IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Protection of Power System with 100% Inverter-Based Resources**	
Project Number	**IMURA1093**	
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Research Clusters:

Highlight which of the Academy's CLUSTERS this project will address?
*(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*

1	*Material Science/Engineering (including Nano, Metallurgy)*
2	***Energy, Green Chem, Chemistry, Catalysis, Reaction Eng***
3	*Math, CFD, Modelling, Manufacturing*
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*
8	*HSS, Design, Management*

Research Themes:

Highlight which of the Academy's Theme(s) this project will address?
(Feel free to nominate more than one. For more information, see www.iitbmonash.org)

1	***Artificial Intelligence and Advanced Computational Modelling***
2	*Circular Economy*
3	***Clean Energy***
4	*Health Sciences*
5	*Smart Materials*
6	***Sustainable Societies***
7	*Infrastructure*

The research problem

Renewable energy (RE) sources are being rapidly integrated to the power systems across the world, with some countries/regions experiencing more than 100% power penetration from RE sources. However, along with the obvious advantages, RE integration introduces a range of technical challenges to secure and stable grid operation. One of the critical challenges is maintain adequate protection of such systems, particularly at ultra-high penetration of renewables as short circuit characteristics/fault response of Inverter-Based Resources-IBRs (wind, Solar PV, Battery etc.) are significantly different than the conventional synchronous generator dominated conventional system. Existing protection schemes are primarily driven by inherent ability of synchronous machines to inject very high current, as high as 700-800% of full load current during a fault induced voltage dip. IBRs on the other hand are restricted to inject maximum of 1.5 to 1.7 per unit current under a fault condition. Therefore, displacement of conventional generators with IBRs thereby resulting in low short circuit currents pose significant challenge to the protection schemes currently designed based on synchronous machine short circuit characteristics.

Several grid operators/transmission utilities have already experienced impact of high IBR penetration on the system strength and have initiated countermeasures to address such impacts. For example, ERCOT, independent system operator in Texas has installed synchronous condensers in high IBR regions for voltage support, fault current and other grid support services. Similarly, EirGrid, system operator in Ireland has set limit on instantaneous penetration from IBRs to maintain grid stability while deploying various measures including advanced protection systems. However, in 100% IBR based system, protection schemes, protection philosophy, and protection settings would need to be revisited and designed adequately that fits best for IBR short circuit characteristics. Grid forming and grid following inverters have different short circuit characteristics despite having some common limitations, such as low fault current limits, delayed short circuit response influenced by the associated controller of IBR, which will also influence the protection systems for 100% IBR systems.

Therefore, in the backdrop of critical protection challenges for 100% IBR based grid, this PhD project is expected to revisit the fundamentals of system protection, and explore the protection schemes, and system protection philosophy that will help in maintaining system protection under 100% IBR penetration.

Project aims

The project aims to:

- Impact analysis of IBRs (Grid forming and Grid following) on protection of bulk power system under 100% RE penetration.
- Identify key challenges of protection in 100% IBRs based grid
- Explore alternatives to address protection challenges of 100% IBR based system
- Develop as hardware-in-loop test bed for protection studies of 100% IBR based system
- Propose new/advanced fundamental concepts for protection of IBR dominated system
- Develop novel protection schemes for 100% IBR based system
- Develop protection coordination framework for grid forming and grid following IBR based systems considering varying proportion of the IBR mix.
- Develop a pragmatic approach for transition to/implementation of new/advanced protection system

Expected outcomes

Highlight the expected outcomes of the project

The expected outcomes are:

- Impact analysis of 100% IBR penetration on protection system of bulk power system
- Identify key technical challenges in protection system of 100% IBR based power system
- Developing a framework for protection coordination in IBR based system
- Develop new/advanced protection schemes for 100% IBR based system
- Develop way forward/implementation strategy for new protection system in 100% IBR based grid
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How will the project address the Goals of the above Themes?

Describe how the project will address the goals of one or more of the 6 Themes listed above.

-The project will help solving limited hosting capacity of **clean energy sources** in modern power systems by providing cheap solutions that can highly increase the hosting capacity of clean energy and enable widely-deployment of clean energy sources with less problems related to power system operation, stability, and security.

-The project will increase the hosting capacity of clean energy and increase the decarbonisation in modern grid resulting in sustainable energy sector and **sustainable modern communities and societies**.

- **Artificial Intelligence and Advanced Computational Modelling** will be used in order to achieve aggregated EVs and the suitable implementation of grid-forming inverter techniques.

Capabilities and Degrees Required

A highly motivated applicant with background in Electrical Power engineering and strong

commitment to quality research. Masters in electrical power or related area is preferred, however, an outstanding undergraduate applicant will also be considered.

Following points, though not mandatory, will be of added value.
Hands on with electrical power related hardware tools, such as, Converter control, Control and Power Hardware-in-Loop (HIL), DigSILENT PowerFactory, PSS/E, OpalRT, RTDS, Typhoon HIL, Labview, MATLAB, PSCAD, and Optimisation tools, such as, GAMS etc.