Abstract

Two aspects of thyristorised (mainly thyristor bridge driven) dc drives, namely, digital simulation and microprocessor-based state feedback control are described in this thesis.

The first part of the work relates to the digital simulation of various thyristor bridge/dc motor drive systems. The method proposed earlier by Williams and Smith [31-33] based on the fundamental tensor methods of Kron for the simulation of three phase thyristor bridge has been adopted here with suitable modifications and much simplifications to model thyristor bridge driven dc motors for the first time. With the change in conduction states of thyristors, mode change occurs and the modified system equations are to be formed. The formation of these equations in the digital computer is performed directly here from the knowledge of the conduction states of the thyristors available in the system state array in contrast with the method proposed by Williams and Smith [31-33] (where the connection matrix is first formed and then used to determine the modified system equations), thus resulting in further simplification and saving of computer time. A new method for determining thyristor turn-on conditions in the three phase thyristor bridge, when no thyristors are conducting has also been included.

Three cases, namely, single phase thyristor bridge in one-quadrant operation, three phase dual converter in four-quadrant operation both in circulating-current-free and

circulating-current modes have been studied. The validity of the digital simulation model has been established by comparing typical simulation results with the experimental results or the simulation results available from investigations using other methods. The comparison of the results show reasonable agreement. Thus the versatility of the proposed simulation method to study complex cases has been demonstrated. In all these cases, the ac side source impedances have been taken into account.

The second part deals with microprocessor-based state feedback control of single phase thyristor bridge/dc motor drive system. The multivariable system theory as applied to the speed control of a variable speed dc motor drive is initially discussed. The state variable model of the system is developed and its validity is tested by digital simulation and comparison of the open-loop simulation results with experimental results obtained under identical conditions. The feedback control law is derived by the technique of pole assignment in which the closed-loop system poles are placed in preassigned locations to improve the dynamic response. The control law is a function of the states, that is, armature current and speed of the dc motor and integral of error of output speed, thus resembling the classical P-I controller to some extent.

Further, feedforward control law in terms of reference input and load torque (disturbance) is applied in conjunction with the integral feedback control law such that the output speed follows the reference input (set point) with minimum delay. A minimal order observer is also designed for the estimation of armature current, assumed to be inaccessible, from output speed and inputs. These laws along with the observer are derived in a form suitable for implementation by a microprocessor, as the instantaneous control input can be computed by storing the controller gains in the memory, obtaining the states through interfacing and by using suitable software.

The hardware and software aspects of microprocessor implementation of the closed-loop control of thyristor bridge driven dc motor are presented using a SDK-85 kit based on Intel 8085 processor. A data acquisition module consisting of suitable amplifiers, filters, analog multiplexer and analog-to-digital converter is designed to feed the states and other parameters such as motor current, speed, reference input and load torque (disturbance) in real time. The thyristors are fired in pairs after phase angle delay from the zero crossings of the ac line signal. For this purpose, two modules are developed. Synchronising module consisting of zero-crossing detectors and buffers feeds the two zero-crossing points of the ac line signal to the processor at the input port. The pulses from the output port are first buffered, mixed with carrier frequency, amplified and then fed to the thyristor gates via pulse transformers using direct digital control module. The application software for all these modules have also been evolved. The necessary software for the implementation of the various control laws and minimal order observer is developed.

The complete set-up has been fabricated and thoroughly tested in laboratory conditions under both steady-state and transient conditions such as step changes in reference input and load torque. The experimental results so obtained are then compared with digital simulation results and found to be in reasonable agreement.

A brief discussion of a microprocessor-based state feedback controller for dc thyristor chopper/motor drive system is also included, where a hardware timer generates the time delay for chopper control as contrasted with the previous scheme of single phase thyristor bridge, the time delay of which has been generated through software.

The digital simulation schemes and the microprocessor-based closed-loop state feedback control implementation of thyristor bridge/dc motor drive system studied here are quite general and can be easily extended with minor changes to other similar or complex drive systems.