CHAPTER 2
A SIMPLE MODEL FOR A THYRISTOR DRIVEN DC-MOTOR CONSIDERING CONTINUOUS AND DISCONTINUOUS CURRENT MODES

2.1 Introduction

Modelling is an indispensable step in the synthesis of high performance control systems. The model must represent the most relevant characteristics of the system for the proposed application. The modelling of a DC-motor is by now standard and discussed in traditional text-books (Slemon, 1966; Fitzgerald et. al, 1971; Fröhr and Ortenburger, 1971). However, when the DC-motor is supplied with an AC-DC converter, the current and armature voltage in steady state are no longer smooth. They are composed of a mean-value component and sinusoidal harmonic terms. These terms influence the construction of the motor (Robinson, 1968), as well as the "mean-value" or "pseudo-instantaneous" (Bland, 1967) model, which will be discussed later, due to the existence of a discontinuous current mode of operation. The proposed model (Stepahn, 1991) will be established for a single-phase bridge, as in this case the influence of the bridge on the DC-motor performance is larger than in three or six phase bridges. Nevertheless, the motor model can be easily extended to those configurations.

Fig. 2.1 shows a fully controlled single-phase thyristor bridge supplying a DC-motor. The AC input voltage is given by $v=\sqrt{2}U_{ac}t$. The well known (Buxbaum, 1980; Pfaff, 1982) steady-state relationship between the firing angle $\alpha$, the current mean-value $I_d$ and the back voltage $e$, for negligible source impedance ($Z=0$), is repeated in Fig. 2.2. These curves indicate that the relation between the input voltage and current is nonlinear in the discontinuous current mode.
The dynamic variation of the current for a step variation of the firing angle from \( \alpha_1 \) to \( \alpha_2 \) in discontinuous current operation mode is shown in Fig. 2.3a. It can be seen that the current reaches its steady-state wave form during the first cycle after the new firing angle comes into operation. This characteristic indicates that the armature time constant in the discontinuous mode has little influence on a mean-value model. It is important to notice that the armature time constant influences the shape of conduction periods, but the current "mean-value" changes as a system without time constants.