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Paper Code: PN1019

Dynamic Response Improvement to Load Disturbance of Model-Free Predictive Controlled PMSMs by Integral Sliding Mode Controller

M. Ghodrati, S. Vaez-Zadeh, and M. Khalilzadeh

Model-free predictive control of permanent magnet synchronous motors does not require a mathematical model of the motor under control. Therefore, the control algorithm can be implemented without a knowledge of the motor parameters. However, the dynamic response of the drive under this control method is not immune to load disturbances, and still is dependent to the load parameters. In this paper, an integral sliding mode controller is proposed for speed control loop to improve the disturbance-rejection performance of the speed controller. Therefore, the proposed control method is not only immune to motor parameter variations but also to the external disturbances. The proposed and the conventional model-free control methods are implemented in Matlab/Simulink and compered to each other. The simulation study demonstrates that the proposed method not only achieves good dynamic response under abrupt load changes, but also is robust to motor parameter variations.

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Paper Code: PN1023

A New Multilevel Inverter Topology Based on Three-Positive-Level with Limited Devices

A. Seifi, S. H. Hosseini, M. Tarafdar Hagh, and M. Hosseinpour

Multilevel inverters have been introduced in the new industry as functional converters for high/medium power applications. In the meantime, inverters with a limited number of switching components attract more attention due to their volume and low cost, high efficiency, and simple control. The suggested inverter uses a novel cell and H-bridge configuration to generate high voltage levels with a minimal number of switching components. An investigation of efficiency and power loss has been conducted for the suggested multilevel inverter. A thorough evaluation of the suggested multilevel inverter's worth has been conducted by comparing the number of devices and other topologies. The comparison depends on the output levels. This paper uses the basic frequency switching modulation for simulation and experimental. Simulation and experimental findings have verified the performance of the proposed multilayer inverter with two cells.

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15th Power Electronics & Drives: Systems and Technologies Conference (PEDSTC 2024)
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Paper Code: PN1024

Comparison of Different Permanent Magnet Arrangements in E-Type Outer-Rotor Doubly-Salient Motors

M. R. Sarshar, M. A. Jalali Kondelaji, M. Mirsalim, and A. Khorsandi

This research study presents a proposal for three doubly-salient permanent magnet (DSPM) motors. These motors primarily consist of a hybrid design that combines biased flux PM (BFPM) and stator slot PM (SSPM) motor structures. The primary motor configuration, known as Dual-PM, which incorporates both yoke and slot PMs, has demonstrated the most favorable combination of high average torque and low torque ripple in the rated current. The study of the operating principle involves the utilization of the Magnetic Equivalent Circuit (MEC) to analyze the behavior of both yoke and slot PMs, with a specific focus on the flux in the air gap. Furthermore, the outcomes of finite element analysis (FEA) are evaluated in terms of their performance in both no-load and full-load conditions. A thorough analysis is conducted to identify the benefits of the Dual-PM structure.

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Paper Code: PN1025

Cost and Reliability Design Consideration for CHB-based Converter Based on Decomposition Optimization

M. Azimi and M. Asadi

In this paper, an optimal solution is introduced for CHB-based inverters to improve reliability while the total cost is reduced. The trade-off between the conflicting objectives (minimizing cost and maximizing reliability) can be solved using decomposition optimization methods such as goal attainment and goal programming. In the proposed optimization framework, the objective functions are degraded into one single-objective function, repeated for 200 different weight factors. Thus, an accurate approximation of the Pareto set is determined. The proposed optimization scheme can control both reliability and total cost within the allowable range. In addition, the number of redundant cells is determined to make the converter more reliable. Eventually, the optimal number of cascade cells is determined as (13,5) for cold redundancy and (7,4) for hot one.

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Paper Code: PN1026

Performance Improvement of Coaxial Magnetic Gear with Asymmetric Rotor Structure

M. Madanchi Zaj and S. A. Afsari Kashani

This paper presents an optimal asymmetric permanent magnet (PM) aligning and rotor pole shaping topology in a coaxial magnetic gear (CMG) to mitigate cogging torque and augment torque density. Proposed design is based on using asymmetric interior PM placement and applying oval structure on high-speed rotor's surface. The suggested magnetic gear consists of 12 outer and 3 inner pole pairs. The targeted goals are accomplished by implementing the recommendations, according to the results. Finite element analysis results evaluate and verifies the topological performance.

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Paper Code: PN1028

A New High Step-Up Converter with Low Voltage Stress on the Power Switch

Sh. Shabani Mojaveri and M. Delshad

In his In this paper, a high step-up converter with very high voltage gain and low voltage stress as well as switching at zero voltage for both main and auxiliary switches is presented. The auxiliary circuit not only absorbs the energy of the leakage inductor well, but also provides soft switching conditions for the converter elements. The auxiliary circuit has only one snubber capacitor, one auxiliary switch, and one resonant inductor, and the circuit capacitors are used as clamp capacitors. The proposed high step-up converter is implemented and the practical results confirm the theoretical analyzes of the converter.

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Paper Code: PN1031

Direct Integration of Rooftop Photovoltaic Generation in Electric Railway Systems: Optimizing Power Flow and Efficiency

M. Davoodi, O. Nasirkhani, H. Jafari Kaleybar, and M. Brenna

This study proposes a solution to global concerns surrounding the energy crisis and environmental impact by directly integrating photovoltaic (PV) generation with electric railway systems (ERS). Focusing on sustainable alternatives, the approach involves implementing railway energy management systems (REMS) to address challenges related to energy consumption and greenhouse gas emissions from ERS. Utilizing mixed integer linear programming, the research optimizes the electrical system operation cost of Milan's Bovisa railway station, considering factors like the electrical grid, energy storage systems, regenerative braking energy (RBE), and the direct integration of a rooftop PV plant, designed using PVsol software. By accounting for probabilistic and stochastic behaviors, along with real-time data using MATLAB, the proposed REMS model achieves significant cost reductions in the daily operations of the smart railway station, showcasing practical evidence for real-world applications.

