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Ján Kaňuch, Peter Girovský

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The Device to Measuring of the Load Angle for Salient-Pole Synchronous Machine in Education Laboratory

Ján Kaňuch*, Peter Girovský

Department of Electrical Engineering and Mechatronic, Faculty of Electrical Engineering and Informatics, Technical University of Košice, Letná 9, 04200 Košice, Slovakia.

**Corresponding author. E-mail address: jan.kanuch@tuke.sk*

Abstract

This paper presents information about a new device for measuring the synchronous machine load angle in laboratory conditions using the optical encoder. The prototype device is used in education for practical measuring exercises in the study course of electrical machines. Described in the article is block diagram of the measuring device. The operation principle of the device and the measurement principle of load angle of the synchronous machine presents a subject of the article, too. Moreover, the device evaluates operating mode (motor or generator) of the synchronous machine.

Keywords

Load angle, Synchronous machine, Measurement, Calculation, Vector diagram.

1. Introduction

Measuring the synchronous machine load angle ϑ is important not only at operating alternators but also the synchronous motor, at the overload, at the control e.t.c. The load angle of a synchronous generator is the essential variable for transient stability studies of power systems. In recent years, an application of the load angle as an input variable in the excitation control and protection systems of synchronous generators and power systems has been investigated. Therefore, real-time measurement of the load angle is required for various applications [1]; [2]; [3].

Developed for measuring the load angle ϑ was a number of measuring methods. The measuring methodology is selected as the one that is the most suitable considering the aim of measurement, the required measuring accuracy, and compliance with complicity of the measuring device [4]; [5]. A more detailed review of the measuring methods can be found in literature [6].

The problem at measuring the load angle is the rotor position detection. The load angle measurement system that had been used was described in [7]. The load angle was determined based on the measured terminal voltage and rotor position signal. The load angle measurement for detecting the rotor position based on a photoelectric sensor mounted on the stator is presented in [8].

From the literature and the Internet available information it was impossible to determine which simple devices are nowadays used for measuring the synchronous machine load angle in the tuition process in school laboratories.

2. Estimation of Load Angle

Load angle ϑ ($^{\circ}$ electrical) of a synchronous machine is commonly defined as the angle of the deflection magnetic axis of the synchronous rotated rotor from the magnetic axis, the stator field at the load. In the phasor diagram (Fig. 1), load angle ϑ reflects phase

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