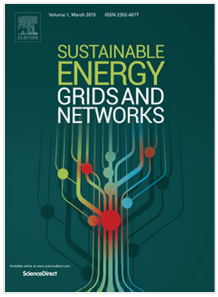
Accepted Manuscript



PMU-assisted overcurrent protection for distribution feeders employing Solid State Transformers

H. Hooshyar, M.E. Baran, S.R. Firouzi, L. Vanftretti

PII: S2352-4677(16)30105-9
DOI: http://dx.doi.org/10.1016/j.segan.2017.02.003
Reference: SEGAN 94

To appear in: *Sustainable Energy, Grids and Networks*

Received date: 5 October 2016

PMU-Assisted Overcurrent Protection for Distribution Feeders Employing Solid State Transformers

H. Hooshyar, *Member, IEEE*, M. E. Baran, *Fellow, IEEE*, S. R. Firouzi, *Student Member, IEEE*, and L. Vanfretti, *Senior Member, IEEE*

***Abstract*-- Solid State Transformer (SST) has recently emerged as an approach to facilitate the integration of Distributed Energy Resources (DERs) at the distribution system level. However, SSTs impact the operation and coordination of protection relays as they will contribute to the fault current during a fault. This paper shows that the impact of SSTs on the overcurrent protection relays can be considerable. The paper proposes an enhancement to the traditional overcurrent scheme by exploiting embedded PMU functionality in SSTs and in feeder protective relays. Performance of the proposed scheme has been assessed through the use of hardware-in-the-loop simulation on a sample distribution feeder.**

***Index Terms*-- distribution system, overcurrent protection, PMU, solid state transformer (SST).**

I. Introduction

A. Motivation

Overcurrent protection has been traditionally the primary scheme employed for protection of distribution feeders. This is mainly due to its simplicity of operation and low maintenance costs [1].

Recently, there has been considerable effort towards infusion of new technologies into distribution systems in order to facilitate the integration of Distributed Energy Resources (DERs) into a distribution system [2-3]. Microgrids have emerged as one of the approaches [4], and an extended version of this approach employs power electronics based Solid State Transformer (SST) to replace the magnetic distribution transformer at every node to facilitate DER integration [5]. SST offers very desirable features such as regulated voltage at the secondary side, reactive power compensation at the primary side, voltage sag ride-through, and fault isolation between the primary and the secondary sides [6-8]. These features coupled with communication capabilities facilitate the management of generation, storage, and loads at the distribution level [9].

As SST acts as an active component in the distribution system, after a fault occurrence it remains connected to the feeder and contributes to the fault current until its self-protection trips. SSTs that serve a balanced combination of generation and load or those that are remote to the fault location remain connected to the feeder for a relatively long time before their self-protection trips [10]. Hence, SSTs impact feeder overcurrent protection as they will contribute to the fault current during a fault, which will in turn impact the operation and coordination of protection relays considerably [11]. As illustrated in [10], SST response during a fault is more complex and quite different from that of an inverter-interfaced DG (Distributed Generator). In addition, the special self-protection scheme employed for the SST makes the current contribution from a SST different than that of a regular converter [10].

Recently, there has been growing interest and research towards adoption of Phasor Measurement Units (PMU) at the distribution system level [12-17]. This has been prompted by an ongoing and rapid evolution of distribution systems from passive to active networks. PMUs make it possible to observe system's response at the same point of time from different locations by providing real-time synchronized phasor measurements, i.e.

This work was supported in part by ERC Program of the National Science Foundation in US under Award Number EEC-08212121, the FP7 IDE4L project funded by the European Commission, and the STandUp for Energy Collaboration Initiative in Sweden.

H. Hooshyar, S. R. Firouzi, and L. Vanftretti are with the KTH Royal Institute of Technology, Stockholm 11428 Sweden (e-mail: {hosseinh,srfi,luigiv}@kth.se).

M. E. Baran is with the North Carolina State University, Raleigh, NC 27606 USA (e-mail: baran@ncsu.edu).