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Paper Code: PN1033

Study of the Effect of the Number of Flux-Barrier Layers on von-Mises Stress Distribution in the Rotor Core of a Synchronous Reluctance Motor

A. Jamali-fard and M. Mirsalim

Due to several blank spaces inside the rotor core of a synchronous reluctance motor (SynRM), it experiences significant stresses and deformations. In the case of improper design, extreme deformations can cause contact between the rotor and stator which impedes the safe operation or even permanent failure of the motor. This paper aims to provide some mechanical design guidelines for the rotor structural analysis of the case study SynRMs. Several rotor cores considering a different number of flux-barrier layers with and without radial ribs have been analyzed. Stresses of all case-study rotor cores have been calculated through the finite element analysis (FEA). The paper concludes by proposing a design procedure for a modified rotor core. In the modified design the aim is to have a good trade-off between the electrical and mechanical performances of the rotor core.

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15th Power Electronics & Drives: Systems and Technologies Conference (PEDSTC 2024)
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Paper Code: PN1034

Switching Phase Shift to Improve Performance Three Phase Transformer for Klystron Amplifier

M. Yousefi, A. Nasiri, and M. Ammarloo

In this paper, the effect of phase shift technique on the performance of a power modulator with output characteristics of -25 kV, 5 A for the klystron amplifier is investigated. This modulator is composed of a DC-DC converter structure with three high frequency transformers in a three-phase structure. In this circuit, the voltage of 500 VDC is converted to -25kV pulse. DC-DC converter structure, consists of three full-bridge converter modules with high frequency transformer. In this research, by using switching phase shifted, the transformer magnetic current is balanced and reduces the current stress of the switches. The series resonance circuit has also been used to reduce switching losses. The function of the converter is simulated and verified by PSCAD software.

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Paper Code: PN1035

Simple and Efficient Structure for Power Cycling of the IGBT in a Single-Phase H-Bridge Inverter with Online Measurement of the Aging Precursors

S. Mohammadian, F. Simonetti, S. Tedeschini, M. Dezhbord,
C. Buccella, and C. Cecati

Collector-emitter saturation voltage of the IGBTs in the conduction state, v_{CE}, is considered in literature as an indicator to detect the incoming failure of the switch. Typically, a change (e.g., in the range of 5%) in this indicator can be counted as the device bond-wire lift-off and its failure. Since this voltage drop is in the range of few volts, an accurate measurement structure must be adopted. This paper proposes a simple and efficient set-up to acquire switch voltage, current, and temperature with an arbitrary sampling rate. It utilizes the ordinary current and voltage sensors available on the inverter boards and, by a simple modification on the micro-controller code, the power cycling for accelerated aging is applied to the switch and the sampled data of the IGBT saturation voltage, current and temperature are sent to the PC online through SCI communication protocol. A Visual Studio code is adopted to store the data on the PC. The data can be used to train an artificial intelligent approach to detect the deviation from the monotonic behavior of the switch.

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Paper Code: PN1037

A Novel Soft-Switched Quasi-Resonant Bidirectional DC/DC Converter for Electric Vehicle Application

M. Shahabi, S. H. Fathi, and A. Khorsandi

In this paper, a novel high gain, non-isolated, coupled-inductor (CL) based, bidirectional DC/DC converter (CLBDC) is presented. In step-up mode, the CLBDC operates in quasi-resonance (QR) mode due to the leakage inductance (Lk) of the CL. QR operation offers several advantages, such as soft-switching conditions of boost switch turn-on (ZVS) and diodes turn-off (ZCS), which significantly reduce switching losses and increase the converter's efficiency. The CLBDC benefits from a wide range of high voltage gain in both step-up and step-down modes due to the presence of the CL and boost capacitor. Furthermore, the CLBDC's input current has a low ripple. These features make this converter useful for electric vehicle applications and two-way power flow. The operating principles and steady-state analysis are discussed for both boost and buck modes. To verify the CLBDC feasibility, simulations are performed in Simulink/MATLAB software. The simulation results prove the validity of the converter specifications well.

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A 17-Level Single DC Source Switched-Capacitor-based Multilevel Inverter with Self Voltage Balancing

F. Esmaeili and H.R. Koofigar

In this paper, a novel switched-capacitor multilevel inverter with boost capability is proposed. The presented topology consists of one DC source, one diode, 19 power switches, and 3 capacitors, which can produce 17 separate output voltage levels. This topology has several notable advantages, including high voltage gain, low switch voltage stress, and voltage self-balancing ability. A performance study of the proposed topology, as well as theoretical calculations, is provided. To highlight the advantages of the proposed structure, a comparison between traditional inverters and the proposed inverter is made. Finally, the simulation results are extracted to demonstrate the performance of the proposed topology and the correctness of the theoretical relations.

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Coupled Inductor-Based Step-Up DC-DC Converter with High Gain for Photovoltaic Systems

M. Karimi Hajiabadi, A. Mosallanejad, and A. Salemnia

This paper presents a non-isolated step-up DC-DC converter for photovoltaic systems. It is designed by a triple-winding coupled inductor (TWCI) and two voltage multiplier cells (VMCs). The topology comprises one power switch, a TWCI, four diodes, and four capacitors. The converter can achieve high voltage gain by selecting the duty cycle and the turn ratio of the TWCI, which avoids operating at an extreme duty ratio. Besides, the power switch has been located on the converter's low-voltage side, which tolerates low-voltage stresses. Therefore, the switch is selected from low on-resistance low-voltage rating switches, reducing the conduction losses and improving the efficiency. The operating principle and the steady-state analysis of the proposed converter are described in detail. The performance of the proposed converter is verified through simulation in MATLAB/SIMULINK to justify the analysis.

