Hybrid Isochronous-Droop Control for Power Management in AC Microgrids

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***Abstract*—The application of droop control as the sole mechanism for power management in microgrids is limited due to its difficulty in achieving operational economy and regulation of frequency. Consequentially, these needs are usually managed using higher level communication-based distributed or centralised control layers. To address these issues, this paper introduces an alternative approach for power management in AC microgrids, using a hybrid isochronous-droop (HID) control scheme that does not require communication. The proposed HID scheme is fully autonomous, and achieves a performance that is comparable with communication-based approaches. It enables generation sources to be scheduled in a defined priority, reduces the number of generation sources in operation for light load conditions, and improves the microgrid frequency load variation, all without requiring communication links. This enables efficient and reliable microgrid power management. Moreover, the proposed power management scheme is straightforward, easy to implement, and cost-effective, which are certainly features preferred by industry. The performance and robustness of the proposed scheme have been validated using an example microgrid operating under a variety of load conditions.**

Keywords—Autonomous Power Management, Distributed Generation, Microgrids Control and Management, Distributed Control, Hierarchical Control, AC–DC–AC power conversion

I. INTRODUCTION

Microgrids are formed by clustering alternative generation sources and loads into a single controlled entity to realise potential benefits such as the optimal utilisation of generation sources and enhanced power supply quality and reliability [1]. To maximise these benefits, it is essential to have a proper control and management system in place which should ideally be economical and easy to implement while meeting the microgrid's load requirements. Due to rapidly increasing interest, various control and management schemes have been investigated recently, which can be broadly classified into four main categories – centralised [2], distributed [3], hierarchical [4-5] and fully autonomous [6-7].

Among these schemes, centralised control systems have a superior performance in optimising resources and achieving high power quality in microgrids [2]. However, the main concerns with the centralised control architecture are its high cost of implementation, non-expandability, and potential poorer reliability due to a single point of failure. In comparison, distributed and hierarchical control systems are more reliable, more flexible for future expansion, and can achieve the same operational performance as centralised systems [2-5]. However, their operational performance is dependent on a communication network, and thus the high cost of their implementation remains a main concern. Hence this solution may not be suitable for all types of microgrids, especially where the generation sources are widely dispersed.

Fully autonomous operation of microgrid can be achieved using droop control which is straightforward to implement, cost effective, reliable and supports plug-n-play [6]. However, traditional droop control has implicit difficulties in achieving operational economies and regulation of frequency. Therefore, the application of the droop control to microgrids is usually limited to the primary response control for both distributed and hierarchical control architectures.

To achieve operational economy in a microgrid without a communication network, various non-linear droop schemes have recently been proposed [7-8]. In these schemes, the dispatching of generation source and power sharing are based on the operational cost of the sources, instead of their power rating. Non-linear droop schemes have demonstrated the potential of achieving operational economy and better frequency regulation in a microgrid without requiring a communication infrastructure. However, limited research has been carried out so far in achieving the key objectives of a microgrid – i.e. economic operation and regulation of frequency regulation, without requiring a communication infrastructure. This important theme of research is now pursued here.

This paper now presents a communication independent power management scheme for AC microgrids using a hybrid isochronous-droop (HID) control. The proposed scheme offers several new features which have so far mostly been realized using communication-based distributed or centralized control schemes. With the proposed HID scheme, the generation sources can be scheduled in a specific priority order, the number of generation sources in operation can be reduced during light load conditions, and the frequency in the microgrid can be regulated in a narrow range. The sequential dispatching

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