Electrical Power and Energy Systems 33 (2011) 124–130

Contents lists available at ScienceDirect

Electrical Power and Energy Systems

journal homepage: www.elsevier.com/locate/ijepes

Non-linear representation of voltage sag profiles for fault location in distribution networks

Hazlie Mokhlis [a,*], Haiyu Li [a,b]

[a] Center of Research for Power Electronics, Drives, Automation and Control (UMPEDAC), Department of Electrical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia
[b] School of Electrical and Electronic Engineering, The University of Manchester, Manchester M13 9PL

ARTICLE INFO

Article history:
Received 19 June 2009
Received in revised form 1 April 2010
Accepted 7 June 2010

Keywords:
Faulted section
Non-linear voltage sags profile
Fault distance
Fault resistance
Distribution networks

ABSTRACT

Fault location for distribution networks with multiple laterals would requires additional information such as from fault indicators and protective devices. As SCADA systems to provide such information are limited in 11 kV or lower voltage distribution networks, effective fault location method that only use information from a measurement at primary substation is needed. This paper presents the application of calculated non-linear voltage sag profiles and voltage sag measurement at primary substation to locate a fault in distribution networks. The proposed method firstly identifies the faulted section. From the indentified section, fault distance is calculated. The method has been tested under different fault scenarios that include various fault resistance, loading variation and data measurement errors. The results indicate the possibility of using this method to support automatic fault management system.

1. Introduction

The deregulation and privatization of power industry demand power utilities to deliver uninterrupted and high quality of power supply. Power supply is however often interrupted by faults that lead to Customer Minutes Lost (CML). According to a report by Office of Gas and Electricity Markets (OFGEM) in UK [1], over 75% of CML were caused by faults in distribution networks. This occurs since most of distribution networks in UK operate in radial configuration and only protected by a circuit-breaker at the primary substation. Moreover, most of the networks, in particular 11 kV or lower voltage systems are not supported by SCADA system to provide sufficient information for effective faults location. Hence, a fault location method that relies on minimum information is needed.

Fault location methods can be classified into travelling-wave technique, knowledge-based technique and impedance-based technique. Different requirements are needed in order to use these techniques effectively. Travelling-wave technique requires accurate monitoring equipment at one end or two end of a line to measure travelling time of voltage or current reflection waveform from the fault location to the measurement point to calculate fault distance [2,3]. The technique however has difficulty to locate a fault if multiple laterals exist between the fault location and the measurement points due to multiple reflections. Impedance-based technique uses voltage/current measured at a monitored node to locate a fault using mathematical equations [4–8]. Since fault at different locations could produce the same voltage/current value at the monitored node, multiple fault location usually produced in a network with multiple laterals. Additional information such as from fault indicators or protective devices was commonly used to find the most likely fault location [7,8]. Knowledge-based technique uses learning algorithm such as expert system, artificial neural network and fuzzy logic to locate a fault [9,10]. The main requirement to use the technique is to provide suitable and sufficient data for training or for developing logical set of rules in the algorithm.

Recently, data matching technique also has been proposed for fault location. The technique works by matching the measurement data with a list of data from fault calculation. The match will lead to the possible fault location. Different types of data were reported to be used. In [11], a reactance value from a distance relay was matched with simulated one to locate a fault. Voltage sag measurement also was reported to be used [12–15]. In [12], voltage sag waveform from measurement is matched with the simulated one using genetic algorithm. In [13], voltage sag measured from different locations is matched with the simulated vulnerable voltage sag's contours to locate a fault in a transmission line system. Data matching technique using voltage sag measurement was also reported in our previous papers [14,15]. In [14], voltage sag pattern characteristic was used to locate a faulted section in distribution networks. Latter, the method was improved by determining the fault distance [15]. However, it was found that the selection

* Corresponding author. Tel.: +60 379675238; fax: +60 379675316.
E-mail address: hazli@um.edu.my (H. Mokhlis).

0142-0615/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ijepes.2010.06.020