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Paper Code: PN1042

A General Pattern-Based Optimization of PM for Axial-Flux Magnetic Gear

M. Madanchi Zaj, M. Malakooti, and S. A. Afsari Kashani

More researchers are becoming fascinated with magnetic gears (MGs) lately since they have several advantages over traditional mechanical gearboxes, such as contactless operation, reduced noise and vibration, and no maintenance requirements. One of the magnetic gear topologies that is easier to assemble and works well for applications involving a physical separation between the input and output shafts, is axial-flux MGs (AFMGs). In this paper a general parameterized PM magnetization pattern is introduced. It is possible to achieve a higher torque density than with a traditional layout by selecting the optimal parameters of PM arrangement in this general pattern of AFMG. The proposed structure is evaluated by the 3-D finite element method analysis and optimized based on genetic algorithm.

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Design of an Efficient Step-up DC-DC Converter with Fault-Tolerant Capability

M. Nikbakht, H. Rastegar, and F. Mohammadi

A fault-tolerant (FT) DC-DC boost converter is designed for high-reliability applications. The presented converter incorporates FT features, and the FT technique relies on a reconfiguration strategy eliminating the need for additional components. The topology can be reconfigured to ensure consistent operation even under various switch-fault conditions. Furthermore, it supports full-power post-fault operation, which allows for fast fault recovery and minimizes system downtime. This makes the topology suitable for using in mission-critical applications. Furthermore, the power flow is considered in the configuration design, resulting in a reduction of the excess processed power. Therefore, the converter structure becomes more efficient. Based on various switch faults, the new configuration of the proposed converter enables operation with new characteristics. The converter operating in the CCM is demonstrated a high voltage gain with a low voltage stress on devices. To ensure a precise assessment, the converter is simulated using MATLAB and the results are presented.

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A Step-up DC-DC Converter with High Voltage Gain Suitable for Renewable Energy Sources

S.M. Salehi, S. Hasanzadeh, and M. Farsijani

Low and variable production voltage of renewable energy sources such as solar cells, fuel cell in terms of DC voltage range is always a big challenge in the field of connecting these sources to the national power grid. In order to connect these sources to the inverter and then to the power grid, a DC-DC interface with the ability to convert the input voltage level to 230 or 400 volts is required. This converter should be a step-up DC-DC converter with high voltage gain. So far, many boost structures have been proposed to create a constant voltage due to the variability of the input voltage. In this research, a step-up DC-DC converter with high voltage gain is proposed using a voltage multiplier cell (VMC) and a coupled inductor. Main equations of the converter in steady state have been calculated and simulation of the converter has been done to verify the calculations.

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Paper Code: PN1045

Hybrid Excited Two-Phase Switched Reluctance Motor with Improved Torque Characteristics

A. Moghani, M. Arabahmadi, and H. Torkaman

This paper proposes a novel permanent magnet (PM) arrangement for a two-phase switched reluctance motor(SRM) to achieve enhanced torque density and reduced PM volume. The proposed motor, termed the YPMSRM, incorporates PMs embedded within the stator yoke. The paper compares the YPMSRM to an existing hybrid reluctance motor (HRM) with PMs placed within the common poles. The finite element method is employed to analyze the flux lines and densities of both motors. The results demonstrate that the YPMSRM exhibits a significantly higher flux density in the air gap compared to the HRM. Additionally, the YPMSRM delivers higher torque with lower PM volume and reduced cogging torque compared to the HRM. The YPMSRM presents a promising topology for achieving improved torque characteristics in SRM applications.

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Paper Code: PN1046

Soft-Switched Dual-Input Single-Output DC/DC Converter with Hybrid Voltage Multiplier

K. Choobdari Omran and R. Beiranvand

In this paper, a Dual-Input Single-Output (DISO) DC/DC converter with soft switching operation is presented. The proposed converter structure consists of coupled inductors (CI) and voltage multiplier (VM) circuit, which increases the voltage gain in practice. In addition to improving the voltage gain, the use of the VM circuit, which is a combination of Dickson and Cockcraft-Walton multipliers cells, reduces the voltage stresses of the power semiconductors. In this converter, the soft switching conditions are provided for the power semiconductors through the resonance between the VM circuit capacitors and the CI leakage inductance. Therefore, no additional components, such as resonant tanks, are required. Since the VM circuit is shared between the two inputs legs, the component count is reduced. The proposed converter topology, its principles and modes of operation as well as the steady-state analysis are presented in this paper. Also, to verify the performance and theoretical analysis of the proposed converter, it is designed and simulated for 1.5 kW output power with 20-30 V inputs and 400 V output voltages, and its results are discussed in detail.

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A Novel Model Predictive Control for Three-Phase Split-Source Inverter with Reduced Common-Mode Voltage

S. H. Montazeri, J. Milimonfared, and M. R. Zolghadri

Single-stage split-source inverter (SSI) is particularly appropriate for transformerless applications with low input voltage. The common-mode voltage (CMV) can cause destructive effects in systems without galvanic isolation. This paper focuses on mitigating CMV in three-phase SSI. To achieve this, the finite-set model predictive control (FS-MPC) is employed to reduce CMV effects and improve the performance of SSI. The proposed algorithm is simplified by controlling only output currents of SSI, which eliminates the need for weighting factors in the cost function. In three-phase SSI, the zero vector, which is associated with inductor charging mode, causes the negative peak of CMV. Thus, to decrease the peak-to-peak value of CMV, this vector is replaced by two active vectors with opposite directions. These vectors are chosen based on minimizing switching losses and changes in CMV. By the proposed method, the peak-to-peak value of CMV is decreased by 50% compared to conventional approaches. Additionally, the total harmonic distortion (THD) of the output current is improved. The effectiveness of this method is verified by simulation results. Results confirm an effective reduction in CMV and leakage current.

