Available online at www.sciencedirect.com
ScienceDirect
Energy Conversion and Management 49 (2008) 151–156
ENERGY CONVERSION & MANAGEMENT
www.elsevier.com/locate/enconman

Diagnosis of voltage collapse due to induction motor stalling using static analysis

F. Karbalaei *, M. Kalantar, A. Kazemi

Center of Excellence for Power System Automation and Operation, Department of Electrical Engineering, Iran University of Science and Technology, Tehran, Iran

Received 26 April 2006; received in revised form 29 November 2006; accepted 29 June 2007
Available online 22 August 2007

Abstract

Induction motor stalling is one of the important reasons for voltage collapse. This paper presents that, for induction motor stalling diagnosis, it is not necessary to use a third or first order dynamic model of induction motors. Instead, a method is presented based on algebraic calculations for which the steady state model of the induction motor considering different kinds of mechanical loads (constant and variable torque) is added to the power flow equations. Simulation results for a simple system confirm the correctness of the proposed method as compared to dynamic simulation results.

Keywords: Voltage collapse; Motor stalling; Static analysis

1. Introduction

As power systems are increasingly operating under heavy loads, voltage stability becomes a critical concern. Since long term voltage instability that causes slow voltage collapse is directly related to power system loadability, many research projects have been performed to increase system loadability [1–4]. Also, optimum load shedding, as a preventive/corrective control for voltage stability, is usually calculated based on loadability level [5]. When the loads behave as constant power (for example, due to tap changer action), voltage collapse occurs only if the load values are larger than the power system loadability. When a disturbance occurs, loadability decreases, and computation of the new loadability is very important. This is why many papers have been presented on fast computation of loadability [6–8].

One more reason for voltage collapse is induction motor stalling that causes fast voltage collapses. In voltage stability studies, induction motors are sometimes modeled as an exponential recovery dynamic load [9], and it is generally assumed that the steady state behavior of an induction motor is as constant power. This assumption implies that motor stalling (and voltage collapse) does not occur until the power drawn by the motors have been more than the system loadability, but motor stalling can occur before system loadability is exceeded. In Ref. [10] the reason for motor stalling has been presented. When the motor voltage decreases, the motor maximum torque is also reduced, and if the mechanical load characteristic of the induction motor is as constant torque, it is probable that there is not any intersection between the motor and load characteristics. In this case, motor stalling and voltage collapse finally occurs. A similar condition can also happen when a variable torque load is used. If the intersection is after critical slip, the speed and voltage may become very low, and the induction motor will be disconnected by protective systems. The exponential recovery model can not indicate these phenomena because it employs separate equations for real and reactive power without any coupling between them [11,12]. On the other hand, in steady state conditions, a constant power model for induction motors may be

* Corresponding author.
E-mail address: f_karbalaei@iust.ac.ir (F. Karbalaei).

0196-8904/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enconman.2007.06.024