Guest Editorial

THIS Special Issue of the IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY is a collection of six papers focusing on the SPARC Toroidal Field Model Coil (TFMC) Program, a collaboration between the Massachusetts Institute of Technology Plasma Science and Fusion Center (MIT PSFC), a leader in high-field magnet development for decades, and Commonwealth Fusion Systems (CFS), a company spun out from the MIT PSFC with the objective of commercializing fusion as an energy source. This three-year effort between 2018 and 2021 had the goal of designing, building, and testing a first-in-class, high-field (∼20 T), representative fusion-scale (∼3 m) superconducting toroidal field coil made with the high-temperature superconductor (HTS) Rare Earth Barium Copper Oxide (REBCO). The TFMC was a prototype for establishing the technology now being integrated into the toroidal field magnet of the SPARC tokamak, a net-energy magnetic fusion device currently under construction in Devens Massachusetts at CFS. The progress made as part of this program is a significant step forward in demonstrating high-field HTS magnet technology as an enabler of the high magnetic field pathway to compact, net-energy fusion machines.

The six papers of this Special Issue attempt to provide a comprehensive review of the program's background, objectives, activities, and achievements. A brief summary of the topical areas covered by each paper are as follows.

1) In [A1], Hartwig et al. present a self-contained, high-level technical and programmatic overview of the entire TFMC Program to provide the context for understanding the rest of the papers within this Special Issue.
2) In [A2], Viera et al. present a technical overview of the magnet requirements and conceptual design, the engineering, fabrication, and assembly of the major components of the magnet including the instrumentation package within the magnet.
3) in [A3], Golfinopoulos et al. present a description of the test facility necessary to test the model coil. The paper encompasses the electrical and cryogenic services to the magnet, the instrumentation and control associated with operation of the facility and characterization of the magnet under test, and the overall facility infrastructure.
4) In [A4], Fry et al. present the design and operation of the current leads used to transmit current from the test facility's room temperature power supplies to the TFMC magnet at 20 K. The REBCO cold bus system based on VIPER REBCO cables and an overview of the instrumentation within the current leads is also presented.
5) In [A5], Michael et al. present a technical description of the 600 W at 20 K cryocooler-based helium cryogenic system and its performance during the test campaigns of the TFMC.
6) In [A6], Whyte et al. present a collection of the results obtained during the experimental testing of the TFMC with the additional perspective of validating computation models used to predict TFMC performance.

The papers can be read as standalone documents, but it is recommended you read the first one to have a high-level view of the program, its objectives, and its context within fusion energy and superconducting magnet development. The other five papers in the Special Issue are more targeted toward each specific technical area of the TFMC program.

Our hope is that you will find all six informative and interesting. Happy reading!

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APPENDIX: RELATED ARTICLES

[A1] Z. S. Hartwig et al., "The SPARC Toroidal Field Model Coil Program," *IEEE Trans. Appl. Supercond.*, vol. 34, no. 2, Mar. 2024, Art. no. 0600316, doi: 10.1109/TASC.2023.3332613.

[A2] R. Vieira, "The design, fabrication, and assembly of the SPARC toroidal field model coil," *IEEE Trans. Appl. Supercond.*, vol. 34, no. 2, Mar. 2024, Art. no. 0600615, doi: 10.1109/TASC.2024.3356571.

[A3] T. Golfinopoulos et al., "Building the runway: A new superconducting magnet test facility made for the SPARC toroidal field model coil," *IEEE Trans. Appl. Supercond.*, vol. 34, no. 2, Mar. 2024, Art. no. 0600416, doi: 10.1109/TASC.2024.3352395.

[A4] V. Fry et al., "50 kA capacity, nitrogen-cooled, demountable current leads for the SPARC toroidal field model coil," *IEEE Trans. Appl. Supercond.*, vol. 34, no.2, Mar. 2024, Art. no. 0600518, doi: 10.1109/TASC.2024.3354237.

[A5] P. C. Michael et al., "A 20-K, 600-W, cryocooler-based, supercritical helium circulation system for the SPARC Toroidal Field Model Coil Program," *IEEE Trans. Appl. Supercond.*, vol. 34, no. 2, Mar. 2024, Art. no. 0600113, doi: 10.1109/TASC.2023.3332266.

[A6] D. G. Whyte et al., "Experimental assessment and model validation of the SPARC toroidal field model coil," *IEEE Trans. Appl. Supercond.*, vol. 34, no. 2, Mar. 2024, Art. no. 0600218, doi: 10.1109/TASC.2023.3332823.

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