MULTI-RESOLUTION ANALYSIS BASED ANN ARCHITECTURE FOR FAULT DETECTION IN DC MICROGRIDS

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Degree of Master of Philosophy by Research

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DECLARATION

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ABSTRACT

DC microgrids present an effective means for integration of renewable energy sources to the utility network while offering clear benefits such as higher efficiency, better compatibility with DC sources and loads and simpler control, compared to its AC counterpart. However, protection challenges associated with DC networks, such as lack of frequency and phasor information, lack of standards, guidelines and practical experience are of particular concern.

Lack of effective solutions for protection of DC networks presents a major barrier for the widespread integration of DC microgrids to the utility network. There are several conventional DC network protection techniques employed in wide range of DC network applications in the fields of telecommunication, data centers and shipboard networks. However, straightforward application of these conventional techniques for protection of DC microgrids is impracticable due to intermittent nature of DGs connected to the network, operation in both grid-connected and islanding mode and high sensitivity to fault impedance.

Hence, for the safe operation of DC microgrids, it is imperative to have reliable fault detection and relay coordination scheme. This thesis presents novel fault detection and grounding scheme for DC microgrids. In the proposed fault detection scheme, fault features contained within fault transients are extracted using a multi-resolution analysis technique and are used alongside an ANN classifier scheme for fault classification.

To evaluate the performance, a comprehensive study on the proposed scheme is presented. Simulation based test results asserted that the proposed technique has accurate, fast and intelligent fault detection capability compared to existing DC protection schemes.

Possible improvements to the current technologies and future directions for research, which could enhance the protection of DC microgrids, are also outlined in this thesis.

Keywords— Artificial Neural Networks, DC microgrid protection, Fault detection, Fault localization, Wavelet transform

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DCMG	DC microgrid
RE	Renewable energy
DG	Distributed generator
RES	Renewable energy source
ACMG	AC microgrid
PV	Photovoltaic
EV	Electric vehicle
ESS	Energy storage system
V2G	Vehicle to grid
DWT	Discrete wavelet transform
ANN	Artificial neural network
CB	Circuit breaker
ACCB	AC circuit breaker
HVDC	High voltage DC
MVDC	Medium voltage DC
IED	Intelligent electronic device
di/dt	Derivative of current
FTT	Fast Fourier transform
STFT	Short-time Fourier transform
WT	Wavelet transform
SVM	Support vector machines
ETO	Emitter turn off
MMC	Modular multi-level converter
FCL	Fault current limiter
DCCB	DC circuit breaker

SSCB	Solid-state circuit breaker
IGBT	Insulated gate bipolar transistor
IGCT	Insulated gate commutated transistor
ZSCB	Z source circuit breaker
SCR	Silicon controlled rectifier
SiC	Silicon Carbide
GaN	Gallium Nitride
HCB	Hybrid circuit breaker
FMS	Fast mechanical switch
G-VSC	Grid-connected voltage source converter
MPPT	Maximum power point tracking
SOC	State of charge
BEMS	Battery energy management system
DESAT	Desaturation