Project: Power converter controlled as a synchronous machine with fault ride through capability

Key focus: virtual synchronous machine, fault ride through, low inertia, reactive current injection

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Background

National Grid (the Transmission System Operator for Great Britain) has set ambitious targets for power system decarbonisation by 2025. Renewable energy generation currently represents 35.8% of the total electrical power generation of the UK as stated in the UK in 2019 [1]. The rapid integration of renewable energy resources, which are power converter based, has introduced new challenges to the power system operation and control. One of these challenges is the decrease of the system inertia (see Figure 1) which acts to slow the rate of change of frequency in the event of a power imbalanced. In a traditional power network, dominated by synchronous generators, the rotors of the generators naturally contribute to the frequency event by converting the kinetic energy stored in the rotor into electrical energy slowing the rate of change of grid frequency. Converter based renewable resources cannot achieve this naturally however, and so the wind power industry is investigating alternative methods to deliver this inertia from wind turbines in a safe and reliable manner.

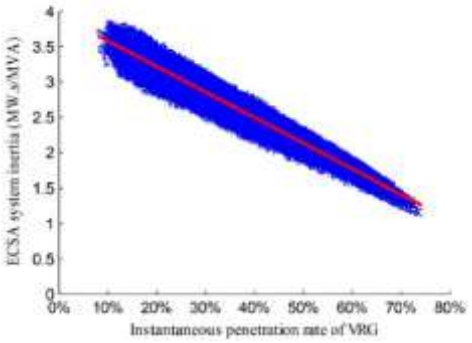

Figure 1: The relation between renewable energy penetration and inertia [2]

Project description

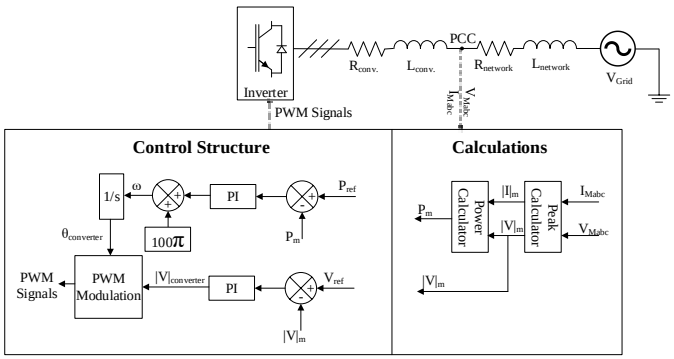

Figure 2: Simple representation of a power converter controlled as VSM connected to the grid

One promising solution is to emulate the synchronous machine's dynamic behaviour through intelligent control of the wind turbine's power converter. This is commonly referred to as Virtual Synchronous Machine (VSM) control. An example of a VSM control topology is shown in Figure 2. Various implementations of VSM are being investigated by both academic and industrial researchers, but a standard implementation does not exist yet. Some of these structures are built on standard converter control technologies and others are based on the synchronous machine swing equation, without a Phase Locked Loop (PLL) or current controller.

The latter option has been identified as being more advantageous, but still presents some challenges in areas such as its Fault Ride Through (FRT) capability. This PhD project then, aims to build a VSM structure without current or PLL controllers, which can ride through different types of electrical faults.

Research outcomes/impact

The PhD focuses on the FRT capability of the VSM, as the implementation of a robust FRT method would increase the VSM TRL level. Nowadays, the VSM implementation lacks the ability to control the converter during faults making this technology unviable commercially. The VSM control must limit the converter current during the fault, as well as facilitate a fast transient recovery after faults. This will increase the reliability renewable energy sources and help maintain system stability. Furthermore, VSM control could enable the provision of future ancillary services, including inertia support and enhanced fault current provision [3].

References:

[1] "UK Electricity generation, trade and consumption, January to March 2019," Department for Business, Energy & Industrial Strategy, 2019.

[2] Y. Wang, V. Silva and M. Lopez-Botet-Zulueta, "Impact of high penetration of variable renewable generation on frequency dynamics in the continental Europe interconnected system," in IET Renewable Power Generation, vol. 10, no. 1, pp. 10-16, 1 2016

[3] “Nationalgrid ESO,” [Online]. Available: https://www.nationalgrideso.com/balancing-services/system-security-services/transmission-constraint-management?market-information#tab-3. [Accessed 24 01 2020].

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