

IEEE Transactions on

INDUSTRIAL ELECTRONICS

JANUARY 2023

VOLUME 70

NUMBER 1

ITIED6

(ISSN 0278-0046)

REGULAR PAPERS

Multi-Phase Systems

Sensorless Current Balancing Control for Interleaved Half-Bridge Submodules in Modular Multilevel Converters A. Viatkin, M. Ricco, R. Mandrioli, T. Kerekes, R. Teodorescu, and G. Grandi	5
A Simple 36-Pulse Rectifier With Passive Pulse-Tripling Circuit at the DC Side J. Wang, A. Chen, L. Li, C. Zhao, X. Yao, and Q. Chen	17
Five-Level Switched-Capacitor ANPC Inverter With Output Voltage Boosting Capability C. Rech and W. A. P. Castiblanco	29
VSFPWM Based on Circulating Current Ripple Prediction for ZVS in Two Paralleled Grid-Tied Inverters With Coupled Inductors Q. Li, Y. Ma, X. Zhao, D. Jiang, and Y. Zhang	39
Finite-Set Model Predictive Control for Hybrid Active Power Filter W.-K. Sou, P.-I. Chan, C. Gong, and C.-S. Lam	52
Input Current Step-Tripling for 12-Pulse Rectifier Using a Passive Four-Tap Changer J. Wang, Y. Lv, X. Yao, L. Li, and Q. Chen	65
Control of a Hybrid Modular Solid-State Transformer for Uninterrupted Power Supply Under MVdc Short-Circuit Fault J. Zhang, Y. Zhang, J. Zhou, J. Wang, G. Shi, and X. Cai	76
Research on Master–Slave Windings Motor Drive System and Control Strategy Z. Liang, S. Hu, Z. Li, and M. Tahir	88
Decoupled Control Scheme for THD Reduction and One Specific Harmonic Elimination in the Modular Multilevel Converter Q. Xiao, S. Yang, Y. Jin, H. Jia, J. Pou, R. Teodorescu, and F. Blaabjerg	99
A Novel Detection and Localization Approach of Open-Circuit Switch Fault for the Grid-Connected Modular Multilevel Converter Y. Jin, Q. Xiao, H. Jia, Y. Ji, T. Dragičević, R. Teodorescu, and F. Blaabjerg	112
A Novel Modular Multilevel Converter Based on Interleaved Half-Bridge Submodules A. Viatkin, M. Ricco, R. Mandrioli, T. Kerekes, R. Teodorescu, and G. Grandi	125
Multidimensional Pulsewidth Modulation for Cascaded Split-Source Inverter S. H. Montazeri, J. Milimonfared, and M. R. Zolghadri	137
Feedback Linearization of a Grid-Tied Synchronverter C. A. Busada, S. G. Jorge, and J. A. Solsona	147

(Contents Continued on Page 1)

Machines and Drives

Comparative Study of Yokeless Stator Axial-Flux PM Machines Having Fractional Slot Concentrated and Integral Slot Distributed Windings for Electric Vehicle Traction Applications *W. Geng, Y. Wang, J. Wang, J. Hou, J. Guo, and Z. Zhang* 155

Neural Speed–Torque Estimator for Induction Motors in the Presence of Measurement Noise *S. Verma, N. Henwood, M. Castella, A. K. Jebai, and J.-C. Pesquet* 167

Position Sensorless Control for PMSM Drives With Single Current Sensor *H. Yan, W. Wang, Y. Xu, and J. Zou* 178

An Analytical Prediction Model of Balanced and Unbalanced Faults in Doubly Fed Induction Machines *F. Maurer, T. L. Toftevaag, and J. K. Nøland* 189

Current Reconstruction by One-Step Compensation for Permanent Magnet Synchronous Motor With Fixed Sampling Interval in Position Sensorless Control *L. Tian, Z. Wang, Q. Yu, C. Tang, and H. Zhang* 200

Nonlinear Modeling, Identification, and Optimal Feedforward Torque Control of Induction Machines Using Steady-State Machine Maps *J. Kullick and C. M. Hackl* 211

Speed Fluctuation Mitigation Control for Variable Flux Memory Machine During Magnetization State Manipulations *Y. Zhong, H. Lin, J. Wang, Z. Chen, and H. Yang* 222

