2026 Helmholtz – OCPC – Program

for the involvement of postdocs in bilateral collaboration projects

Title of the project:

System-Level Integration of Superconducting Power Devices in High-Demand Electrical Networks

Helmholtz Centre and/or institute:

Karlsruhe Institute of Technology (KIT), Institute for Technical Physics (ITEP)

Project leader:

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Description of the project (max. 1 page)**:**

The ongoing electrification of transport, industry, and urban infrastructure is driving a substantial increase in power demand worldwide. In China in particular, rapid load growth, large-scale renewable integration, and continuous expansion of high-voltage (HV) and medium-voltage (MV) networks are creating new technical challenges, including rising short-circuit levels, grid congestion, and increasing requirements for compact, high-capacity transmission solutions.

Superconducting power technologies, such as power cables, fault current limiters (SFCL), transformers, and rotating machines can provide a promising pathway to address these challenges. Their extremely high current density, low electrical losses, compact footprint, and inherent fault current limiting capability enable efficient reinforcement of existing grids without extensive spatial expansion. However, their large-scale implementation requires detailed investigation

of dynamic behaviour, protection coordination, converter interaction, and system-level integration under realistic grid conditions.

The proposed project aims to investigate the integration of superconducting power devices into modern electrical systems using advanced real-time simulation and Power Hardware-in-the-Loop (PHIL) methodologies at KIT. The Institute for Technical Physics (ITEP) operates a 1 MW PHIL infrastructure, enabling realistic testing of power components under dynamically simulated grid conditions. This platform allows the reproduction of steady-state and transient events, protection sequences, and converter-driven disturbances in a controlled laboratory environment.

Using this infrastructure, the project will study scenarios particularly relevant to rapidly expanding HV and MV networks in China, including:

- Interaction between superconducting devices and converter-based renewable generation
- Fault behaviour and protection coordination involving superconducting fault current limiters
- Stability assessment in high-load-density urban grids
- Thermal–electrical coupling and quench behaviour under dynamic operating conditions
- Evaluation of integration strategies for high-growth power systems

In addition, ITEP (KIT) is planning a dedicated liquid hydrogen (LH_2) infrastructure, enabling investigation of the combined use of LH_2 systems and superconducting technologies. This development opens new research perspectives on integrated cryogenic energy carriers and superconducting power transmission concepts, which may become highly relevant for future large-scale energy systems.

The Chinese postdoctoral researcher will contribute to modelling, experimental validation, and system-level analysis of superconducting components within this advanced testing environment. The collaboration aims to combine expertise of ITEP (KIT) in superconducting grid integration with the extensive experience of China in large-scale grid deployment, supporting the development of resilient, efficient, and high-capacity electrical networks capable of meeting rapidly growing power demand.

Description of existing or sought Chinese collaboration partner institute (max. half page)**:**

The proposed bilateral research collaboration will be established with the Department of Electrical Engineering at Tsinghua University, one of leading institutions in power systems and electrical engineering research in China. Tsinghua University consistently ranks among the top universities globally and has a long-standing commitment to advancing technologies that support rapidly evolving energy and power infrastructure in China.

Within the Department of Electrical Engineering, the collaboration will be anchored by Professor Dr. Xinzhou Dong, a distinguished scholar and internationally recognized expert in power system protection and high-voltage transmission technologies. Prof. Dong serves as the head of the power system protection team and director of the Power System Research Institute at Tsinghua University, and holds fellowships in major professional societies including IEEE, IET, AAIA, and the Chinese Society for Electrical Engineering. He also directs the Green Energy and Power Safety Beijing International Science and Technology Cooperation Center, reflecting his leadership in both fundamental research and international scientific engagement.

Prof. Dong's research expertise encompasses transient fault analysis, traveling wave theory, relay protection, intelligent substation systems, and system-level power grid security technologies. These

areas are strategically relevant for resilient and high-performance electrical networks. He has led major national research programs, contributed to international research collaboration projects, and holds leadership roles in technical committees of CIGRE and IEEE, positioning him as a key facilitator of Sino-European research cooperation.

The partnership will leverage strengths of Tsinghua University in power system dynamics, protective relaying, and high-voltage grid operations to complement expertise of ITEP (KIT) in superconducting power device integration and real-time hardware-in-the-loop experimentation. By aligning modelling, simulation, and experimental approaches across both institutions, the collaboration aims to address critical challenges in large-scale, high-demand electrical networks and support the modernization of Chinese HV/MV grid infrastructure.

Required qualification of the postdoc:

- PhD in Electrical Engineering, Power Systems Engineering, Energy Systems Engineering, or a closely related field (completed within the past five years).
- Strong background in power system analysis, protection engineering, grid dynamics, or high-voltage engineering.
- Solid understanding of transient behavior, short-circuit analysis, and protection coordination in HV/MV networks.
- Experience with numerical tools such as MATLAB/Simulink, PSCAD, DIgSILENT PowerFactory, or equivalent software environments.
- Ability to work independently in an interdisciplinary and international research environment.
- Excellent proficiency in English (written and spoken).