Jun Wang

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Research Interests

High-frequency intelligent WBG and UWBG power electronics and packaging; terrestrial and space sustainable infrastructure; heavy-duty transportation electrification; machine-learning-enabled semiconductor diagnosis and prognosis; biomedical power electronics.

Education

Ph.D. Electrical Engineering, Virginia Tech, Blacksburg, VA, 2018
Advisors: Dushan Boroyevich (NAE Member, LFIEEE) and Rolando Burgos (SMIEEE)

M.S. Electrical Engineering, Zhejiang University, Hangzhou, China, 2010
Advisor: Xiangning He (FIEEE, FIEE)

B.S. Electrical Engineering, Zhejiang University, Hangzhou, China, 2007

Employment History

University of Nebraska-Lincoln — Lincoln, NE
Assistant Professor — 08/2020—present

Virginia Tech (CPES) — Blacksburg and Arlington, VA
Research Assistant Professor — 01/2018—07/2020

GE Power Conversion — Shanghai, China
Electrical Engineer — 04/2010—07/2012

Awards and Honors

- Best Paper Award, IEEE 21st *Int. Symp. Power Electron.*, Novi Sad, Serbia, 2021.
- William M. Portnoy First Prize Paper Award, IEEE Industrial Applications Society, 2020.
- William M. Portnoy Third Prize Paper Award, IEEE Industrial Applications Society, 2018.
- GE individual awards: Management Award, 2011 and 2010.
- GE team awards: Engineering Award, 2011; Outstanding Technical Innovation and Best New Product Introduction, 2011; CTC Technology Award, 2011; Oil & Gas Engineering VP Award, 2010.

Courses Taught

- ECEN-428/828: Power Electronics (senior/graduate). Textbook: "Fundamentals of Power Electronics" by Robert W. Erickson. Course deliverables: Flyback converter prototype.
- ECEN-898: Modeling and Control of Three-phase Power Converters (graduate). Developed slides. Course deliverables: PM machine drive emulation platform based on two VSIs.
- ECEN-998: WBG Semiconductor Device Characterization and Applications (graduate). Developed slides. Course deliverables: SiC MOSFET Double-Pulse Tester and data analysis.

Synergistic Activities

- Grant reviewerships: German Research Foundation (DFG) reviewer, Jan. 2023.
- Grant reviewerships: NSF reviewer, 2023.
- Grant reviewerships: DOE PowerAmerica Member Initiated Projects Round #4, Oct.—Nov. 2021.
- Invited talk: "Auxiliary circuit design for 10 kV SiC MOSFET modules," *IEEE Int. Workshop Integr. Power Packag.*, Grenoble, France, Aug. 26, 2022.
- Invited talk: "Key challenges in enabling SiC-based high-density, high-efficiency, and robust energy infrastructure," *SiC Workshop*, Cleveland, OH, USA, Aug. 11, 2022.
- Invited talk: "High-density medium-voltage SiC-based modular power converters for naval applications," *IEEE PELS Webinar*, Virtual, Aug. 6, 2020.
- Conference tutorial: "PESNet 3.0: A next-generation distributed communication and control network for modular power converters (updated)," *IEEE Int. Symp. Ind. Electron.*, Anchorage, Alaska, USA, May 31, 2022.
- Conference tutorial: "PESNet 3.0: A next-generation distributed communication and control network for modular power converters," *IEEE Electric Ship Technol. Symp.*, Virtual, Jul. 27, 2021.
- Roadmap authorship: Coauthor of "IEEE international technology roadmap of power electronics for distributed energy resources (ITRD)," 2021.
- Journal editorships: Guest Associate Editor of *IEEE J. Emerg. Sel. Topics Power Electron.*
- Journal reviewerships: *IEEE Trans. Power Electron.*, *IEEE Open J. Power Electron.*, *IEEE Trans. Ind. Electron.*, *IEEE J. Emerg. Sel. Topics Power Electron.*, *IEEE J. Emerg. Sel. Topics Ind. Electron.*, *IEEE Trans. Ind. Appl.*, *IEEE CPSS Power Electron.*, and *IEEE Access*.

