VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Sachin Kumar Bhoi**

The public defense will take place on **Monday 30th November 2026 at 5pm** in room **LIC.0.04 Learning Theatre** (LIC, VUB Main Campus)

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ENABLING DIGITAL TWIN TECHNOLOGIES FOR POWER ELECTRONICS CONVERTERS

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Abstract of the PhD research

Power electronics converters control and convert electricity in technologies we use in day-to-day life, starting from mobile phone chargers to electric vehicles, data centres, and industrial equipment. The reliable operation of these systems is crucial. However, understanding what is happening inside the converters, identifying unusual behaviour, and assessing how their components age remains challenging.

This PhD research investigates how digital twins can help address these challenges. A digital twin is a digital representation of a physical system that uses real data and computer models to understand its behaviour and track its condition over time. Through advances in several research areas, from mathematical models to software technologies, this research contributes to the development of digital twin for power electronics converters.

The research first examines existing approaches to identify the main gaps and challenges in applying the proper digital twin concept to power electronics. It then develops a framework for connecting power electronics converters to digital models through widely available internet-connected infrastructure. This framework is demonstrated by detecting unusual behaviour in the electrical supply of an electric motor drive as it operates.

The research also develops a tool to assess the reliability and health of semiconductor devices, which are essential components of power electronics converters. During the design stage, this tool helps estimate the useful lifetime of these devices. During operation, it also helps monitor their ageing. Both capabilities are demonstrated through experimental case studies. Finally, the research develops a virtual sensor that uses data-driven models to estimate the internal temperature of semiconductor devices. This temperature is difficult to measure directly during operation, yet it is essential for understanding how the devices age.

Together, these contributions enable a foundation for digital twins that can monitor the condition of power electronics converters and make better-informed decisions about their design and operation.