Modeling and Multilevel Design Optimization of an AC–DC Three-Degree-of-Freedom Hybrid Magnetic Bearing *M. Wu, H. Zhu, H. Zhang, and W. Zhang* 233

Vibration Reduction Design of Consequent Pole PM Machine by Symmetrizing Local and Global Magnetic Field *S. Zhu, J. Ji, W. Zhao, G. Liu, and C. H. T. Lee* 243

A Consequent Pole Single Rotor Single Stator Vernier Design to Effectively Improve Torque Density of an Industrial PM Drive *W. Liu, J. Wang, and T. A. Lipo* 255

Rotor Attitude Estimation for Spherical Motors Using Multiobject Kalman KCF Algorithm in Monocular Vision *S. Zhou, G. Li, Q. Wang, J. Xu, Q. Ye, and S. Gao* 265

Single-Phase Electronics

An Accurate Model of Magnetic Energy Harvester in the Saturated Region for Harvesting Maximum Power: Analysis, Design, and Experimental Verification *Z. Liu, Y. Li, H. Yang, N. Duan, and Z. He* 290

Modified Deadbeat Predictive Current Control Method for Single-Phase AC–DC PFC Converter in EV Charging System *Y. Bi, C. Wu, T. Zhao, H. Li, J. Xu, G. Shu, and Y. Wang* 286

Integrated Regenerative Braking Energy Utilization System for Multi-Substations in Electrified Railways *J. Chen, Y. Ge, K. Wang, H. Hu, Z. He, Z. Tian, and Y. Li* 298

Periodic Time-Triggered Hybrid Control for DC–DC Converter Based on Switched Affine System Model *W. Ma and B. Zhang* 311

Capacity and Volume Balance of Buffering Converters for the Marine Pulsed Power System *L. Sun, W. Huang, R. Li, F. Gao, N. Tai, and M. Yu* 322

A Fast Self-Positioning-Based Optimal Frequency Control for Inductive Wireless Power Transfer Systems Without Communication *K. Chen, K. W. E. Cheng, Y. Yang, and J. Pan* 334

Low Parasitic-Inductance Packaging of a 650 V/150 A Half-Bridge Module Using Enhancement-Mode Gallium-Nitride High Electron Mobility Transistors *S. Lu, T. Zhao, Z. Zhang, K. D. T. Ngo, R. Burgos, and G.-Q. Lu* 344

Automatic Tuning Receiver for Improved Efficiency and EMI Suppression in Spread-Spectrum Wireless Power Transfer *S. A. Chowdhury, S.-W. Kim, S.-M. Kim, J. Moon, I.-K. Cho, and D. Ahn* 352

Variable Duty Control in Two-Mode LDC for Soft-Change at the Mode Transient *S.-H. Lee, D.-H. Kwon, and J.-K. Kim* 364

A Four-Capacitor Model for Interprimary-Winding Capacitances Analysis in the Input-Series Transformer-Integration Converters *T. Meng, H. Ben, and C. Li* 373

Renewable Energy Systems

Soft-Switching Operation With a Variable Switching Frequency Control for Switched-Quasi-Z-Source Bidirectional DC–DC Converter in EVs *Y. Zhang, S. Gao, S. Jing, and X. Huang* 384

Novel Reconfigurable Topology-Enabled Hierarchical Equalization of Lithium-Ion Battery for Maximum Capacity Utilization *H. Cui, Z. Wei, H. He, and J. Li* 396

Lithium-Ion Battery Calendar Health Prognostics Based on Knowledge-Data-Driven Attention *T. Hu, H. Ma, K. Liu, and H. Sun* 407