Publications

Journal Papers

[J1] S. Zhao, R. Kheirollahi, Y. Wang, H. Zhang, X. Song, B. Fan, J. Wang, Y. Cao, and F. Lu, "Soft turn-off DC solid-state circuit breakers with flexible dual tripping schemes," *IEEE J. Emerg. Sel. Topics Power Electron.*, vol. 12, no. 1, pp. 997–1010, Feb. 2024.

[J2] Y. Rong, Z. Shen, J. Wang, J. Yu, B. Fan, S. Mocevic, D. Boroyevich, and R. Burgos, "PESNet 3.0: A WRN-based communication network with ±0.5 ns synchronization error for large-scale modular power converters," *IEEE J. Emerg. Sel. Topics Power Electron.*, vol. 11, no. 2, pp. 1827–1837, Apr. 2023.

[J3] R. Kheirollahi, S. Zhao, X. Zan, H. Zhang, X. Lu, J. Wang, A.-T. Avestruz, and F. Lu, "Fast Y-type thyristor-based dc SSCB using complementary commutation in a capacitor-capacitor pair structure," *IEEE Trans. Power Electron.*, vol. 38, no. 1, pp. 1144–1154, Jan. 2023.

[J4] S. Mocevic, V. Mitrovic, J. Wang, R. Burgos, and D. Boroyevich, "Gate-driver integrated junction temperature estimation of SiC MOSFET modules," *IEEE J. Emerg. Sel. Topics Power Electron.*, vol. 10, no. 5, pp. 4965–4980, Oct. 2022.

[J5] S. Zheng, R. Kheirollahi, J. Pan, L. Xue, J. Wang, and F. Lu, "DC circuit breakers: A technology development status survey," *IEEE Trans. Smart Grid*, vol. 13, no. 5, pp. 3915–3928, Sept. 2022.

[J6] R. Kheirollahi, S. Zhao, H. Zhang, X. Lu, J. Wang, and F. Lu, "Coordination of ultrafast solid-state circuit breakers in radial DC microgrids," *IEEE J. Emerg. Sel. Topics Power Electron.*, vol. 10, no. 4, pp. 4690–4702, Aug. 2022.

[J7] R. Kheirollahi, H. Zhang, S. Zhao, J. Wang, and F. Lu, "Ultrafast solid-state circuit breaker with a modular active injection circuit," *IEEE J. Emerg. Sel. Topics Ind. Electron.*, vol. 3, no. 3, pp. 733–743, July 2022.

[J8] R. Kheirollahi, S. Zhao, Y. Wang, H. Zhang, X. Zan, S. Zheng, X. Lu, J. Wang, A.-T. Avestruz, and F. Lu, "High-frequency high step-up inductive power transfer-based capacitor charger in active injection dc circuit breakers," *IEEE J. Emerg. Sel. Topics Ind. Electron.*, vol. 3, no. 3, pp. 572–582, July 2022.

[J9] Q. Meng, H. Nguyen, A. Vrana, S. Baldwin, C. Q. Li, A. Giles, J. Wang, Y. Yang, and H. Lu, "A high-density theta burst paradigm enhances the aftereffects of transcranial magnetic stimulation: Evidence from focal stimulation of rat motor cortex," *Brain Stimulation*, vol. 15, no. 3, pp. 833–842, May 2022.

[J10] S. Mocevic, J. Yu, B. Fan, K. Sun, Y. Xu, J. Stewart, Y. Rong, H. Song, V. Mitrovic, N. Yan, J. Wang, I. Cvetkovic, R. Burgos, D. Boroyevich, C. DiMarino, D. Dong, J. K. Motwani, and R. Zhang, "Design of a 10 kV SiC MOSFET-based high-density, high-efficiency, modular medium-voltage power converter," *IEEE iEnergy*, vol. 1, no. 1, pp. 100–113, Mar. 2022.

[J11] C. Zhang, S. Srdic, S. Lukic, K. Sun, J. Wang, and R. Burgos, "A SiC-based liquid-cooled electric vehicle traction inverter operating at high ambient temperature," *IEEE CPSS Trans. Power Electron. Appl.*, vol. 7, no. 2, pp. 160–175, June 2022.

