Zirui Liu

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SKILLS

Programming: C, MATLAB, Python, LaTeX

Tools: Simulink, Embedded Coder, Altium Designer, JMAG, Pspice, CAD

EDUCATION

Huazhong University of Science and Technology **Hubei, China**
Ph.D. in Electrical Engineering *Sept. 2019 –Jun. 2025*

- Project: The National Natural Science Foundation of China (Grant 52377050)
- Thesis: "Nonlinear Electro-Thermal Parameters Real-Time Estimation for VSI Driven Electrical Machine System"
- Advisor: Professor **Ronghai Qu**
- Main Subjects: PMSM, Power Electronic, Modern Control & Observe Theory, Artificial Intelligence, Data & Model Fusion, Nonlinear Electrical Machine & Controller Model

Hunan University **Hunan, China**
B.Sc. in Electrical Engineering and Automation *Sept. 2015 – Jun. 2019*

- GPA**: 3.77/4.00** RANK: **2/263**
- Thesis: "Design of Modulation Method for High-speed PMSM"
- Advisor: Professor **Keyuan Huang**
- Main Subjects: PMSM, Nonlinear system, Sensorless Control, SiC MOSFET

EXPERIENCE

University of Michigan **Ann Arbor, MI, US**
Postdoctoral Research Fellow *Sept. 2025 – Present*

- Conduct advanced research in power electronics, electric machines, and renewable energy systems with a focus on high-performance converter design and energy harvesting applications.
- Lead the design and implementation of hardware-in-the-loop (HIL) and experimental test platforms, supporting high-power and real-time validation of control algorithms.

PROJECTS

Grants Proposals Development 2022 – 2025

- The project of the National Natural Science Foundation of China for power controller & electrical machine real-time monitoring in both electrical and thermal states
- The key project of the National Natural Science Foundation of China for fault-tolerant and high-power density integrated motor in more electrical aircraft application
- Contributed to the preparation of grant applications

100kW High Temperature Integrated Two-level VSI & PMSM System 2019 – 2023

- Power device, capacitor and other controller components early selection and design
- Design of SiC MOSFET module gate drive for high temperature operation (up to 175℃)
- Self-sensing and auto-tuning algorithm for dual three-phase PMSM with Embedded Coder
- Prototype testing in different operation condition with environmental simulation chamber (including high temperature, full load operation)

1200 V Cascaded Multilevel Converter 2019 – 2021

- Led early device selection and system modeling simulation
- Designed a gate driver for SiC MOSFET discrete devices and developed a 4-level single-phase prototype
- Developed a capacitor voltage balancing and pre-charge strategy

1kW 28V Low Voltage High-speed Electrical Pump System 2020 – 2021

- Design of control chip, inverter and EMC in one PCB
- Low cost resistor-based phase current sampling with full-closed-loop position sensorless control
- Development of harmonic current injection for low electrolytic capacitance design
- Prototype testing in different operation condition

12kVA interleave DC/DC & Three Phase DC/AC Controller 2020 – 2022

- Schematic design of the control board and power board
- Testing of the integrated interleave Bidirectional DC/DC & Three Phase DC/AC
- Design of the three-layer controller & Power electronic drive & Power loop PCB structure.
- Control strategy for engine starter & generator integration using synchronous reluctance machine

All-In-One Thermal Controller for EV Application 2020 – 2022

- Design and testing of IGBT drive and EMC for integrated controller
- Loss calculation for thermal Finite element analysis
- PCB schematic and layout review
- Simulation design for PMSM and BLDC sensorless control

IPMSM Test Platform for EV application 2022 – 2024

- FEA for nonlinear flux characteristic analysis for IPMSM
- Up to 20 temperature sensors installed inside different positions
- Developed of model & data fusion framework for online thermal modelling and temperature estimation of electric machines and power electronics without sensors
- Open sourced project on thermal modelling: LPTN-informed-LSTM

AWARDS

Three times National Scholarship 2016, 2017, 2024
Four times The first prize Scholarship 2018, 2022, 2023, 2024
Three times Merit Student 2016, 2017, 2018
Meritorious Winner in The Mathematical Contest in Modeling (MCM) Mar. 2017
Second Prize of Mid China Area in The National Undergraduate Electronic Design Contest Nov. 2017
Outstanding Winner in the Huawei Future Smart Car Competition Nov. 2021

SELECTED PUBLICATIONS

Part I: Nonlinear Parameter Identification & Control

- **Z. Liu,** X. Fan, W. Kong, L. Cao and R. Qu, "Improved Small-Signal Injection-Based Online Multi-parameter Identification Method for IPM Machines Considering Cross-Coupling Magnetic Saturation". *IEEE Transactions on Power Electronics,* vol. 37, no. 12, pp. 14362-14374, Dec. 2022
- **Z. Liu**, W. Kong, X. Fan and R. Qu, "Online Multi-Parameter Observation of IPM Machine with Reconstructed Nonlinear Small-Signal Model Based on Dual EKF". *IEEE Transactions on Industrial Electronics,* vol. 71, no. 2, pp. 1234-1245, Feb. 2024

