

Non-Intrusive Load Monitoring and Load Disaggregation of Distributed DC Networks

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A dissertation submitted to the Faculty of Engineering and the Built Environment,
University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for
the degree of Master of Science in Engineering.

Johannesburg, May 2021

Declaration

I declare that this dissertation is my own, unaided work, except where otherwise acknowledged. It is being submitted for the degree of Master of Science in Engineering to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other university.

Signed this 17 day of May 2021



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Abstract

The work presented extends and contributes to research in non-intrusive load monitoring and load disaggregation which focuses on utilizing these techniques by measuring the grid voltage on distributed DC electrical networks to observe and distinguish the operation of devices on the network. Although previous work in this area has produced practical guidelines and models that may be used to detect and distinguish devices operating on electrical networks, there has not been an investigation into applying the techniques to distributed DC systems. In the research presented, the techniques of non-intrusive load monitoring and load disaggregation have been applied to such systems by measuring the voltage of the network. Measurements are obtained by the design and construction of an automated system such that a combination of devices and distributed DC networks as well as a number of test protocols/scenarios can be tested. The measurement data—voltage transients of device operation events—are then run through a pre-processing pipeline (feature extraction, filtering, and normalization) followed by clustering algorithms that are used to determine if devices exhibit unique and repeatable transient signatures when operating (changing states). It is shown that it is indeed possible to distinguish device operation by measuring the grid voltage because different devices exhibit unique and repeatable transients onto the grid voltage. Limitations appear where devices emit noise onto the grid, drowning out the transients of further device switching; the limitations on the sampling rates on such systems—to achieve sufficient disaggregation performance—should exceed 20 kS/s. This sampling limitation is based on the observations that low-power devices exhibit small transients on the grid voltage and higher-powered devices have larger and longer lasting transients. This represents a unique and valuable contribution to engineers working in the field of non-intrusive load monitoring and load disaggregation as it creates visibility to the operation of devices on distributed DC electrical networks.