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Study of a Reliable Buck Topology for High Step-Down DC-DC Power Conversion

I. Talebian, N. Padar, E. Babaei, and V. Marzang

A reliable buck topology for high step-down DC-DC power conversion is proposed in this study. This converter is a versatile power supply that can be used in a wide range of applications such as telecommunication equipment, solar power conversion, industrial automation, and many other areas, especially in low-voltage industrial applications. The main advantage of this structure besides the low output voltage ripple, is the simple structure with just one power switch and ease of analysis and experimentation due to simple operational modes. In order to investigate the proposed structure, a state-of-the-art theoretical analysis in terms of the operational modes, voltage conversion ratio, and voltage stress across the components is conducted in this research, and the reliability evaluation of this converter is carried out, in order to prove its durability and longevity. Furthermore, the proposed configuration is compared with similar topologies to prove its advantages. Finally, the converter is simulated in PLECS software, in order to derive the voltage and current of elements to prove the theoretical analysis and features of the converter.

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A Framework for Assessing Harmonic Effects on Transformers under Various Loading Conditions

K. Moosavi and H. Mokhtari

The presence of harmonics in power networks has detrimental effects on transformers, such as increased losses, heat generation, and accelerated aging of insulation, reducing their life. To effectively monitor aging and remaining service life, transformer hot spot temperature is commonly used to calculate aging acceleration rates. This paper proposes a framework that examines the impact of harmonics on transformers by assessing capacity reduction and life reduction. The framework utilizes the IEEE thermal model to analyze harmonics' influence and emphasizes the importance of considering various loading conditions, including climate and operation. Simulation results on a transformer feeding a six-pulse converter and a real distribution network reveal that harmonics significantly decrease the maximum permissible load and transformer life. Neglecting different operating conditions can lead to erroneous results and incorrect decisions concerning transformer operation. Therefore, the presented framework provides a comprehensive approach to address this issue.

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Electromagnetic Forces on the End Windings and Terminal Connections of Large Electric Machines: Calculations, Considerations, and Capabilities for Stress Analysis

H. Tahanian, AA. Vahaj, and F. Kiani

End windings are the integral part of electrical machines, which should be mechanically supported through appropriate measures. The determination of electromagnetic force distribution under the worst-case scenario is a prerequisite for conducting the mechanical stress analysis. This paper presents a detailed description of a proper approach for this kind of force calculation. Large turbo-generators have been targeted for this purpose, although this method can be extended to other machines. 2D transient FEA has been employed to obtain the required information for the worst-case scenario, i.e. the sudden three-phase short circuit at the machine terminals. These data, including the stator currents, field current, and rotor position, are taken as the inputs of 3D magnetostatic models, which provide the adaptive meshing capability. The force calculation has been repeated for different setups to investigate the amount of details that should be taken into account while creating the FE models. It reveals that the active (e.g. cores) and inactive (e.g. support brackets) surrounding magnetic materials as well as the rotor current and position are the most influential factors on both the distribution and magnitude of the end winding forces. Furthermore, due to conceptual and geometrical differences, both the drive and non-drive ends of the machine have been analyzed. Therefore, the forces on the circuit rings and terminal connections could also be evaluated. The geometry of the terminal connections has been modified according to these results to achieve an acceptable force distribution.

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A Novel High Gain Transformerless DC-DC Converter with Continuous Input and Output Currents

M. Lotfi, E. Afjei, and M. Kheradmandi

In this article, a high-efficiency, non-isolated converter is proposed by combining Cascade Boost Additional and Enhanced Luo converters that generate high-output voltages without the need for excessively high duty cycle values. Additionally, incorporating continuous input current renders the converter well-suited for renewable energy applications. Noteworthy advantages of the presented design encompass continuous output current, positive output voltage polarity, common ground for both load and input source, and diminished voltage and current stress on semiconductors compared to the output voltage and input current. The analysis of the operational modes and relevant equations in continuous conduction mode has been presented. Subsequent investigations delved into semiconductor stress parameters and relationships associated with component losses. The proposed design was then compared with several converters concerning component count and voltage gain. Ultimately, simulation results were assessed using PLECS software.

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Capacitor voltage ripple Reduction in modular multilevel converters in drive application

A. Aarabi and A. Yazdian Varjani

Given the increase in demand for medium voltage (MV) electric motors and their high-power capacity (ranging from hundreds of kilowatts to several megawatts), especially in power-intensive industries like oil, gas, and mining, there is a growing preference for multilevel converters. This is due to their ability to offer superior output quality, lower nominal voltage of semiconductor switches, reduced dv/dt, lower switching frequency, and minimized losses compared to the two-level voltage source converter (VSC). Specifically for high-power variable frequency drives in industrial settings, the Modular Multilevel Converter (MMC) has emerged as a highly promising topology within the multilevel converter family. The MMC boasts several advantages, including the absence of high voltage semiconductor switches, isolated DC sources, and complex transformers. These qualities position it as a favorable choice for addressing the needs of modern industrial applications. In this paper the method proposed for reduction of capacitor voltage ripple is to use the boost converter due to the change in the MMC input voltage led to the reduction of this ripple at low frequencies during the motor operation. The simulation results show the performance of boost-based method for ripple reduction in capacitor.