A Peak Current Reducing Method for Input-Independent and Output-Series Modular Converters With LC-Branch-Based Power Balancing Unit	418
..... Y. Zhuang, F. Liu, W. Huang, S. Wang, J. Jiang, S. Pan, and X. Zha	
A Blockchain-Enabled Demand Management and Control Framework Driven by Deep Reinforcement Learning	430
..... R. Ma, Z. Yi, Y. Xiang, D. Shi, C. Xu, and H. Wu	
A New Virtual Inductance Control Method for Frequency Stabilization of Grid-Forming Virtual Synchronous Generators	441
..... Y. Yang, J. Xu, C. Li, W. Zhang, Q. Wu, M. Wen, and F. Blaabjerg	
Harmonic Transfer-Function-Based $\alpha\beta$ -Frame SISO Impedance Modeling of Droop Inverters-Based Islanded Microgrid With Unbalanced Loads	452
..... J. Guo, Z. Meng, Y. Chen, W. Wu, S. Liao, Z. Xie, and J. M. Guerrero	
Observer-Based Backstepping Sliding Mode Control Design for Microgrids Feeding a Constant Power Load	465
..... M. Alipour, J. Zarei, R. Razavi-Far, M. Saif, N. Mijatovic, and T. Dragičević	
Minimum Backflow Power and ZVS Design for Dual-Active-Bridge DC–DC Converters	474
..... F. Xu, J. Liu, and Z. Dong	
High Step-Up SEPIC-Based Trans-Inverse DC–DC Converter With Quasi-Resonance Operation for Renewable Energy Applications	485
..... S. Hasanpour, T. Nouri, F. Blaabjerg, and Y. P. Siwakoti	
Stable Maximum Power Extraction and DC Link Voltage Regulation for PMVG-Based WECS	498
..... Y. H. Joo, R. Antonysamy, T. Ramasamy, and S. R. Lee	
A Hybrid-Frame Control Based Impedance Shaping Method to Extend the Effective Damping Frequency Range of the Three-Phase Adaptive Active Damper	509
..... Z. Lin, X. Ruan, H. Zhang, and L. Wu	
Genetic Algorithm Assisted Parametric Design of Splitting Inductance in High Frequency GaN-Based Dual Active Bridge Converter	522
..... C. Wang, T.-G. Zsurzsan, and Z. Zhang	
Impedance Characteristic Analysis and Stability Improvement Method for DFIG System Within PLL Bandwidth Based on Different Reference Frames	532
..... B. Hu, H. Nian, M. Li, Y. Liao, J. Yang, and H. Tong	
Control of ILC in an Autonomous AC–DC Hybrid Microgrid With Unbalanced Nonlinear AC Loads	544
..... S. Jha, B. Singh, and S. Mishra	
Embedded Distributed Temperature Sensing Enabled Multistate Joint Observation of Smart Lithium-Ion Battery	555
..... Z. Wei, J. Hu, H. He, Y. Yu, and J. Marco	
Three-Port Forward Converters With Compact Structure and Extended Duty Cycle Range	566
..... G. Zhou, Q. Tian, and H. Li	
<i>Robotics and Mechatronics</i>	
Multi-Objective Synchronization Control for Dual-Robot Interactive Cooperation Using Nonlinear Model Predictive Policy	582
..... Y. Zhang, X. Zhao, B. Tao, and H. Ding	
Object Clustering With Dirichlet Process Mixture Model for Data Association in Monocular SLAM	594
..... S. Wei, G. Chen, W. Chi, Z. Wang, and L. Sun	
Chase and Track: Toward Safe and Smooth Trajectory Planning for Robotic Navigation in Dynamic Environments	604
..... C. Wang, X. Chen, C. Li, R. Song, Y. Li, and M. Q.-H. Meng	
Ultrasound-Guided Wired Magnetic Microrobot With Active Steering and Ejectable Tip	614
..... Z. Yang, L. Yang, M. Zhang, N. Xia, and L. Zhang	
High Precision Calibration for Three-Dimensional Vision-Guided Robot System	624
..... Z. Liu, X. Liu, Z. Cao, X. Gong, M. Tan, and J. Yu	
SPT-Based Composite Hierarchical Antidisturbance Control Applied to a Quadrotor UAV	635
..... Y. Xie, X. Yu, Y. Shi, and L. Guo	
Hybrid Filtered Disturbance Observer for Precise Motion Generation of a Powered Exoskeleton	646
..... K.-W. Park, J. Choi, and K. Kong	
Balancing and Tracking Control of Ballbot Mobile Robots Using a Novel Synchronization Controller Along With Online System Identification	657
..... D. Ba Pham, X. Quang Duong, D. Sang Nguyen, M. Cuong Hoang, D. Phan, E. Asadi, and H. Khayyam	
New Stabilization Controller of State-Constrained Nonholonomic Systems With Disturbances: Theory and Experiment	669
..... Z. Zhang, S. Zhang, and Y. Wu	
<i>Actuators and Motors</i>	
Topology Optimization for the Manufacturable and Structurally Safe Synchronous Reluctance Motors With Multiple Iron Webs and Bridges	678
..... C. Lee, J. Lee, and I. G. Jang	
A Positive and Negative Pressure Soft Linear Brake for Wearable Applications	688
..... J. H. Jang, A. Coutinho, Y. J. Park, and H. Rodrigue	

