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Modelling of V-Hz and vector controlled ASDs in PSCAD/EMTDC for voltage sag studies

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ABSTRACT

This paper deals with modelling and performance of adjustable speed drives (ASDs) subjected to voltage disturbances in electric supply. The aim of this study was to develop appropriate models of typical ASD and investigate their sensitivity to voltage disturbances under various practical modes of operation and control. Accordingly, scalar controlled open and closed loop volts–hertz (V–Hz) and vector controlled closed loop ASDs are modelled in PSCAD/EMTDC environment, and their performance in the presence of voltage disturbances is investigated under typical operating and loading conditions.

The drive sensitivity to three-phase, two-phase and single-phase voltage sags and short interruptions was assessed, and the findings are discussed in the paper. Depending on the type of drive control, type of voltage sag, applied load torque and adjusted speed, various sensitivity curves were established and analyzed.

1. Introduction

A pulse width modulated (PWM) AC adjustable speed drive (ASD) is a highly complex and sophisticated equipment that changes the constant frequency and voltage input into variable frequency and voltage output. Developments in fields of power electronics, microprocessors, and digital communication technologies have enhanced their overall performance and control flexibility, allowing the use of AC machines in various drive applications.

Although PWM ASDs are widely employed due to their various advantages, namely, increased efficiency, variable speed and torque operation, reduced maintenance, etc., they are highly sensitive to voltage disturbances. The results of laboratory measurements presented in [1] showed that the ASDs are more sensitive to voltage sags than data processing equipment. An ASD is only a part of a system [2], in which it operates along with other electrical equipment, and is generally employed to drive critical system load. Malfunction of such a critical equipment/load in a continuous industrial process due to a voltage disturbance could lead to a severe loss in revenue and even equipment damage. The average process interruption costs of an industry employing ASDs are about eight times higher than those of the same industries without them [3]. There is an increasing concern over the economic impact that a malfunctioning of the critical load could inflict on the industry and hence an extensive research in this direction has been initiated.

ASDs operating under various conditions were extensively tested in the laboratory and their sensitivity was assessed for various types of voltage sags and short interruptions in [2]. These results were verified in [4] through simulation of an open loop V–Hz controlled drive in PSCAD/EMTDC [5].

It has been recognised that different types of equipment, and even different brands or models of the same type of equipment, may present important differences with respect to their sensitivity to voltage sags [1]. As only an open loop V–Hz controlled drive was considered in [4], this paper presents in detail modelling of both V–Hz (open and closed loop) and vector (closed loop) controlled AC drives and investigates their sensitivity to voltage sags and short interruptions. One of the main aims of this paper is to present guidelines for modelling and detailed models of ASDs in PSCAD/EMTDC (one of the most widely used software environments for this type of studies) for the assessment of the effects of voltage disturbances on their operation. When modelling the ASD, it was ensured that the model complies with general simulation guidelines for power electronic subsystems mentioned in [6].

Once developed, ASD models were assessed to ensure their compliance with normal drive operating behaviour, and then used for voltage sag sensitivity studies.

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