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Totem-Pole PFC Rectifier Current Spike Investigation and Mitigation Using Predictive Control

R. Heydari Dizaji and M. R. Zolghadri

With the advent of wide bandgap (WBG) semiconductors, use of the totem-pole power factor correction rectifier (TP-PFCR) is increased in power electronic applications. However, this converter is suffering from an inherent current spike in the vicinity of grid voltage zero crossing. In this paper firstly, the effect of control unit in zero crossing phenomena is investigated and the cause of the current spike is extracted. To solve this problem, a new predictive control method is proposed and applied to the converter. Simulation results confirm the effectiveness of the proposed controller to mitigate current spikes of voltage zero crossing.

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Nonlinear Fault Ride-Through of Grid Forming Converters with Power Synchronization Control

Y. Khayat, P. Chen, and M. Bongiorno

Grid-forming (GFM) converters, recognized as a key mechanism for providing frequency and voltage support to weak power grids, confront a significant challenge in maintaining stability during severe voltage dips and providing fault ride through (FRT) capability. To tackle this challenge, this study first uncovers why GFM converters lose their synchronization during the current limit operation mode subjected to grid-side voltage dips. Then, a nonlinear analytical control law for power synchronization control (PSC) based GFM power converters to enhance their FRT capability during grid side severe voltage dips is provided. The effectiveness of the proposed methods is shown through time-domain EMT simulation results, and it is investigated for grids with different short circuit ratios (SCRs).

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A Bi-mechanism Approach for the Detection of Inter-Turn Faults in BLDC Machines Using Autocorrelation and Harmonic Indices

M. Mahmodian, M. Khalilzadeh, and A. Yazdian Varjani

Brushless DC (BLDC) motors are widely used in modern industrial applications. Given their importance, detecting incipient faults such as inter-turn faults (ITFs) in these motors can be essential. The traditional fault detection methods are either inaccurate, computationally burdensome, or require additional hardware that needs to be integrated into the motor. This paper proposes a method for detecting ITF by integrating two novel fault detection mechanisms in parallel. The first mechanism is a novel approach that detects ITFs in real-time using two indicators: autocorrelation of a quasi-torque signal named T_{eq} and autocorrelation of the reference current. To identify faults in steady-state, the second mechanism uses the Fast Fourier Transform (FFT) to extract two novel fault indicators: the 2nd-order harmonic of T_{eq}, a variable which is defined in the paper, and the 3rd-order harmonic of i_β in $\alpha\beta$ stationary reference frame. A mathematical model is required to model the ITF accurately and easily. Therefore, a precise model of ITF in qd synchronously rotating reference frame is proposed. The proposed fault detection method and the ITF model are both verified through simulation studies. The results demonstrate that the proposed method yields minimal delay, high accuracy, and low computational burden, and requires no additional hardware, indicating promising performance.

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Double Switch High Step-Up DC-DC Converter Based on Two-Winding Coupled Inductor

S. Abbasian, M. Farsijani, and T. Roinila

High-voltage DC-DC converters are essential elements in most renewable-energy applications. For such converters, it is important to consider their features such as input current and voltage gain. The present paper proposes a novel topology for high step-up DC-DC converter. The suggested converter provides high voltage gain and minimal switch voltage stress using a magnetic-coupling-based voltage multiplier approach. In addition, a boost inductor at the input provides constant input current, which is advantageous for battery, fuel cell, and solar applications. Furthermore, the MOSFETs are switched at zero voltage, resulting in negligible switching losses. In addition, the linked inductor is biased to zero DC, resulting in a compact magnetic area and reduced core losses. This work presents the functionality of the proposed converter, provides the design considerations, and analyzes the converter performance. The converter operation and properties are validated through several simulations.

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Soft-Switching Ultra-High Step-Up DC-DC Converter Featuring Coupled Inductor and Low Voltage Stress on Switches

A. Nadermohammadi, P. Abolhassani, M. Maalandish, A. Seifi, P. Aghakhanlou, and S.H. Hosseini

This paper introduces a non-isolated DC-DC converter for achieving ultra-high step-up (UHSU) voltage conversion with the use of a two-winding coupled inductor (CI). In this proposed UHSU converter, a significant increase in voltage is achieved by employing low duty cycles and a reduced turn ratio for the CI, which results in a smaller CI core size. Additionally, the presented UHSU converter features soft-switching capabilities for both power switches and diodes, contributing to high efficiency. This design keeps the voltage stress on the switches low, thereby minimizing losses and enhancing overall efficiency. Detailed analysis of the operational modes is provided, along with a comparison to other topologies to showcase the effectiveness of the suggested UHSU converter. Finally, the performance of the proposed UHSU circuit is verified through the construction and testing of a 150-W laboratory prototype operating at a switching frequency of 50kHz with V_{in}=20V and V_{out}=300V.

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A High-Voltage DC Power Supply with Extremely Low Ripple for Traveling Wave Tubes

M. Ziaoddini and S. Kaboli

This research delves into voltage fluctuations in high-voltage DC power supplies (HVDCPSs), employing a low-frequency rectifier structure for depressed collector traveling wave tubes (TWTs). It investigates the impact of HVDCPS output voltage ripple on depressed collector TWT performance. Excessive ripple can elevate undesired harmonics in the TWT output power spectrum, diminishing accuracy. Through simulations and tests, the study identifies ripple causes and proposes solutions, highlighting resonance between stray capacitance and leakage inductance during rectifier diode turn-off. It suggests placing a capacitor in the collector terminal to mitigate ripple, considering stored energy. The findings enhance HVDCPS design for depressed collector TWTs, offering insights to elevate TWT system performance and accuracy. By comprehending ripple causes and effects and proposing effective solutions, the study contributes to the overall enhancement of TWT system performance and accuracy.

