Dynamic Response and Short-Circuit Modeling of Inverter Based Resources (IBRs)

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Abstract

Traditional synchronous generators (SG) directly connected to the grid can provide significant short circuit current contribution during a fault, but the modern renewable energy sources that are connected to the grid via power electronic converters—also known as inverter-based resources, or IBRs— which are very fragile and sensible to the overcurrent causing a very distinct fault response characteristics. The fault current of an IBR usually has a low amplitude and is controlled by fast switching of power electronics devices dependent upon manufacturer-specific and frequently proprietary IBR control schemes. The short circuit current of a traditional SG is typically high in amplitude (several times the rated current), uncontrolled, and primarily defined by the electrical parameters of the SG and the impedance of the short-circuit path. Modern fault analysis techniques and tools use a voltage source behind a linear impedance model to model an SG. On the other hand, the IBRs cannot use this model, and new advancements have led to industry-accepted short-circuit modelling. This keynote is dedicated to understanding how IBRs behave during a fault and the differences compared to SGs. It also shows the most recent advances in state-of-the-art IBR fault-ride-through (FRT) controls and IBR FRT performance specifications.

Keywords: Control, faults, inverter-based resources, modelling, protection.

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He is a former Lecturer in Electrical Power Systems at Wolfson School of Mechanical, Electrical and Manufacturing Engineering and a member of the Centre for Renewable Energy Systems Technology (CREST) at Loughborough University, UK. He is a former academic staff of the Department of Aerospace, Electrical and Electronic Engineering at Coventry University, where he started as a Lecturer in Electrical Engineering in 2012 and was promoted to Senior Lecturer in Electrical Engineering in 2013. He was formerly with the School of Electrical and Electronic Engineering, The University of Manchester as a Postdoctoral Research Associate (2009-2011). He is a former associate professor (1995-2009) and Chair (1999-2001) of the Department of Electrical Engineering of Universidad Nacional Politécnico de la Fuerza Armada Nacional, Venezuela (1995-2009).

He is the author or editor of several books (Spanish and English), including: "Power Factory Applications for Power System Analysis", Springer; "Advanced Smart Grid Functionalities Based on PowerFactory" Springer, and "Dynamic Vulnerability Assessment and Intelligent Control for Sustainable Power Systems", Wiley.

He has written 20+ book chapters,50+ journal and magazine papers and 100+ conference papers. His work has over 4.5k+ citations, and his *h*-index is 33 (May 2023), according to Google Scholar. He has been invited as a professor at the Master of Renewables at the University of Seville, Spain, the Master of Renewable at the University Carlos III Madrid, Spain, and many other universities worldwide. He has been invited speaker at several top universities: KTH-Sweden, Leuven-Belgium, TU Delft-The Netherlands, etc.; keynote speaker at several important conferences, including session chair at very well-known IEEE conferences. He is an associate editor in several top-ranked scientific journals in the area of power systems.

He is Vice-President of the *Venezuelan Wind Energy Association*, a Senior Member of the Institute of Electrical and Electronic Engineering (IEEE), a member of The *Institution of Engineering and Technology* - the IET (UK), a member of the *International Council on Large Electric Systems* -CIGRE. He received professional recognition as FHEA – Fellow of the Higher Education Academy in January 2014. His research interest includes innovative (operation/control) schemes to optimise the performance of future energy systems. His research is or has been supported by the *Royal Society*, British Council, UK India Education Research Initiative (UKIERI) –UK. He has been collaborating on European research projects, including: "Integration of Offshore wind power into the Spanish Power

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Two special research projects financially supported by the Royal Society and British Council deserve mention: "*Exploring beyond the Frontiers to Build a Smarter Grid (EBF2BSG)*" and "*Smart Multi-Terminal DC micro-grids for autonomous Zero-Net-Energy Buildings*". More recent projects include Newton-Bhabha India UK Advanced Training School (IUATS), Optimal Design and Control of Smart Community: New Ideas for Off-grid Communities.