[J12] K. Sun, J. Wang, R. Burgos, D. Boroyevich, and J. Stewart, "Design and multi-objective optimization of an auxiliary wireless power transfer converter in medium-voltage modular conversion systems," *IEEE Trans. Power Electron.*, vol. 37, no. 8, pp. 9944–9958, Aug. 2022.

[J13] Y. Rong, J. Wang, Z. Shen, S. Zhou, B. Wen, R. Burgos, D. Boroyevich, J. Verhulst, and M. Belkhayat, "A synchronous distributed communication and control system for SiC-based modular impedance measurement units," *IEEE J. Emerg. Sel. Topics Power Electron.*, vol. 10, no. 3, pp. 3182–3194, June 2022.

[J14] B. Fan, J. Wang, J. Yu, S. Mocevic, Y. Rong, R. Burgos, and D. Boroyevich, "Cell capacitor voltage switching-cycle balancing control for modular multilevel converters," *IEEE Trans. Power Electron.*, vol. 37, no. 3, pp. 2525–2530, Mar. 2022.

[J15] K. Sun, E. Raszmann, J. Wang, X. Lin, R. Burgos, D. Dong, and D. Boroyevich, "Modeling, design, and evaluation of active dv/dt balancing for series-connected SiC MOSFETs," *IEEE Trans. Power Electron.*, vol. 37, no. 1, pp. 534–546, Jan. 2022.

[J16] K. Sun, Y. Xu, J. Wang, R. Burgos, and D. Boroyevich, "Insulation design of wireless auxiliary power supply for medium voltage converters," *IEEE J. Emerg. Sel. Topics Power Electron.*, vol. 9, no. 4, pp. 4200–4211, Aug. 2021.

[J17] S. Mocevic, J. Yu, Y. Xu, J. Stewart, J. Wang, I. Cvetkovic, D. Dong, R. Burgos, and D. Boroyevich, "Power cell design and assessment methodology based on a high-current 10-kV SiC MOSFET half-bridge module," *IEEE J. Emerg. Sel. Topics Power Electron.*, vol. 9, no. 4, pp. 3916–3935, Aug. 2021.

[J18] J. Wang, S. Mocevic, R. Burgos, and D. Boroyevich, "High-scalability enhanced gate drivers for SiC MOSFET modules with transient immunity beyond 100 V/ns," *IEEE Trans. Power Electron.*, vol. 35, no. 10, pp. 10 180–10 199, Oct. 2020.

[J19] J. Hu, J. Wang, R. Burgos, B. Wen, and D. Boroyevich, "High-density current-transformer-based gate-drive power supply with reinforced isolation for 10-kV SiC MOSFET modules," *IEEE J. Emerg. Sel. Topics Power Electron.*, vol. 8, no. 3, pp. 2217–2226, Sept. 2020.

[J20] S. Mocevic, J. Wang, R. Burgos, D. Boroyevich, M. Jaksic, C. Stancu, and B. Peaslee, "Comparison and discussion on shortcircuit protections for silicon-carbide MOSFET modules: desaturation versus Rogowski switch-current sensor," *IEEE Trans. Ind. Appl.*, vol. 56, no. 3, pp. 2880–2893, May-June 2020.

[J21] K. Sun, J. Wang, R. Burgos, and D. Boroyevich, "Design, analysis, and discussion of short circuit and overload gate-driver dual-protection scheme for 1.2-kV, 400-A SiC MOSFET modules," *IEEE Trans. Power Electron.*, vol. 35, no. 3, pp. 3054–3068, Mar. 2020.

[J22] Y. Xu, X. Feng, J. Wang, C. Gao, R. Burgos, D. Boroyevich, and R. E. Hebner, "Medium-voltage SiC-based converter laminated bus insulation design and assessment," *IEEE J. Emerg. Sel. Topics Power Electron.*, vol. 7, no. 3, pp. 1715–1726, Sept. 2019.