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Wireless Power Transfer based on Improved Multilevel Inverter Fed by Z-Source Network

H. Jafari, S. Vaez-Zadeh, M. Hamzeh, and E. Babaei

In this paper, a new circuit for multi-level inverters is proposed. The approach of this structure is to reduce the number of components. This circuit consists of basic and H-bridge topologies, which are responsible for generating and symmetry voltage levels, respectively. This converter can extend to several higher levels by cascading more basic topologies. However, one basic topology with an H-bridge is considered as the case-study topology to perform all simulations. Since Z-source increases the reliability and flexibility of the converter, the inverter is fed by Z-sources. Furthermore, due to the many advantages of wireless power transmission, the proposed converter has been developed and simulated for wireless power transmission. The simulations are done in MATLAB/Simulink for various modulation indexes, loads, and compensation inductances of the system. Finally, the superiority of the proposed converter is verified by comparing the number of devices and its total blocking voltage with some recent converters.

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Implementing IGBT-Based DC/DC Converters for Advanced Control of DC Traction Motors in Train Refurbishment

M. Ghorbanali Afjeh, M. Fazeli, A. Nassaji, M. Shakor, and A. Shakor

The first-generation trains of Tehran Metro are designed with a DC propulsion system and the DC traction motor current control with multiple resistors and contactors. The disadvantage of this structure is the diversity of mechanical elements, high failure rate, torque shocks during operation, and the failure to regenerate braking power to the DC network. By studying the structure of the existing train system and reviewing the principles of DC motor controlling, the modernization of this propulsion system is proposed to solve the existing problems. This new converter consists of a Half-bridge DC/DC Converter used for field current control a Bidirectional DC/DC used for four quadrant operation of the train and a chopper converter for over-voltage protection and dynamic braking. The electrical performance of this new converter was analyzed and approved by simulations in MATLAB software and the experimental results.

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A Control Approach for Reducing Components Stress of Power Supplies with Pulsed Load

M. Qumi, M. Zarghani, and S. Kaboli

In this paper, a control strategy is presented for the power supplies with pulsed current load. In these power supplies, a decrease in output voltage of the power supply is expected when the pulsed current is applied. In this situation, there is a great difference between the peak and the RMS value of the inverter output current which results in a nonoptimal design for keeping the inverter switches safe which is not suitable in many applications. A traditional way to solve the problem caused by the surge current after the Pulse interval is to use a huge output filter with a slow voltage control system in which the inverter current won't be affected by the load pulsed current. In this paper, a control method is presented which has the ability of improving the peak current stress in the inverter without disadvantages of the conventional method. An inner control loop is added to the control system which has the duty of controlling the inverter current amplitude without the disadvantages of the conventional ones. This method is implemented and up to 65% decrease in the peak switch current stress has been observed. The effect of using such a method on improving the inverter current stress is verified in experimental tests.

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Modular Multilevel Converter Current Regulation Using Linear Matrix Inequality (LMI) Approach

H. Sheikhi Jouybary, D. Arabkhaburi, A. El Hajjaji,
and A. Mpanda Mabwe

This paper delves into an approach for regulating the output current of a grid-connected Modular Multilevel Converter (MMC) by employing Linear Matrix Inequality (LMI) approach. The design process is thoroughly investigated, and the controller's performance is evaluated in the paper. The suggested control approach presents benefits in terms of its simplicity, as well as its systematic and mathematically precise method for gain selection. Furthermore, this paper incorporates the utilization of a Proportional-Resonant (PR) circulating current harmonic attenuation method in hybrid with the LMI approach. Finally, the paper presents simulation outcomes conducted using MATLAB/Simulink, including an examination of steady-state and dynamic performances.

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Flying Capacitor Clamped Current Source Inverter with Improved Reliability

F. Faraji and H. Cha

Multilevel current source converters (MLCSCs) have garnered increased attention in various applications, and several new topologies have been introduced in recent years. One such topology is the flying capacitor clamped current source inverter (FC^3SI). However, akin to traditional CSCs, this topology suffers from the open circuit fault (OCF), which is the most prevalent and destructive fault among these converters. To address this limitation, a novel circuit derived from FC3SI is introduced in this paper, referred to as FC^3SI with improved reliability (FC^3SI^2R). Consequently, the occurrence of OCF in the proposed topology is no longer a concern, even if it happens frequently and simultaneously among all switches. The phase-shifted pulse width modulation (PS-PWM) strategy is employed to achieve natural balancing of the flying capacitors' voltage. The proposed remedy is both straightforward and effective, and simulation results validate the feasibility of the suggested structure.

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Cogging Torque Reduction of a BLDC Motor used for Evaporative Water Coolers

M. Karmi, A. Darjazini, M. Karimi, and M. Cheraghi

In recent years, Permanent Magnet Brushless DC (BLDC) machines have attracted significant attention in evaporative water cooler applications due to their high efficiency, high torque density, and wide range of speed control capability. However, their relatively large cogging torque has been recognized as a notable challenge for such applications. This paper, therefore, aims to introduce an alternative approach to address the cogging torque issue without compromising other motor characteristics. In this regard, by developing two-dimensional finite-element (2D-FE) models, four schemes are analyzed, separately, including stator slot skewing, rotor step-skewing, rotor pole-notching, and non-uniform air gap. Then, by utilizing a multi-objective problem, an optimum design is achieved, demonstrating superior performance in terms of minimum cogging torque, and maximum back-EMF and efficiency.

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Paper Code: PN1083

Optimal Design and Analysis of a Less-rare-earth Hybrid PM Magnetic Gear

M. Malakooti and S. A. Afsari Kashani

Magnetic gears (MGs), like mechanical gears, rework power between exclusive speeds and torques; however, magnetic gears' contactless nature affords inherent capability blessings over mechanical gears but the charge fluctuation and the unstable deliver chain of rare-earth PM have posed capacity risks for in addition application of MG. To reduce the use of rare earth PM materials, a less-rare-earth MG design is proposed that uses a parallel-series magnetic circuit in inner rotor and filled magnet cavities filled with each rare earth and ferrite PMs. In this paper, the output performance is optimized and investigated via 2-D finite element analysis.