An Impact Inertial Piezoelectric Actuator Designed by Means of the Asymmetric Friction	699
. <i>W. Sun, Z. Xu, K. Wang, X. Li, J. Tang, Z. Yang, and H. Huang</i>	
A Self-Tuning LCC/LCC System Based on Switch-Controlled Capacitors for Constant-Power Wireless Electric Vehicle Charging	709
. <i>Z. Luo, Y. Zhao, M. Xiong, X. Wei, and H. Dai</i>	
A Low Detent Force DS-PMSLM Based on the Modulation of Cogging and End Forces	721
. <i>C. Zhang, F. Chen, S. Qiu, T. Pei, W. Gao, J. Chen, J. Zhang, and G. Yang</i>	
<i>Control and Signal Processing</i>	
Adaptive Implicit Inverse Control for a Class of Butterfly-Like Hysteretic Nonlinear Systems and Its Application to Dielectric Elastomer Actuators	731
. <i>Y. Wang, X. Zhang, Z. Li, X. Chen, and C.-Y. Su</i>	
A 400-V Half Bridge Gate Driver for Normally-Off GaN HEMTs With Effective Dv/Dt Control and High Dv/Dt Immunity	741
. <i>S. Yu, Q. Zhou, G. Shi, T. Wu, J. Zhu, L. Zhang, W. Sun, S. Zhang, N. He, and Y. Li</i>	
Practical Terminal Sliding-Mode Control and Its Applications in Servo Systems	752
. <i>H. Dong, X. Yang, H. Gao, and X. Yu</i>	
Output Feedback Tracking Control for a Class of Nonlinear Systems With Sensor Uncertainties	762
. <i>W. Wang, Y. Lin, and Q. Meng</i>	
On Sign-Projected Gradient Flow-Optimized Extended-State Observer Design for a Class of Systems With Uncertain Control Gain	773
. <i>Y. Wang, Z. Chen, M. Sun, Q. Sun, and M. Piao</i>	
Blockchain Protocol-Based Predictive Secure Control for Networked Systems	783
. <i>Y. Yu, G.-P. Liu, X. Zhou, and W. Hu</i>	
A Disturbance Estimation Approach to Self-Calibration of Gimbal Resolver-to-Digital Conversion System	793
. <i>H. Li, X. Chen, G. Liu, and X. Cui</i>	
Fixed-Time Neural Control of Robot Manipulator With Global Stability and Guaranteed Transient Performance	803
. <i>C. Zhu, Y. Jiang, and C. Yang</i>	
Variational Bayesian-Based Moving Horizon Estimation of Toolface for Rotary Steerable Drilling Tool Systems	813
. <i>Y. Niu, L. Sheng, M. Gao, Y. Wang, and D. Zhou</i>	
Suspension Control Strategies Using Switched Soft Actor-Critic Models for Real Roads	824
. <i>H. Yong, J. Seo, J. Kim, M. Kim, and J. Choi</i>	
Accelerated and Adaptive Power Scheduling for More Electric Aircraft Via Hybrid Learning	833
. <i>B. Xu, F. Guo, L. Xing, Y. Wang, and W.-A. Zhang</i>	
Event-Triggered Formation Tracking Control With Application to Multiple Mobile Robots	846
. <i>Z. Huang, R. Bauer, and Y.-J. Pan</i>	
Analysis and Design of Active Disturbance Rejection Control With an Improved Extended State Observer for Systems With Measurement Noise	855
. <i>Y. Du, W. Cao, and J. She</i>	
Analysis and Design of Adaptive Cruise Control for Smart Electric Vehicle With Domain-Based Poly-Service Loop Delay	866
. <i>W. Cao, S. Liu, J. Li, Z. Zhang, and H. He</i>	
Modeling and Robust Control for Tendon–Sheath Artificial Muscle System Twist With Time-Varying Parameters and Input Constraints: An Exploratory Research	878
. <i>X. Wang, N. Yu, J. Han, and Y. Fang</i>	
Control of Beam-Pendulum Dynamics in a Tower Crane With a Slender Jib Transporting a Distributed-Mass Load	888
. <i>J. Ye and J. Huang</i>	
<i>Diagnosis and Monitoring</i>	
Statistical Diagnosis for Quality-Related Faults in BIW Assembly Process	898
. <i>Y.-kai Fu, G.-H. Yang, H.-J. Ma, H. Chen, and B. Zhu</i>	
Online DC-Link Capacitance Monitoring for Digital-Controlled Boost PFC Converters Without Additional Sampling Devices	907
. <i>Z. Zhao, P. Davari, W. Lu, and F. Blaabjerg</i>	
Tuning-Free Bayesian Estimation Algorithms for Faulty Sensor Signals in State-Space	921
. <i>S. Zhao, K. Li, C. K. Ahn, B. Huang, and F. Liu</i>	
Failure Prevention in DC–DC Converters: Theoretical Approach and Experimental Application on a Zeta Converter	930
. <i>M. Bindi, F. Corti, F. Grasso, A. Luchetta, S. Manetti, M. C. Piccirilli, and A. Reatti</i>	
<i>Instrumentation and Sensors</i>	
A Novel Plug-and-Play Factor Graph Method for Asynchronous Absolute/Relative Measurements Fusion in Multisensor Positioning	940
. <i>S. Bai, J. Lai, P. Lyu, B. Ji, B. Wang, and X. Sun</i>	
Structural Coupled Electromagnetic Sensing of Defects Diagnostic System	951
. <i>G. Ru, B. Gao, D. Liu, Q. Ma, H. Li, and W. L. Woo</i>	