Part II: AC Machine Position Sensorless Control

- **Z. Liu,** B. Shen, W. Kong, X. Fan, K. Peng and R. Qu, "Analytical Approach for Position Observation Error Correction in IPMSM Sensorless Drives Using Online Multi-Parameter Estimation". *IEEE Transactions on Power Electronics*, vol. 39, no. 8, pp. 9230-9243, Aug. 2024
- **Z. Liu,** W. Kong, X. Fan, F. Wang and R. Qu, "Online Multiparameter Estimation with Position Error Correction for Unified Synchronous Machine Sensorless Drives". *IEEE Energy Conversion Congress and Exposition (ECCE)*, 2023, pp. 4882-4888
- **Z. Liu,** W. Kong, H. Liu, K. Peng, F. Wang, X. Fan, R. Qu. "Online Multiparameter Estimation with Position Error Correction for Unified Synchronous Machine Sensorless Drives." *IEEE Transactions on Industry Applications,* vol. 61, no. 1, pp. 345-358, Jan.-Feb. 2025

Part III: Real-time Thermal Modelling and Temperature Estimation

- **Z. Liu**, W. Kong, X. Fan, Z. Li, P. Kai, R. Qu, "Hybrid Thermal Modeling with LPTN-Informed Neural Network for Multi-Node Temperature Estimation in PMSM" *IEEE Transactions on Power Electronics,* vol. 39, no. 9, pp. 10897-10909, Sept. 2024
- **Z. Liu**, W. Kong, X. Fan, Z. Li, P. Kai, R. Qu, "Hybrid Thermal Modeling with LPTN-Informed Neural Network for Multi-Node Temperature Estimation in PMSM" *IEEE Dataport*, doi: https://dx.doi.org/10.21227/sbwe-k671

Others

- **Z. Liu,** W. Yu, H. Guo, W. Kong, C. Gan and R. Qu, "A Capacitor Voltage Sorting Algorithm for Modular Multilevel Converters (MMC) under Low-Frequency Carrier Modulation". *International Conference on Electrical Machines and Systems (ICEMS)*, Harbin, China, 2019, pp. 1-4
- L. Li, X. Fan, **Z. Liu**, D. Li, T. Zou, X. Chen, R. Qu, "A Computationally Efficient Semi-Analytical Method for Circulating Current Loss of High-Speed Permanent Magnet Machines". *IEEE Transactions on Energy Conversion*, vol. 39, no. 1, pp. 675-687, March 2024
- J. Liu, R. Qu, **Z. Liu,** W. Kong, D. Li, "Torque Ripple Mitigation Strategy for Bearingless Flux-Reversal Slice Motors Considering Rotor Eccentricity". *IEEE Transactions on Transportation Electrification,* 2025, doi: 10.1109/TTE.2025.3550169.
- H. Liu, **Z. Liu**, W. Kong, J. Tu, X. Wu, D. Li," Amplitude-Frequency Characteristics-Based Parameter Estimation of Cascaded Transformers for High-Frequency Multilevel Inverters''. *IEEE Journal of Emerging and Selected Topics in Power Electronics*, 2025, doi: 10.1109/JESTPE.2025.3600869.
- Z. Li, W. Kong, **Z. Liu**, B. Shen and R. Qu, "A Novel Adaptive Nonlinear Reaching Law for DC-link Voltage Control of DC-biased Vernier Reluctance Generator". *IEEE Transactions on Transportation Electrification*, vol. 11, no. 1, pp. 922-933, Feb. 2025

SERVICES

Reviewer:

- IEEE Transactions on Power Electronics
- IEEE Transactions on Transportation Electrification
- IEEE Journal of Emerging and Selected Topics in Power Electronics
- IEEE Transactions on Industrial Informatics

Conference

- Reviewer of the 7th International Electrical and Energy Conference 2024 (CIEEC 2024)
- Reviewer of the 26th international Conference on Electrical Machines and Systems 2023 (ICEMS 2023)
- Reviewer & Volunteer of the 6th International Electrical and Energy Conference 2024 (CIEEC 2023)
- Section Chair of the 3rd China International Youth Conference on Electrical Engineering (CIYCEE 2022)

Open Sourced Project on Real-Electrical Machine Temperature Prediction

- LPTN-informed-LSTM: The implementation and results of a LPTN-informed LSTM for multi-node temperature estimation in PMSMs.

Open Sourced Project on Embedded Code for Electrical Machine Drive

- SynMotor_FSO_ParamEst: Simulations and code for model-based sensorless control of synchronous machines, integrating a full state observer.

Open Sourced Project on System Estimation under Electrical Machine Sensorless Control

- AdaptParamOb_ACMotorSensorlessControl: Model-based adaptive observer for unified synchronous machine sensorless drives in full speed region, including code, simulation in both Matlab and python.

INTERNSHIPS

Hardware Developer, Huawei Intelligent Vehicle Solutions BU, Shanghai, China Feb. 2021 – Apr. 2021
Project: All-In-One Integrated Thermal Management Controller Design for EV Application

- Power electronics loss calculation for thermal analysis
- PCB schematic and layout review
- Final report editing