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A Novel Topology of Quasi-Resonant DC-DC Boost Converter for Electric Vehicle Charging Stations

F. Mohammadzadeh Shahir, N. Hadifar, A. Rajabi, and M. Taheri

The electric vehicle (EV) charging stations based on grid-connected photovoltaic (PV) system need suitable DC-DC boost converter to adapt the output voltage PV panels for the voltage of DC link. A new topology of quasi-resonant DC-DC Boost converter is proposed to increase the output voltage of PV panels in EV charging stations. The relations between the voltage and the current are analyzed in operating modes. The proposed converter eases the control by using only one single power switch. Moreover, compared with other DC-DC converters, it can reduce the cost and size for EV charging stations without using transformer or coupled-inductor. The simulation and experimental results are presented to validate the operating and performance of the proposed DC–DC converter.

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A Fault Location Scheme for Distribution Networks with Inverter-Based Resources

M. Behbahanipoor and S. F. Zarei

Fault location is an important task for distribution network (DN) operators, specifically for modern systems with the penetration of inverter-based distributed generations (IBDGs) such as photovoltaic and type IV wind generators. Accordingly, numerous techniques have been suggested to pinpoint fault locations in power distribution systems with DGs. Traditional methods encompass three primary approaches: traveling waves, impedance-based methods, and artificial intelligence (AI)-based techniques. In this paper, an efficient and simple feature is extracted by evaluating the pros and cons of these techniques. First, the principles and fundamentals of these methods are elaborated. Then, by analyzing the performance of these schemes, an improved fault location method based on impedance estimation is introduced. The proposed method does not suffer from the inherent drawback of the impedance-based methods, which is the need to know the network structure, lines and load data, and voltage and current measurements along the feeder in multiple points. The proposed feature could be used in AI-based techniques, which considerably improves the accuracy and reduces their complexity. To verify the effectiveness of the proposed scheme, in addition to the mathematical proof, a various set of time-domain simulations are carried out. The results show that the proposed scheme provides effective performance in the presence of IBDGs under the fault with different resistances at different locations.

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New Method of Optimizing Solar Energy Prediction through Simultaneous Calculations of Fuzzy Logic and Mean Error Percentage

F. Mohammadzadeh Shahir and N. Hadifar

Photovoltaic electricity generation is completely dependent on uncertain and uncontrollable meteorological factors such as solar radiation, space temperature, module temperature, pressure and wind direction, and humidity. The electricity output from the photovoltaic system changes dynamically in time according to the changes of environmental factors. Therefore, it is very difficult to accurately predict the amount of electricity produced from a solar system. In this article, a fuzzy logic-based model for solar energy forecasting is developed and presented, which includes meteorological parameters such as dew point in addition to commonly known parameters such as duration of sunlight, ambient temperature, wind speed and relative humidity of the climate region. It uses differently. The results obtained from intelligent modeling with measured data for several weather stations representing several different climate zones, i.e. combined climate, hot and dry, hot and humid, cold and cloudy and climate zone. It is average, they will be compared. Then the performance of the proposed model is evaluated based on statistical indicators.

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A Sequence Component-Based Feature for Passive and Artificial-Intelligence-Based Islanding Detection

A. Alizadeh, S. F. Zarei, and M. Shateri

Feature selection is a critical aspect of designing islanding detection schemes, as it affects the method's accuracy, speed, complexity, and overall performance. Various features are suggested in the literature and integrated into different artificial intelligence (AI)-based methods to achieve high performance in islanding detection. In this paper, a feature based on electrical zero sequence components is proposed, which can be used as the sole feature for islanding detection. The proposed feature demonstrates favorable results of 97.84% when using a simple threshold model. Additionally, the proposed feature can be employed in AI-based methods to achieve a high balanced accuracy. Based on the obtained results, using the proposed feature as the only feature in a one-dimensional convolutional neural network (1D CNN) model yields a competitive result of (99.78±0.012). This feature is a key aspect when comparing the results of AI-based methods, such as sophisticated Long Short-Term Memory (LSTM) neural networks, that utilize a higher number of different features. The data collection for the tests includes different islanding/non-islanding conditions; such as islanding: i) islanding under different loading conditions and various power factors, ii) islanding under different quality factor values; and non-islanding: i) switching on/off the large loads, ii) switching on/off the capacitor banks, iii) applying various short-circuit faults at different locations with different fault resistances.

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Analysis and Design of a High Step-up Coupled-Inductor DC-DC Converter with a Voltage Multiplier

M. Daneshfar, M. Feizi, R. Beiranvand, and M. Ebadi

The need for efficient and low cost high step-up dc-dc converters is imminent considering the steady growth of renewable energies, expansion of electric vehicles and several other emerging applications. In this paper, a high step-up dc-dc converter is proposed. The converter utilizes coupled inductors and a voltage multiplier to achieve high voltage gain. The circuit comprises a single switch, four diodes, a pair of coupled inductors and three capacitors. The control of the converter is implemented using a pulse width modulation (PWM) control strategy as the control ground is common with the output voltage. Voltage and current stresses of the components are low and high efficiency operation of the converter is obtained without using auxiliary circuits to reduce switching losses. The converter is analyzed using Laplace equations in each mode, and the time equations are derived solving the equations. A simulation is performed in Cadence Capture software for a 400W converter to better introduce the converter and ensure validity of the theoretical analysis. Finally, the converter is compared with some converters of the same ilk to highlight its features.