Blind-Zone-Free Metal Object Detection for Wireless EV Chargers Employing DD Coils by Passive Electromagnetic Sensing	<i>S. Niu, S. Niu, C. Zhang, and L. Jian</i>	965
Two-Dimensional Equivalent Circuit Model of Ultrasonic Wireless Power Transmission	<i>Y. Du, Y. Zhao, Z. Wang, H. Wang, J. Wang, Y. Geng, and L. Sun</i>	975
An Ultrathin Flexible Loudspeaker Based on a Piezoelectric Microdome Array	<i>J. Han, J. H. Lang, and V. Bulović</i>	985
<i>Embedded Systems</i>		
Enhanced IDA-PBC Applied to a Three-Phase PWM Rectifier for Stable Interfacing Between AC and DC Microgrids Embedded in More Electrical Aircraft.....	<i>M. Lapique, S. Pang, J.-P. Martin, S. Pierfederici, M. Weber, and S. Zaim</i>	995
<i>Intelligent Systems</i>		
Unified Modeling for Multiple-Energy Coupling Device of Industrial Integrated Energy System	<i>Y. Liu, J. Zhao, L. Wang, and W. Wang</i>	1005
K-Means Clustering-Based Kernel Canonical Correlation Analysis for Multimodal Emotion Recognition in Human–Robot Interaction.....	<i>L. Chen, K. Wang, M. Li, M. Wu, W. Pedrycz, and K. Hirota</i>	1016
Accurate SOC Prediction and Monitoring of Each Cell in a Battery Pack Considering Various Influencing Factors	<i>L. Zhao and P. Qin</i>	1025
Statistical-Based Optimal ϵ -Stealthy Attack Under Stochastic Communication Protocol: An Application to Networked Permanent Magnet Synchronous Machine Systems ...	<i>X.-X. Ren, G.-H. Yang, and X.-G. Zhang</i>	1036
<i>Networking</i>		
DEID-Based Control of Networked Rapid Control Prototyping System: Design and Applications.....	<i>G. Huang, X. Wu, F. Guo, L. Yu, and W.-A. Zhang</i>	1047
<i>Letters</i>		
Neural Predictor-Based Dynamic Surface Predictive Control for Power Converters	<i>X. Liu, L. Qiu, J. Rodríguez, W. Wu, J. Ma, Z. Peng, D. Wang, and Y. Fang</i>	1057
Constant Current and Constant Voltage Charging of Wireless Power Transfer System Based on Three-Coil Structure.....	<i>Y. Zhang, Z. Shen, W. Pan, H. Wang, Y. Wu, and X. Mao</i>	1066
Adaptive Fuzzy Q-Learning Control Design and Application to Grid-Tied Nine-Level Packed E-Cell (PEC9) Inverter.....	<i>M. Gheisarnejad, M. Sharifzadeh, M.-H. Khooban, and K. Al-Haddad</i>	1071
