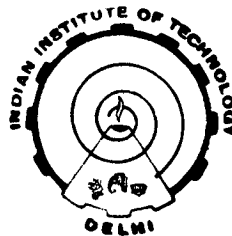


**MICROPROCESSOR BASED
CLOSED-LOOP CHOPPER CONTROL
OF
WOUND ROTOR INDUCTION MOTOR**

by
ANAND KUMAR WAHI

Thesis Submitted to the
Indian Institute of Technology, Delhi
for the award of the degree of

DOCTOR OF PHILOSOPHY



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AUGUST, 1988

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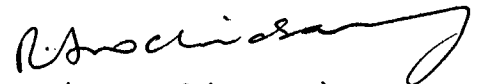
Certificate

Certified that the thesis entitled "Microprocessor Based Closed-loop Chopper Control of Wound Rotor Induction Motor" which is being submitted by Anand Kumar Wahi in fulfilment for the award of the Degree of Doctor of Philosophy in Electrical Engineering of the Indian Institute of Technology, Delhi, India, is a record of the students own work carried out by him under our joint supervision and guidance. The matter embodied in this dissertation has not been submitted for the award of any other Degree or Diploma.



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ACKNOWLEDGEMENT

I am deeply indebted to my supervisors, Prof. R.Arokiasamy and Dr C.M.Bhatia from whom I received continuous encouragement, advice and guidance. I wish to express my sincere thanks to them.

I am grateful to Mr R.Mulchandani and Mr.S.K.Sood of Instrument Design and Development Centre for valuable help in the development of hardware and software for the microprocessor based system.

I am thankful to Prof. J.Nanda Ex. Head of the Electrical Engineering, Prof. S.S.Lamba the present Head and Mr. S.S.Swaminathan, Head IDDC for permitting me to avail the laboratory facilities of their departments.

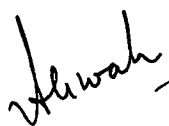
I also express my sincere thanks to Prof.C.S.Jha & Prof.B.P.Singh for their valuable suggestions during the course of this work.

I also acknowledge the help extended to me by laboratory staff Messers R.P.Sharma, Meharban Singh, Deep chand, Tiwari, Chand Singh, Hardayal singh and work shop staff Messers. R.N.Singh, Darshan singh and Gaur's .

I also acknowledge the help extended to me by my co-researchers Mr.D.S.Chauhan, Mr.T.M.George, Mr.M.M.Ektessabi, Mr.K.K.Ray and Mr. R.Anbarasu from time to time during the completion of this work.

I also wish to thank deeply the authorities of the Institute of Technology, for sponsoring me under the Quality Improvement Programme of the Government of India.

I appreciate efforts of my wife Manju for the help in preparation of the manuscript and to my daughter Shikha for keeping patience in living away from her grand parents during this period.


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ABSTRACT

Variable speed operation of an electrical drive plays an important role in industry. Direct current machines which are easy to operate in such a mode, suffer from various design and mechanical constraints. Induction motors do not have such limitations, moreover rapid progress in thyristor control technology has given rise to increasing use of thyristor converters for speed control of induction motors. These converters offer numerous advantages; such as higher efficiency, better reliability, fast time response and compact size. In most applications, where motor is required to be started on load, the use of wound rotor induction motor (WRIM) is generally preferred, with a suitable control of rotor resistance. Although, the use of stepped resistors in this control results in lower starting current, it produces saw-tooth type of run-up characteristic. Therefore, for smooth variation of rotor resistance the use of phase-controlled rectifiers in the rotor circuit has been preferred. These solid state converters, in addition, offer reliability as well as simplicity. However, such a control technique in general suffers from the limitations of poor induction motor power-factor at low levels of speed and generation of line current harmonics. Operation of the system at low power-factor results in reduction of power output and increase in system losses. Although the problem posed by the

phase-controlled thyristor converters may be overcome by installing harmonic filters and reactive power compensators, their use has been restricted due to increase in the system cost.

Choppers connected in the rotor circuit of induction motor have been used for the control of effective resistance and hence for the speed control. Such an arrangement is less expensive and results in high power-factor, which permits large torque to current ratio. The range of speed control that could be achieved in this case depends on the value of the external resistance used in the chopper circuit. An increase in the value of this resistance, for obtaining a wide variation in speed, results in commutation problem and also causes large voltages across the thyristor. In addition the speed regulation becomes poor, particularly at low speeds. In the past attempt has been made to keep the speed of the wound rotor induction motor constant by using analog feed-back and firing circuits for the SCR,s of the chopper. Although highly accurate analog speed controllers with current loops have become popular, with the advancement in LSI technology, much smaller as well as faster microprocessor and peripheral circuits for digital control are now available at lower cost. The microprocessor control of thyristor converters is therefore attractive because in addition to the above mentioned advantages it also offers

the possibility of improved reliability and increased flexibility, particularly in the design of variable speed drives.

The main objectives of the work are as follows:

1. To critically review speed control methods of wound rotor induction motor.
2. To design and fabricate a chopper suitable for operation with a 5HP wound rotor induction motor.
3. To design and develop a 8085 microprocessor based digital controller for generation of firing sequence and suitable control signals for chopper.
4. To develop software for microprocessor controller for the open-loop and closed-loop constant speed operation of the wound rotor induction motor.
5. To study the performance of wound rotor induction motor-chopper system under the closed-loop control for constant speed operation.

With the above noted objects in mind, the major contributions of the work reported in this thesis are as follows:

1. A 8085 microprocessor based digital controller has been developed for firing and control of an SCR chopper. The controller developed is compact, reliable

and very flexible.

2. The 8085 processor software for open-loop and closed-loop speed control is developed for the induction motor-chopper system.
3. The experimental performance of the WRIM at constant speed and variable load is presented.

A chapter wise outline of the work carried out and reported in the thesis is given below:

1. Chapter-1 introduces the various aspects studied, along with a review of the published literature in this area.
2. Chapter-2 presents various methods of speed control of WRIM with emphasis on the rotor resistance control, using thyristor converters.
3. Chapter-3 explains chopper control strategies and different commutation techniques with their merits and demerits. Operation of the chopper circuit used in the present work and its design guidelines are also presented.
4. The development of the 8085 processor based controller has been described in chapter-4 along with firing and control circuits. Design of the hardware and the development of the software is also presented in this

chapter.

5. Chapter-5 presents the overall WRIM-chopper system used in the experimental setup. The results of extensive experimental investigations in open-loop condition are also presented here. The wave forms of the chopper, as well as motor currents and voltages, as recorded at relevant points in the circuit under different parameter variations are analysed. A mathematical model of the system is also presented and analysed in this chapter. Based on this model, the system software for the main frame computer is written and performance characteristics are obtained. The experimental and analytical results thus obtained are compared.
6. Chapter VI is devoted to the closed-loop constant speed operation of WRIM. Results of the extensive tests at various speed settings have been reported, for different parameter variations. It is shown that torque-speed characteristic similar to that of the DC motor could be obtained even at low speed settings. Transient behaviour of the machine for step change in load and reference speed setting has also been reported. It is shown that the digital speed feedback system designed for this work is very effective for the simple algorithm used for constant speed operation of WRIM.

7. Chapter VII includes the inferences drawn from the work reported and suggestions for further improvements in the present work are recorded.

It is hoped that the results obtained in the present research work would be useful for application engineers in selecting wound rotor induction motor for variable speed drives.

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