Ain Shams University

Faculty Of Engineering

MICROPROCESSOR-BASED INDUCTION MOTOR PROTECTION

BY

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A Thesis

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requirements of the Degree of Master OF

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STATMENT

This dissertation is submitted to Ain Shams University for the degree of master in Electrical Engineering.

The work included in this thesis was carried out by the author in the Department of Elecrical Power and Machines, Ain Shams University, from 14 / 11 / 1983 - 4 / 9 / 1988.

No part of this thesis has been submitted for a degree or a qualification at any other University or Institution.

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SUMMARY

In this study a Microprocessor-based relay for induction motor (I.M) protection is developed, implemented and tested in real time.

The developed relaying algorithm has the advantages of using simple mathematical operations with good tested practical accuracy.

The hardware structure is built around 8-bit simple and cheap Microprocessor (MP) system.

The software is developed in a way to suit the chosen algorithm with the selected hardware configuration.

Testing the implemented prototype in real time in the actual mode of operation under conditions as severe and realistic as the same it may face in practice, shows good practical response under different operating conditions.

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CHAPTER I

INTRODUCTION

The protection of the induction motor (I.M) is a complicated problem owing to the variety of possible abnormal operating conditions and the different modes of failure that may occur within it. The type of protection of the motor is influenced by the size of the motor and the type of service [1--6].

In this chapter, the different abnormal operating conditions in I.M., the different conventional and advanced protecting methods are presented and discussed.

The advantages of the Microprocessor-based relays, how they can be developed and why they should be used for I.M. protection are also discussed.

1.1 ABNORMAL OPERATING CONDITIONS AND CAUSES OF FAILURE IN INDUCTION MOTOR [1,6,7,8]:

In the following subsections different abnormal operating conditions and causes of failure in induction motors which require protection measures are discussed. Table (1.1) shows the corresponding protection methods for each abnormal condition.

Tab. (1.1) Protection Chart For I.M Protection

ABNORMAL CONDITIONS	ALTERNATE FORMS OF PROTECTION FROM WHICH CHOICE IS MADE	REMARKS
Overloads	-Over load release -Thermal over load relays -Inverse overcurrent relays -Miniature circuit breaker with built in trip coils	Overload protection given for almost all motors
Phase faults and earth faults	-HRC fuses -High set instantaneous overcurrnt relays. -Differential protection	Differential protection becomes economical for motors above 1200 HP. Below this, high set instantaneous protection is preferred.
Under voltage	-undervoltage release -Undervoltage relays	Undervoltage release incorporated with every starter Undervoltage relays used in certain application.
Unbalanced voltage	-Negative phase sequence relays	Only in special applications
Reverse phase sequence	-Phase reversal relays	Generally at supply point Prevents reversal of running
Single phasing	-Usual thermal overload -Special single phase preventers	Recently developed static single phasing devices becoming popular.
Stalling	-Thermal relays -Instantaneous overcurrent relays	
Rotor fault	-Instantaneous overcurrent	Only for wound roto motor

1.1.1 PROLONGED OVERLOADING:

The electric motor requires more electrical power as its load is increased.

An increase in the power demand by a motor will increase the current drawn by that motor, resulting in an increase in the motor temperature. If the current becomes greater than rated full-load current, motor overheating will occur.

1.1.2 UNBALANCED SUPPLY VOLTAGE AND SINGLE PHASING:

Large negative sequence currents may be produced in the motor in the following cases:

1- Unsymmetrical supply voltage.

2- accidental opening in one phase.

3- Blown up fuse.

This negative sequence component of motor current produces a counter torque to the motor torque. This torque is absorbed as heat and, therefore the negative sequence current has more significant effect on the motor heating than that produced by the positive sequence component. The thermal effect produced by the zero sequence component of current, if it exists, can be neglected.

Thus, the thermal effect of these positive and negative sequence components can be determined by using an equivalent current defined by the following relation:

$$I^2 = I_1^2 + K I_2^2 \qquad (1.1)$$

Where I_1 : positive sequence current;

I_2 : negative sequence current;

K : numerical constant, ($K = 6$).

1.1.3 MOTOR STALLING:

If the motor can not start due to excessive load, it draws heavy current which would cause overheating. It should be then immediately disconnected from supply by the proper protection scheme.

1.1.4 STATOR FAULTS:

Faults in the stator windings of a motor are mainly caused by a failure of insulation due to temperature rise. These faults are mainly earth faults (more common), phase to phase faults (less probable) and inter-turn faults which usually grow into earth faults.

1.1.5 ROTOR FAILURE:

The faults occur in the wound rotor type induction motor are the same as those occur in the stator windings.

In cage rotor type the mechanical stresses have significant effect on the rotor bars and end rings when the rotor is overheated.

1.1.6 SUPPLY UNDERVOLTAGE:

The undervoltage supply causes increase in motor current for a constant load. The current drawn by the motor will increase the motor temperature. If the supply voltage is still decreasing until the maximum value of the electromagnetic torque equals the load torque then, the over-current relay should disconnect the motor from the line. Otherwise the motor will be burned.

1.2 CONVENTIONAL PROTECTION OF INDUCTION MOTORS:

Table (1.1) depicts the protection chart for induction motor under the different abnormal operating conditions mentioned above.

The majority of over-current relays in use today to protect the I.M. are thermal devices which rely on the line current flowing to a motor for a similar heating effect.