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Analysis of Voltage Ripple in a Floated High Voltage DC Power Supply

M. Ziaoddini and S. Kaboli

The power supply for a Depressed Collector Traveling Wave Tube (TWT) involves two High Voltage DC (HVDC) supplies—one for the cathode and the other for the collector. The cathode supply requires minimal voltage ripple, while the collector supply allows higher ripple levels. Typically, rectification of a step-up transformer's secondary winding, followed by a filter, is employed to reduce voltage ripple. A series resistor limits short circuit energy in the cathode supply. However, upon turning on the collector supply, voltage ripple appears in the cathode terminal. This paper elucidates the origin of this ripple and proposes a solution. Simulation and experimental results are presented to validate the effectiveness of the proposed solution.

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Reducing of Circulating Current in Parallel Interleaved Converters with Modified SVM strategy

S. Shahri, E. Farrokhi, and J. Adabi

In this article, an improved three-level space vector modulation (3L-SVM) is proposed to decrease simultaneously the zero-sequence circulating current (ZSCC) and common-mode voltage (CMV) for a system with two parallel converters and a common-mode inductor (CMI). These objectives are achieved by eliminating zero-sequence vectors (ZSC) in 3L-SVM which leads to a significant improvement in converter output waveform quality. To prove the correctness of eliminating the zero vectors from the switching pattern of two converters, initially theoretical analyses have been presented to achieve the goals stated in the proposed method. The proposed method is simulated and validated through MATLAB software and results are compared with traditional 3L-SVM. As well, it is illustrated that ZSCC, CMV, DMCC, and THD are decreased by the proposed method.

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Investigation of RCD Snubber Voltage Balancing Technique for Series-Connected IGBTs in Inverters

P. Javidi, H. Nouri, M. Zarghani, and S. Kaboli

This paper investigates a voltage balancing technique based on RCD snubbers for series-connected IGBTs in high-power DC/AC converters (inverters). In these converters, bidirectional current capability for semiconductor devices is mandatory, and in certain intervals within a switching period, the load current passes through the anti-parallel diodes while the higher/lower arm IGBTs are in their OFF state. Thus, in these intervals, IGBT voltages will be determined based on the reverse recovery charge profile of their anti-parallel diodes. The reverse recovery profile of diodes changes considerably with junction temperature which can differ among the series-connected IGBTs due to various reasons. This causes unequal voltages across series connected IGBTs that can result in over-voltage breakdown and failure in a number of devices. Furthermore, existing active voltage balancing methods for series-connected IGBTs are no longer effective due to their practicality for unidirectional current flow. However, RCD snubbers can be effectively used in parallel with each IGBT in series for inverter applications to balance their collector-emitter voltage. The investigated scheme is validated with SPICE simulation results for a case study in a Variable Speed Drives (VSDs).

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Γ-Z-Source Inverter Based Half-Bridge Structure with Continuous Input Current

A. Bahador, E. Shokai Asl, and E. Babaei

In this paper, a half-bridge impedance source inverter based on gamma structure (HB-ΓZSI) is proposed. The proposed inverter has a continuous input current. In addition, the voltage boost factor of the proposed topology is higher than other traditional structures. The proposed inverter can generate zero-level voltage at the output. Additionally, by adjusting the transformer turn ratio and the shoot-through (ST) duty cycle in this proposed topology, the voltage gain can be controlled. It is significant to highlight that the proposed inverter can be used in applications involving galvanically isolated converters. The proposed topology is evaluated in various operating modes in this paper. Additionally, the boost factor, capacitor voltage ripple, and inductor current ripple are estimated using theoretical steady-state calculations. In the following, a comparison between the proposed inverter and other common topologies is provided. Finally, the experimental results of the proposed topology prototype are presented in order to prove the correct operation of the HB-ΓZSI.

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Roof-Top Solar Photovoltaic Integration on Trains Supplying Auxiliary Power Systems: A Real Case Study

A. Javanmardi, H. Jafari Kaleybar, and M. Brenna

Transportation contributes significantly to global carbon emissions, and rail transport is no exception. The escalating adoption of photovoltaic (PV) panels in various applications has drawn attention due to its potential to mitigate environmental impacts. Rail transportation stands out as an exceptionally efficient mode of conveyance with high power consumption. This issue positions trains as prime candidates for transitioning to fully sustainable energy sources, integrating with renewable energy sources. Despite the other indirect integration methods of PV generation, the direct rooftop mounting integration into the train has not been addressed so much due to the low production power level which cannot be compared with the required traction power which is in the order of Megawatts. In this research, the feasibility of mounting PV modules on the rooftop of a train is investigated considering a case study train traveling from Milano Cadorna to Saronno through a simulation of the system in PVSOL software. It is shown by results that by placing PV modules on the roof of a regional train, up to 9.8% of the train auxiliary power system can be supplied which is more than 600 MWh annually. Moreover, by implementing the proposed system, more than 27 tons of CO_2 emissions per year can be reduced for a train.

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Creative Hybrid Teaching Method for Attractive Engineering Education: Boost Converter Case Study

M. Gandomzadeh, P. Karimi, A. Parsay, A. Gholami,
R. Ghavagsaz Ghochani, and M. Phattanasak

This paper talks about a new way of teaching that combines different methods, and it looks at how well it worked in a complex electrical engineering course, called the Creative Hybrid Teaching Method. This new way is useful for teaching engineering topics and was tested with a case study of the boost converter for students studying renewable energy engineering. The step-by-step implementation of this new way is explained in the paper. It has been checked how well it worked using some tests and numbers like the non-parametric Wilcoxon signed-rank test to see if it's good for teaching and checking how much students have learned. This method is utilized in electrical experiments for students studying energy, electrical, and mechanical engineering. The results showed that it helped teach better and pass on knowledge in both affective and cognitive domains according to Bloom's Taxonomy.

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