[J23] C. Gao, Y. Xu, J. Wang, R. Burgos, D. Boroyevich, and W. Wang, "Partial discharge online monitoring and localization for critical air gaps among SiC-based medium-voltage converter prototype," *IEEE Trans. Power Electron.*, vol. 34, no. 12, pp. 11 725–11 735, Dec. 2019.

[J24] A. Marzoughi, J. Wang, R. Burgos, and D. Boroyevich, "Characterization and evaluation of the state-of-the-art 3.3-kV 400-A SiC MOSFETs," *IEEE Trans. Ind. Electron.*, vol. 64, no. 10, pp. 8247–8257, Oct. 2017.

[J25] J. Wang, R. Burgos, and D. Boroyevich, "Switching-cycle state-space modeling and control of the modular multilevel converter," *IEEE J. Emerg. Sel. Topics Power Electron.*, vol. 2, no. 4, pp. 1159–1170, Dec. 2014.

Conference Papers (selected out of more than 50 conference papers)

[C1] E. Muravleva, B. Canbaz, J. Wang, L. Qu, and J. Hudgins, "Switch cell design for novel high-frequency press-pack SiC FET modules," in *Proc. IEEE Energy Convers. Congr. Expo.*, 2023, pp. 5455–5461.

[C2] B. Canbaz, E. Muravleva, J. Wang, L. Qu, and J. Hudgins, "Design and optimization of a novel monolithic spring for high-frequency press-pack SiC FET modules," in *Proc. IEEE Energy Convers. Congr. Expo.*, 2023, pp. 5551–5557.

[C3] J. Wang, S. Mocevic, Y. Xu, C. DiMarino, R. Burgos, and D. Boroyevich, "A high-speed gate driver with PCB-embedded Rogowski switch-current sensor for a 10 kV, 240 A, SiC MOSFET module," in *Proc. IEEE Energy Convers. Congr. Expo.*, 2018, pp. 5489–5494, (**Prize Paper**).

[C4] S. Mocevic, V. Mitrovic, J. Wang, R. Burgos, D. Boroyevich, M. Jaksic, and M. Teimor, "Gate-driver integrated junction temperature estimation of SiC MOSFET modules," in *Proc. IEEE Energy Convers. Congr. Expo.*, 2020, pp. 3761–3768, (**Prize Paper**).

[C5] J. Wang, Z. Shen, C. DiMarino, R. Burgos, and D. Boroyevich, "Gate driver design for 1.7 kV SiC MOSFET module with Rogowski current sensor for shortcircuit protection," in *Proc. IEEE Appl. Power Electron. Conf. Expo.*, 2016, pp. 516–523.

[C6] J. Wang, B. Yang, J. Zhao, Y. Deng, X. He, and Z. Xu, "Development of a compact 750 kVA three-phase NPC three-level universal inverter module with specifically designed busbar," in *Proc. IEEE Appl. Power Electron. Conf. Expo.*, 2010, pp. 1266–1271.

[C7] J. Wang, Z. Shen, R. Burgos, and D. Boroyevich, "Integrated switch current sensor for shortcircuit protection and current control of 1.7-kV SiC MOSFET modules," in *Proc. IEEE Energy Convers. Congr. Expo.*, 2016, pp. 1–7.

[C8] J. Wang, R. Burgos, and D. Boroyevich, "A survey on the modular multilevel converters — modeling, modulation and controls," in *Proc. IEEE Energy Convers. Congr. Expo.*, 2013, pp. 3984–3991.

[C9] J. Wang, Z. Shen, R. Burgos, and D. Boroyevich, "Design of a high-bandwidth rogowski current sensor for gate-drive shortcircuit protection of 1.7 kV SiC MOSFET power modules," in *Proc. IEEE Workshop Wide Bandgap Power Devices Appl.*, 2015, pp. 104–107.

[C10] J. Wang, R. Burgos, D. Boroyevich, and Z. Liu, "Design and testing of 1 kV H-bridge power electronics building block based on 1.7 kV SiC MOSFET module," in *Proc. IEEE Int. Power Electron. Conf.*, 2018, pp. 3749–3756.

[C11] J. Wang, S. Mocevic, J. Hu, Y. Xu, C. DiMarino, I. Cvetkovic, R. Burgos, and D. Boroyevich, "Design and testing of 6 kV H-bridge power electronics building block based on 10 kV SiC MOSFET module," in *Proc. IEEE Int. Power Electron. Conf.*, 2018, pp. 3985–3992.

[C12] S. Mocevic, J. Wang, R. Burgos, D. Boroyevich, M. Jaksic, M. Teimor, and B. Peaslee, "Phase current sensor and short-circuit detection based on Rogowski coils integrated on gate driver for 1.2 kV SiC MOSFET half-bridge module," in *Proc. IEEE Energy Convers. Congr. Expo.*, 2018, pp. 393–400.

Patents

[P1] J. Wang, E. Muravleva, B. Canbaz, and L. Qu, "High frequency press-pack SiC FET modules," U.S. Provisional Patent 63/496,779, Apr. 18, 2023.

[P2] J. Wang, B. Canbaz, E. Muravleva, and L. Qu, "Monolithic spring assemblies for high-frequency press-pack modules," U.S. Provisional Patent 63/496,759, Apr. 18, 2023.

[P3] F. Lu, H. Zhang, R. Kheirollahi, J. Wang, E. Muravleva, and M. Haque, "Integrated solid-state circuit breaker with superconducting fault current limiter," U.S. Patent Application PCT/US23/65 346, Apr. 5, 2023.

[P4] J. Wang and E. Muravleva, "Power modules for circuit protection," U.S. Patent Application 18/175,980, Feb. 28, 2023.

[P5] B. Fan, J. Wang, J. Motwani, R. Burgos, and D. Boroyevich, "Switching-cycle voltage deviation control for modular multilevel converters," U.S. Patent Application 17/932,079, Sep. 14, 2022.

[P6] K. Sun, J. Wang, R. Burgos, and D. Boroyevich, "Series/series resonant topology for wireless power transfer," U.S. Patent Application 16/913,066, Jun. 26, 2020.

[P7] H. Song, J. Wang, R. Burgos, and D. Boroyevich, "High-density single-turn inductor structure," U.S. Patent Application 16/865,730, May 4, 2020.

[P8] J. Wang, R. Burgos, and D. Boroyevich, "Hybrid-current-mode switching-cycle control," U.S. Patent 11,368,103 B2, Jun. 21, 2022.

[P9] J. Wang, R. Burgos, D. Boroyevich, J. Stewart, and Y. Xu, "Low impedance multi-conductor layered bus structure with shielding," U.S. Patent 11,335,649 B2, May 17, 2022.

[P10] J. Wang, R. Burgos, and D. Boroyevich, "Circulating current injection control," U.S. Patent 10,153,712 B2, Dec. 11, 2018.

[P11] J. Wang, R. Burgos, D. Boroyevich, and B. Wen, "Power-cell switching-cycle capacitor voltage control for modular multi-level converters," U.S. Patent 9,966,874 B2, May 8, 2018.

[P12] J. Wang, F. Zhang, R. S. Zhang, Y. Zhang, B. E. Lindholm, L. Lan, and Y. Zhao, "Electrical coupler, power converter, and method," U.S. Patent 10,475,551 B2, Nov. 12, 2019.

[P13] X. He, J. Wang, Y. Lou, T. Xin, B. Yang, Z. Xu, and R. Zhao, "Water-cooled three-phase neutral-point-clamped three-level inverter module," Chinese Patent CN 101,741,227 B, May 23, 2012.

Selected Research Experience

University of Nebraska-Lincoln Lincoln, NE

"Ultra-efficient Power Module for MVDC Solid-state Circuit Breakers," by NCESR.

- Duration and role: 01/2022—12/2024, Principal Investigator.
- Objectives: develop novel press-pack techniques for SiC solid-state circuit breakers with efficiency comparable to mechanical circuit breakers.
- Specifications: 99.99% efficiency at 1 kA (or 120 μΩ/kV).
- Achievements: conference [C1, C2] ; three pending U.S. patents.

Virginia Tech Blacksburg and Arlington, VA

"High Power Density 10-kV SiC-MOSFET-based Modular, Scalable Power Converters for Medium Voltage Applications," by ARPA-E CIRCUITS, $2.3M for 36 months.

- Duration and role: 03/2018—07/2020, technical leader and main performer.
- Objectives: develop and demonstrate novel modular converter control techniques at the MV level based on an innovative PESNet 3.0 distributed control network. Switching-cycle control (SCC) and integrated capacitor blocked transistor (ICBT) are developed and implemented at full-power ratings.
- Specifications: device: Gen-3 10 kV, 120 A XHV-9 SiC MOSFET module; power cell: 6 kV dc, 84 A, 10 kHz, 100 V/ns, 99.4%, and 10 MW/m^3; power converter: 2 MW, 24 kV dc SCC-MMC and ICBT.
- Achievements: journal [J12, J14, J16, J19]; patent [P6, P8].

"SiC-PEBB Modules for Next Generation MVDC Integrated Power Systems—Development of the SiC-based PEBB 6000," by ONR, $1.6M for 48 months.

- Duration and role: 01/2018—07/2020, technical leader and main performer.
- Objectives: develop a power cell using 10 kV SiC MOSFET modules (highest power available) from Wolfspeed, targeting ultra-high-power density, partial-discharge-free insulation, low noise susceptibility, self-fed auxiliary power system, and intelligent sensing and protection.
- Specifications: device: Gen-3 10 kV, 240 A XHV-6 SiC MOSFET module; power cell: 6 kV dc, 150 A, 20 kHz, 100 V/ns, 99%, and 20 MW/m^3.
- Achievements: journal [J18, J22, J23]; conference [C3]; patent [P9, P7].

"Switching-Cycle Control (SCC) for High-Power-Density SiC MOSFET-based Modular Multilevel Converter (MMC)," by ONR.

- Duration and role: 01/2014—12/2017, main performer.
- Objectives: reduce the passive component size and switching losses of MMC.
- Concept: regulate the MMC circulating current to an innovative staircase shape by peak-current-mode (PCM) control to balance the capacitor voltages at every switching period; developed a Rogowski switch-current sensor to realize the PCM in high power applications.
- Performance: 93% capacitance reduction, 74% inductor reduction, and 10% total SiC MOSFET loss reduction. With SCC, capacitance are dominated by the switching frequency instead of the line frequency. The scalable SCC method has been validated at 1—24 kV SiC-based converters.
- Achievements: journal [J20, J21, J25]; conference [C5, C7, C8, C9, C10, C11]; patent [P10, P11].

Selected Industry Experience

GE Power Conversion Shanghai, China

"Product Development of a Si IGBT-based 3 MW MV6 Medium-voltage Drive."

- Duration and tasks: 06/2011—08/2012, modular power stage design, integration, and testing.
- Objectives: new product introduction of MV drives for mining and power plant applications.
- Specifications: 3 MW, 0—60 Hz, 6.6 kV or 10 kV, 260 A, nested neutral-point-piloted (NNPP) 5-level or 7-level.
- Achievements: first-of-its-kind commercial NNPP 5/7-level inverter and Vienna rectifier.

"Product Development of a Si IGCT-based 30 MW Medium-voltage Drive."

- Duration and tasks: 04/2010—08/2012, modular power stage design, integration, and testing.
- Objectives: new product introduction of MV drives for Oil & Gas low-speed compressors.
- Specifications: 30 MW, 0—60 Hz, 6.6 kV, 2.6 kA.
- Achievements: successful full-power continuous pump-back test.

"Product Development of a Si IGCT-based 11 MW Medium-voltage High-speed Drive."

- Duration and tasks: 04/2010—08/2012, modular power stage design, integration, and testing.
- Objectives: new product introduction of MV drives for Oil & Gas low-speed integrated compressors.
- Specifications: 11 MW, 0—599 Hz, 6.6 kV, 1.2 kA.
- Achievements: first-of-its-kind 600 Hz IGCT-based MV drive; patent [P12].